



Water markets in federal countries: comparing coordination institutions in Australia, Spain and the Western USA

Dustin E. Garrick¹ · Nuria Hernández-Mora² · Erin O'Donnell³

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Abstract

Water markets are a prime example of decentralised resource allocation, yet their success often depends on strong coordination institutions, particularly as water is redistributed across sectors and political borders. The territorial division of authority in federal countries creates potential intergovernmental coordination challenges in river basins shared by multiple jurisdictions. This paper compares water markets and associated institutional reforms in Australia, Spain and the Western USA—three countries with long-standing experience with water markets but different approaches to distributing authority and intergovernmental coordination. We conduct an institutional mapping of national and sub-national roles in market-based water allocation reforms across the three countries and employ process tracing techniques to examine coordination challenges and institutional responses associated with water markets. We find that (1) policy goals addressed by water markets vary across—and within—the three countries, reflecting differences in the level of decentralisation, but (2) all three countries have required capable coordination institutions to address the distributional conflicts associated with water markets. Coordination institutions can take multiple forms and include both formal and informal venues for planning, financing and conflict management matched to local conditions.

Keywords Water markets · Federalism · Decentralisation · Murray-Darling Basin · Spain · Western USA

Introduction

Severe droughts and intensified competition for water have prompted interest in water markets as a means of reallocating water for cities, agriculture, energy production and ecosystems. The politics, institutional development and performance of water markets have been extensively studied and debated (Easter et al. 1999; Grafton et al. 2011; Maestu 2013; Bennett 2005). Economists have modelled

the potential economic gains from trade (Qureshi et al. 2009), as well as the potential for transaction costs to negate them (Pujol et al. 2006; Garrick et al. 2013). Increasingly, these studies point to the need for ‘integrated water markets’ that include strong institutional foundations (Grafton et al. 2011; Wheeler et al. 2017), attention to equity issues and environmental implications and the development of coordination institutions (Howe et al. 1986). Strong institutions and governance are needed due to the politics of cap-and-trade water allocation (Heinmiller 2009) and the socio-political implications of water redistribution (Hernández-Mora and Del Moral 2015; Meinzen-Dick 1996). The need for strong coordination institutions is expected to be highest when water rights are traded across political or basin boundaries (Young et al. 2000).

Despite the extensive body of literature on water markets and the increasing focus on their institutional foundations, limited attention has been paid to the role of scale and specifically the intergovernmental coordination challenges associated with market-based reallocation. Water markets are closely associated with decentralised environmental and resource governance, yet their success is expected to depend on strong coordination institutions to establish appropriate regulatory

✉ Dustin E. Garrick
dustin.garrick@ouce.ox.ac.uk

Nuria Hernández-Mora
nuriahernandezmora@gmail.com

Erin O'Donnell
erin.odonnell@unimelb.edu.au

¹ Smith School of Enterprise and the Environment, School of Geography and the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, UK

² Madrid, Spain

³ University of Melbourne Law School, Melbourne, Australia

frameworks and address disputes across sectors and jurisdictions (Garrick 2015; Casado-Perez 2016). This study fills a gap by examining intergovernmental coordination challenges associated with water markets and assessing the evolution of institutional responses to these challenges. These coordination challenges are pronounced in federal political systems, which divide authority between territorial (sub-national) and national governments, combining ‘self-rule’ by state governments with ‘shared rule’ by the states and federal levels (Elazar 1987).

The paper compares water markets in federal countries by examining the central versus state (sub-national) government roles in the design and evolution of water markets and how they are coordinated. It seeks to answer two specific questions relevant to water allocation and regional governance in federal political systems:

1. How has the distribution of authority within federal countries affected the goals, institutional reforms and implementation of water markets?
2. What are the intergovernmental coordination challenges associated with water markets, and how have institutions responded to these challenges?

The next section establishes a link between the literature on water markets and the literature on water governance in federal political systems to guide the comparative analysis. The third section outlines the methodology for selecting, developing and comparing the case studies on water markets in Australia, Spain and the USA, drawing on trading data, institutional mapping and process tracing techniques. Fourth, we examine the case studies in terms of the distribution of authority, coordination challenges and institutional responses in water market reforms and implementation. Finally, we compare the cases on these dimensions to distil lessons about the evolution of water markets and coordination institutions in federal political systems.

Water markets and federal political systems: an analytical perspective

There is an extensive literature on both water markets and water governance in federal political systems; however, there is much less attention to the intersection between the two. The territorial distribution of authority in federal political systems can incentivize local innovations, enhance representation of diverse interests and tailor water rights systems to local conditions; however, it can also lead to fragmentation, and poses coordination challenges for water resources governance that affect efforts to design and implement market-oriented reforms (Garrick and De Stefano 2016). We focus on institutional responses to these coordination challenges. Ostrom defines institutions broadly as ‘the prescriptions [including rules and norms] that humans use to organize all forms of repetitive

and structured interactions’ (Ostrom 2005: 3), which therefore transcend the functions of any specific agency or body. Here, we focus specifically on the role of *formal* and *intergovernmental* coordination institutions and emphasise their role spanning political borders and levels of government (Feiock 2013).

This section establishes the analytical approach for comparing the three case studies in terms of the following: the distribution of authority, intergovernmental responses to coordination challenges and accountability issues associated with water markets.

First, the *distribution of authority* between national and sub-national governments is a fundamental institutional design consideration in federal political systems (Bednar 2008). Water markets involve three key institutional reforms (Heinmiller 2007): establishing caps through courts, water laws or planning, creating and allocating tradeable water rights and setting trading rules. These are carried out at different tiers of governance—the state or national level—based on the type of federation and its institutional arrangements for governing water. Three broad approaches to water governance in federal political systems have been identified, ranging from decentralised approaches (exemplified by Canada, the USA and India), centralised approaches (exemplified by Mexico and Spain) and mixed approaches (Australia) (Garrick and De Stefano 2016).

Second, federal systems of water governance require *intergovernmental coordination institutions* to foster cooperation and resolve conflicts between sectors and jurisdictions that share water resource systems (Gerlak 2005). Historically, the apportionment of water among jurisdictions sharing a river has been a flashpoint for conflict, while the development and operation of basin-wide storage and distribution infrastructure create both potential for conflict and cooperation opportunities (Wheeler et al. 2018). Water markets involve several coordination challenges associated with institutional reforms and trading activity, particularly when market-based reallocation has disproportionate impacts on specific jurisdictions (Kenney 2013; Young et al. 2000).

Despite growing recognition of the importance of coordination institutions in water markets, there is still limited understanding of their form and function within and across different political contexts. Meinzen-Dick (2014) differentiates three *ideal types* of coordination institutions, including the state, self-organisation by resource users or the market, which are often mixed in practice. She emphasises that coordination institutions become more important and often more formal as collective action challenges span longer and larger scales; there has been limited analytical clarity and precision about the types of institutional arrangements used for transboundary coordination in water markets. Here we focus on institutional responses to coordination challenges in the context of

federal political systems, which involves institutional arrangements to spur local experimentation and innovation and to facilitate cooperation and conflict resolution across multiple states (horizontal coordination) and tiers of governance (vertical coordination). Intergovernmental coordination institutions can vary in their scope (single versus multi-function) and authority (informal versus formal) (Feiock 2013). In the context of water markets, intergovernmental coordination institutions range from single function to more encompassing arrangements, including the following:

- Regulatory frameworks to harmonise diversion limits, water rights systems and trading rules
- Conflict resolution venues
- Fiscal arrangements (cost, risk and benefit sharing between states and the state and federal governments)
- Planning venues to develop intergovernmental agreements
- Monitoring and data sharing arrangements
- Basin organisations which facilitate coordination across multiple functions

In some cases, one entity (a basin organisation) carries out all of these coordination roles; in other cases, coordination is more fragmented across multiple institutional arrangements. We expect that the level of centralisation and the nature of the federation can have a direct bearing on the type, structure and performance of the intergovernmental coordination institutions in place.

Finally, water trading and associated institutional reforms in federal political systems depend on *accountability and transparency* of coordination institutions to enhance legitimacy. Accountability in the development and implementation of water markets requires transparency in data sharing and decision-making. State governments, river basin organisations and federal agencies therefore play a critical role in establishing water rights registries, ensuring inclusive planning processes and disclosing data about trading and its impacts. The politics of planning, measurement, monitoring and disclosure are highly contested, however. Irrigation communities and water brokers have resisted such disclosure practices due to perceived risks of losing water rights or the potential for increased charges for operations and maintenance costs (Colby 1990; Birkenholtz 2016). Asymmetries in information, where water users have more knowledge than regulatory bodies about historic patterns of water use, may strengthen bargaining positions, weaken enforcement of water rights and undermine protections for third parties, the public and the environment (Matthews 2017). In a multi-level and multi-jurisdictional context, there can be little incentive

for being transparent when there are different levels of governance that benefit from the status quo, or when power dynamics make information a strategic resource in water allocation.

Methodology

Case study selection

We compare the politics and institutional development of water markets in three countries with federal or quasi-federal political systems: Australia, Spain and the Western USA. These three case studies were chosen for two reasons. First, they have at least 15 years of experience with water markets and associated institutional reforms. Second, the three countries vary in terms of their level of centralisation in water allocation and basin planning. At one end of the spectrum, Spain has a centralised approach to water legislation, with river basin authorities having responsibility for water planning and allocation for rivers that cross state boundaries, whereas states¹ have authority over intra-state river basins. At the other end of the spectrum, the Western USA vests allocation authority at the state level with federal roles limited to the financing and management of key reservoirs. Australia's mixed approach involves states' rights over water allocation combined with a growing federal role in basin planning. Together, these considerations make Australia, Spain and the USA ideal countries for understanding and comparing the evolution of coordination institutions in water markets within federal countries.

Materials

We use case-oriented methodology to construct and then compare the three countries across a set of focal institutional reforms (following the example of groundwater governance by Ross and Martinez-Santos 2010). The empirical focus requires an analysis of (1) trading activity within and across state and basin boundaries, (2) the distribution of authority, roles and responsibilities in water market reforms and (3) institutional responses to coordination challenges. We compiled available datasets on trading activity, examining the volume and types of transactions to characterise the trading patterns and contrast the coordination challenges associated with intra-state and interstate trading. We then conduct an institutional mapping of the distribution of authority and governance tasks between national and state levels based on documentary evidence (laws, policy statements and intergovernmental agreements),

¹ Spain has 17 autonomous regions, which are hereafter called 'states' to ease comparison with the sub-national jurisdictions in Australia and the USA.

using a consistent list of governance tasks adapted from the Australian National Water Commission (2011) (Fig. 1). Finally, process tracing techniques were used to examine the evolution of coordination institutions based on a constructed timeline. Collier (2011) describes process tracing as an analytical tool for making descriptive inferences within cases over time by tracing a ‘temporal sequence of events’ (p. 824). We used documentary evidence and secondary literature to identify critical junctures and patterns of trading activity, coordination challenges and institutional responses (based on Garrick 2015; Hernandez-Mora and Del Moral 2015; Fig. 1).

Research setting: water allocation, markets and trading patterns

Australia

Under the Australian constitution, the states have primary responsibility for water resource management within their borders, including the creation of water rights, the establishment of water trading rules, a water rights register and process for formal transfer of water rights, water accounting and reporting (Kildea and Williams 2010; Williams and Webster 2010). In each state, the water rights include a permanent *water access entitlement* (the right to receive water each year) and temporary *water allocation* (the physical water available for use) (National Water Commission 2013). Each state defines these rights

slightly differently, and each state also created specific rules to manage interstate water trading. The Murray-Darling Basin is the most active region for water trading in Australia, comprising approximately 80% of national activity. The basin is shared between five states, with a long history of joint management, including investment in water infrastructure (Connell 2007). The current federal role in the water governance arrangements of the Murray-Darling Basin (MDB) stems from 2007, when the Millennium Drought caused the Australian government to commit \$10 billion to improve the sustainability of the MDB, in return for state support of new federal legislation (Prime Minister of Australia 2007). Water trading has increased from approximately 1000 GL/year (1000 Mm³) in the Murray-Darling in 2007 to over 6000 GL/year (6000 Mm³) in 2016, with the majority of activity in the temporary market (Aither 2016). Most temporary trade occurs within state borders, with total interstate trade of water allocation reaching a maximum of 33% (of total volume traded) in 2008–2009 (National Water Commission 2014; Grafton and Horne 2014), confirming expectations that interstate trading poses coordination challenges due to the distributional conflicts involved. Permanent trade across state borders is subject to additional rules (Murray-Darling Basin Commission 2006), and no such trades have occurred from 2009 to 2016 (Bureau of Meteorology 2016). Water acquisitions for the environment by the federal government comprise one of the main drivers of permanent trading activity.

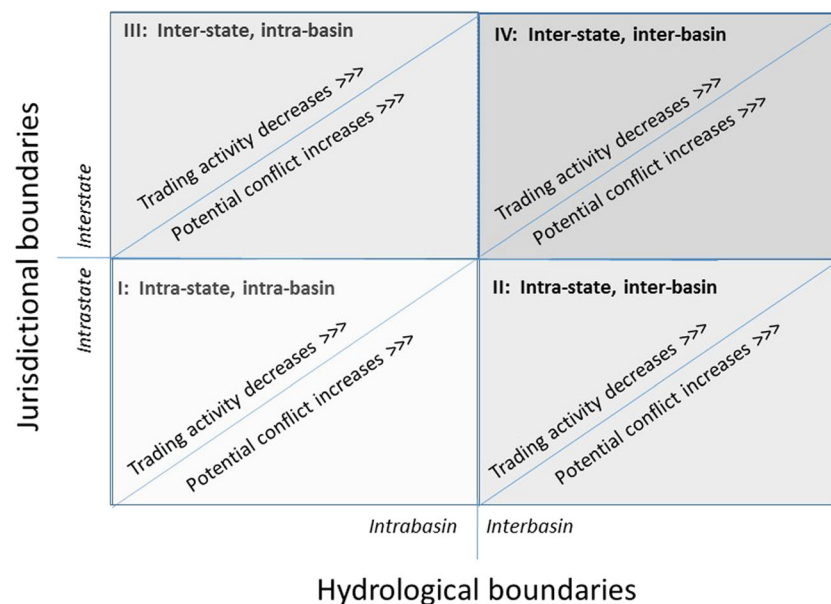


Fig. 1 Water trading across boundaries: expected conflicts and trading activity. Water trading is expected to become more complex and contentious as water moves across hydrological (e.g., basin) and jurisdictional (e.g., state) boundaries. The likelihood of distributional conflicts is projected to increase, and trading activity is projected to decrease, with distance. The shading signifies the likelihood of conflict, with darker shading indicating the highest potential conflict; the greatest

likelihood of distributional conflict and the most limited trading activity are therefore expected in quadrant IV representing trade across basin and state boundaries. The diagonal line represents the expectation that distributional conflict increases and trading activity decreases as water moves across borders—both within cells (involving relatively minor borders, such as irrigation districts or tributary borders) and across cells (involving relatively major borders, across basin or state boundaries)

Spain

Following the transition to democracy that started in 1975, Spain became a decentralised semi-federal country where 17 autonomous regions hold broad powers over most public policy issues. The law distinguishes between river basins that cross more than one autonomous region (interregional river basins) and those that fall entirely within a region. In interregional river basins, planning and management authority is held by nine River Basin Agencies (RBAs) autonomous public institutions that functionally depend on the central Ministry with responsibility over environmental affairs. Water users and autonomous regions are part of RBAs' planning, management and governing boards. Water rights were historically held under different tenure regimes although successive legal reforms have favoured the public nature of these rights.

Water use rights are granted through renewable administrative concessions which are entitlements to annual volumes of water that can be used for a specific purpose in a specific location (Hernández-Mora et al. 2014). Water trading mechanisms were introduced in Spain in 1999, although few transactions took place until the 2005–2008 drought. Intra-basin permit trading has been the dominant form of formal trading in non-drought years, while public water banks and interbasin permit trading have been more prevalent during the drought, representing 53 and 40% of the total 445 Mm³ traded between 2005 and 2009, respectively. Interbasin trading has taken place where water transfer infrastructures exist to make trades possible. Public water banks were operational during the 2005–2008 drought in the Júcar and Guadiana basins to mitigate environmental impacts of groundwater overdraft through the purchase (temporary or permanent) of groundwater rights by RBAs. The year 2008 was a peak year in terms of volumes traded (200 Mm³). Like Australia, the vast majority are temporary trades (97%). Unlike Australia, where water trading comprises a substantial percentage of annual water allocations, trading activity in Spain represented less than 1% of all water used in 2007–2008, when trading was most active, but is more relevant (up to 4%) in highly stressed basins like the Jucar and Segura, where most trading takes place (Palomo-Hierro et al. 2015).

Western USA

State governments hold primary authority for water planning and allocation in the USA. Geographic differences have led to a divergence in the water rights systems between the Western USA and the rest of the country. The 17 states with territory west of the 100th meridian have developed some version of the prior appropriation doctrine—a priority-based water rights system guided by common law (Tarlock 2001) whereby the first to establish and maintain a valid water diversion is the last

to lose access in times of scarcity. The prior appropriation system has evolved from a highly decentralised system of individual claims to administrative permits regulated by each state and granted in perpetuity. The federal government's role in water allocation stems from its historical position financing and operating water infrastructure. The analysis will focus on the Western USA and the states in three interstate and international river basins with water market activity—the Columbia, Colorado and Rio Grande Basins, which collectively illustrate the full spectrum of approaches to water market reforms and interstate coordination.

Over 4000 transactions occurred in 12 Western states from 1987 to 2008 with buyers committing over \$4.3 billion for leases and permanent acquisitions (Grafton et al. 2012). Trading activity is predominantly intra-state and temporary (via leases). Trading varies over time, with pulses of water trading during drought, in response to rapid urbanisation or for environmental acquisitions by the federal government. It varies geographically with Arizona, California, Idaho, Texas and Oregon among the more active states in terms of volume traded (WestWater 2016). Water trading also varies substantially within states. For example, transfers involving water storage projects administered by the federal government have become increasingly prevalent, including California (Central Valley Project and Lower Colorado Project), Nevada (Newland Project), Idaho (Snake River) and New Mexico (San Juan-Chama and Middle-Rio Grande) (US Bureau of Reclamation 2016). Interbasin and interstate transfers have been limited to the San Juan-Chama project involving the reallocation of water from the Colorado River to the Rio Grande, although the market transactions occur only between sectors after the water arrives in New Mexico. Interbasin and intra-state transactions occur primarily in California and Colorado, the latter via the Colorado-Big Thompson, a federal project with approximately 173 Mm³ per year is traded in its seasonal rental market from 2007 to 2014. This comprises one of the more active markets, with 60% of the water available in those years traded through seasonal markets, as well as active permanent sales from 40 to 80 transfers per year often as a response to urban demands (US Bureau of Reclamation 2016). Overall, the volume of water traded has been relatively stable, fluctuating between 1.5 and 2 million acre-feet per year (1850 to 2467 Mm³) from 2006 to 2016 except for 2010 when almost 2.5 million acre feet (3084 Mm³) were traded.² The value of water traded ranges in response to volume and price considerations, spanning from \$220 million in 2013 to almost \$800 million in 2015 during the same 10-year period, according to WestWater LLC (WestWater 2016).

² Time series data on Western US water markets are unavailable since the end of the Water Strategist newsletter circulated by the private firm, Stratecon, Inc. until 2010.

Comparison of trading activity

The literature on water reallocation and markets suggests that political and institutional design challenges increase as transactions move water across sectors, political borders and/or basin boundaries (Hernández-Mora et al. 2014; Marston and Cai 2016). All water transactions pose a risk of conflict and coordination challenges due to third party effects (Colby 1990). However, the literature suggests that water trading across sectoral, state and basin borders pose the greatest challenges and potential for third party effects. Figure 1 categorises trading activity based on two types of spatial boundaries—political and hydrological borders. Trading activity can occur within states or across states; it can also occur within basins or across them. The table illustrates expectations that trading activity will be most prevalent, and conflict less likely, within a state and basin. By contrast, trading will be less active across state and basin border due to the higher risk of conflict and associated transaction costs. As a consequence, trading is far less prevalent than economists predict based on differences in economic productivity between basins and states. Intersectoral trading creates an additional layer of complexity, although we expect water trading between agricultural, urban and environmental water uses to occur in all four quadrants. Water leasing and purchases are becoming increasingly prevalent across the urban-rural divide and occurs at multiple spatial and temporal scales. For example, urbanisation of irrigation districts has led to localised water sales or leases from agriculture to urban (intra-state, intra-basin). Interbasin transfers are a common path for cities to enhance their water security, although market-based interbasin trades are expected to be rare. Such transfers have occurred within states (e.g. the North-South Pipeline transferring water from the Murray-Darling Basin to Melbourne within the state of Victoria) and across them (e.g. Tajo-Segura transfer in Spain).

Comparative analysis

In the succeeding comparative analysis, we start with Spain (the most centralised example) before the USA (the most decentralised) and Australia (the mixed approach) to illustrate the similarities and contrasts.

Distribution of authority and governance tasks in water market reforms

In this paper, we focus on *how* national and state governments are involved in the design of institutional reforms enabling, limiting or regulating water markets, specifically in terms of the balance of national and state government roles (see Fig. 2). We compare the case studies in terms of a set of defined governance functions adapted from the Australian National Water Commission (2011).

Spain represents the most centralised model of market-oriented reform. Until 1999, users could not exchange, sell or otherwise trade water rights without explicit intervention from basin authorities under exceptional drought circumstances, although some informal local water markets did exist in some areas (De Stefano and Hernández-Mora 2016). In the context of a shifting discourse about water supply infrastructure development and in the aftermath of a major nationwide drought in the early 1990s, water markets were seen as an opportunity to introduce flexibility into the rigid concession system and avoid water use restrictions in urban areas surrounded by large irrigation districts. In 1999, two highly regulated water trading mechanisms were introduced: permit trading and public water banks. Water permit trading was restricted to temporary agreements between water use concession holders in the same river basin, limiting trades to water effectively used in the past 3 years, and subject to approvals by RBAs. Public water banks are set up and managed by RBAs. They can operate under exceptional circumstances such as drought or groundwater overdraft and involve temporary or permanent purchases. Between 2005 and 2009, a series of drought decrees were approved by the central government to deal with a severe drought period. Among other measures, these decrees temporarily eliminated some of the restrictions to water trading included in the 1999 reform. Most significantly, they allowed water trading between users in different river basins using existing interbasin transfer infrastructures. The reform aimed to compensate for drought-induced restrictions in the volumes transferred through the Tajo-Segura infrastructure, which transfers water from the Tajo River in central Spain to the Southeastern Segura river basin (Hernández-Mora and Del Moral 2015). Water markets were most active during the drought period, both through public water banks and through permit trading between users in different river basins (Palomo-Hierro et al. 2015). Further legal reforms by the central government starting in 2013, permanently allowed interbasin trades and continued the market deregulation process in response to political pressures from Tajo-Segura transfer recipient regions and users (Hernández-Mora and Del Moral 2015).

By contrast with Spain, the *Western USA* has a highly decentralised approach to water markets and related institutional reforms. The goals of water markets have included allocative efficiency and the delay or avoidance of new water supply infrastructure. However, the local control over water allocation under the prior appropriation doctrine has meant that the goals guiding the development of water markets are highly localised, strongly conditioned by equity criteria and often only implicitly defined (rather than via an overarching policy at the state or national levels). The prior appropriation system and its decentralised approach to water allocation reform place a strong emphasis on irrigation organisations, which have considerable legal authority and political power within their borders, and political power through lobbying. Irrigation associations,

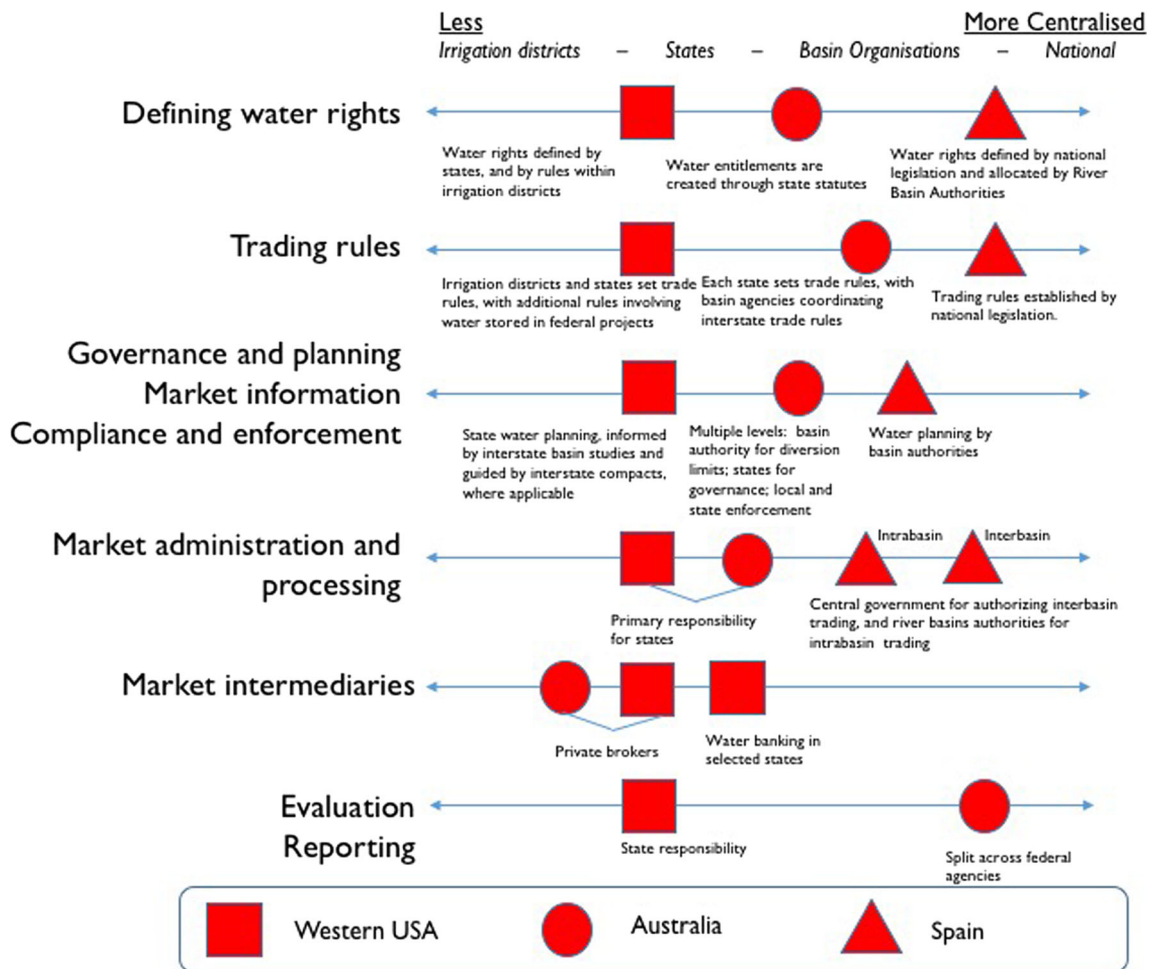


Fig. 2 Governance tasks and institutional reforms: the degree of (de)centralisation in water markets. Symbols for each region are placed along the spectra based on the level of governance where the primary responsibility for each task lies. Explanatory text is provided under each symbol to support the institutional mapping, following the example from Nelson and Perrone (2016). In Spain, there are no private market

intermediaries and no public reporting or market performance evaluation requirements. For market administration and market intermediaries, the explanatory text is identical for the USA and Australia, indicated with the lines. Note: The list of governance tasks is adapted from: National Water Commission, 2011. Strengthening Australia’s water markets. Canberra. National Water Commission

companies and districts represent three distinct types of irrigation water supply institutions in the Western USA. All three wield substantial control over water allocation within their boundaries, including the capacity to restrict water from exiting their jurisdiction (Bretsen and Hill 2006). Water transactions are therefore far more prevalent within than across irrigation organisation boundaries (Ruml 2005).

At the state level, the prior appropriation system has involved administrative reforms and adjudications³ to close basins to new uses, reform water rights and establish trading rules with highly varied progress. Colorado is at one end of the spectrum, where its state water court system and state engineer’s office have established an advanced system of water rights administration

³ An adjudication refers to the process of establishing the extent, validity and priority of water rights under the prior appropriation doctrine; the process involves a judge or an appointed special master reviewing evidence about historic water use and claims, often with substantial data and administrative support from water agencies.

with clear rules governing water transactions. At the other extreme, the Gila River and Yakima River water rights adjudications in Arizona and Washington, respectively, have been underway since the 1970s, creating legal uncertainty and constraints on some types of water transactions in both states (Feller 2007), although trading has been prevalent in selected management areas and irrigation districts. Even though the USA is relatively decentralised, state water plans increasingly engage with trade and some legislatures have tried to enact regulations that would make trade a more available tool for water management by decreasing transaction costs, such as Texas and Oregon.

Despite its limited formal authority over water allocation matters, the federal government has affected the development of water markets through its management of federal reservoirs, where operational rules and contracts with irrigation districts stipulate criteria for water trading (Culp et al. 2014; US Bureau of Reclamation 2016). In 2016, the Department of Interior established the Natural Resources Investment Centre

and conducted a thorough review of the federal government's powers and potential to promote water markets through its role managing federal reservoirs, its funding of water infrastructure and seed grants and its coordination of information relevant to water markets (US Bureau of Reclamation 2016).

The *Australian* reform process has followed a mixed approach, combining strong states' rights with an increasingly important federal role in basin-level planning and coordination of diversion limits, water rights systems and key information. Water rights in the MDB have been legally transferrable since the late 1980s, but the current mature water markets, in which large volumes of 'unbundled' water rights⁴ are traded, did not emerge until 2007 (National Water Commission 2014). Although the states initially led reforms in Australia, water transactions in the 1990s were highly limited, demonstrating the need for greater basin coordination among the states and between the states and Commonwealth government. The states have not made it easy to trade water across state boundaries. Victoria, for example, limited water trades outside a water district, which was challenged by South Australia in the High Court on constitutional grounds, and ultimately settled via negotiated agreement.

A range of reforms addressed these coordination challenges. Firstly, competition reforms in the early 1990s committed the Australian government to the use of market-based instruments to manage resources efficiently (Commonwealth of Australia 1993). This led to the 1994 proposal of a 'cap and trade' water market for the MDB (COAG 1994), and the Murray-Darling Basin cap was set in 1997 (Murray-Darling Basin Commission 1995; Murray-Darling Basin Commission 1998). In 2000, a review of a 2-year pilot program for permanent interstate trade showed that cumbersome administration, inadequate water registers and lax enforcement of water entitlements by the states were limiting the potential of the water markets to increase allocative efficiency (Young et al. 2000). In 2004, an intergovernmental agreement, the National Water Initiative (NWI), committed each state to the creation of transferable, secure rights to water and support for water markets, in return for substantial financial incentives, with progress assessed by the National Water Commission (COAG 2004). The Australian government effectively 'purchased' state actions to improve water resource management in the MDB. However, even after the NWI, water trading was still relatively limited. In Victoria, annual permanent trade volumes hovered around 0.25 GL (250,000 m³) from 1997 to 1998 to 2005–2006 (Department of Sustainability and Environment (Vic) 2008). In 2007, in response to severe drought and environmental degradation in the MDB, the Australian government passed the *Water Act 2007*, which created the Murray-Darling

Basin Authority (MDBA). The MDBA, a more independent organisation than the previous coordinating body, the Murray-Darling Basin Commission (Home and O'Donnell 2014), is responsible for preparing the Murray-Darling Basin Plan (Murray-Darling Basin Authority 2012). The Plan fundamentally affects the development of water markets by establishing a new, lower cap on water use (the sustainable diversion limit) which will apply from 2019, as well as establishing water planning processes and responsibilities at a broad level (Hart 2015), including regulation of water trading rules (prepared by the Australian Competition and Consumer Commission).

Coordination challenges and institutional responses

Australia, Spain and the USA have distinct approaches to water policy reforms resulting from their diverse institutional, political and historical contexts. These are reflected in the different goals of water markets and the varied roles central and sub-national governments play in the reforms discussed above. As a result, they experience different types of coordination challenges, although interstate and interbasin trade has been a source of strain in all instances. In each case, coordination institutions and conflict resolution efforts have been used to address intergovernmental and multi-level challenges with varying levels of success (see Table 1).

In *Spain*, interbasin and interstate trading has been the source of disputes and coordination challenges between states and between the states and the national government. As discussed above, water permit trading between river basins was allowed through the 2005–2008 drought decrees and permanently after a 2013 national policy reform. Trading was most active during the 2005–2008 drought, when over 70% of permit trading (excluding trades in public water bank) took place between users in different regions and over 90% between users in different basins. Autonomous regions (states) most directly affected by interbasin water trading have adopted different positions depending on their situation with regard to the Tajo-Segura water transfer: the main beneficiary states (Murcia and Valencia) supported water trading reforms in line with the position of the powerful water transfer irrigator association. The primary source state (Castilla-La Mancha) strongly opposed the liberalisation of trading conditions. Social and environmental organisations have also opposed the sales and the government of Castilla-La Mancha has consistently (and so far unsuccessfully) challenged interbasin sale decisions in court. The 2014 and 2015 trading agreements between irrigators in the Tajo and Segura basins have also been challenged and are currently awaiting court ruling. Castilla-La Mancha sees interbasin sales as a mechanism to approve water transfers outside ordinary decision-making processes (where the regional government usually participates), damaging the interests of Tajo

⁴ Unbundled water rights separate the permanent water access entitlement and the temporary water allocation from the land where the water is used; in fact, it is not necessary to use water on land at all.

Table 1 Institutional responses to intergovernmental coordination challenges associated with water markets and related reforms

| | Spain | Western USA | Australia |
|---|--|---|--|
| <i>Intergovernmental coordination challenges (Selected)</i> | 1. Intra-basin trading (1999) 2. Drought management (2005–2008; 2015) 3. Interbasin and interstate trading (2005–2008; 2013) | 1. Interstate water apportionment (mid twentieth century) 2. Environmental water transactions (federal-state-tribal) (1990s to present) 3. Interstate ‘water marketing arrangements’ (mid 2000s to present) | 1. Establishing a cap (1997) and sustainable diversion limits (2012) 2. Ensuring compatible water plans and entitlement frameworks (2004) 3. Drought management and recovering water for environment (2000s-present) |
| <i>Institutional arrangements</i> | | | |
| National legal framework | Water Law (1999) Water Law reform (2013) | Not applicable | Commonwealth Water Act (2007) Basin Plan (2012) |
| Intergovernmental agreements (IGAs) | Not applicable | Operational rules and bilateral IGAs (selected) Interim shortage guidelines Arizona-Nevada water banking | Multiple IGAs National Water Initiative (2004) |
| Cooperation venues | Basin organisations: River basin authorities | Basin organisations: Compact commissions Basin studies (Secure Water Act) | Basin organisations: Murray-Darling Basin Commission (1980s–2007)/Authority (2008+) <i>Policymaking forums:</i> Council of Australian Governments High court |
| Conflict resolution venues | National courts | Supreme Court General Stream Adjudications Water Courts (e.g. Colorado) | |
| <i>Instruments and tools</i> | | | |
| Basin planning (diversion limits or caps) | present and addresses water markets indirectly | present and addresses water markets indirectly | present and addresses water markets explicitly |
| Federal financing (environmental transactions) | present and addresses water markets explicitly | present and addresses water markets explicitly | present and addresses water markets explicitly |
| Registries (transactions data) | limited or missing | limited or missing | present and addresses water markets explicitly |

riparian towns and water users and further deteriorating the environmental status of the Tajo River. The misuse of market instruments has raised political wariness vis-à-vis the development of water markets.

Although interstate/interbasin trade has been most conflict-ridden, not all intra-state trading activity has been exempt of conflict. In the case of the Segura river basin, intra-basin trading agreements have been contested by both traditional irrigator associations and social organisations (Calatrava and Martínez Granados 2016). In other cases, however, water markets have facilitated cooperation between states otherwise prone to conflict, particularly through the operation of public water banks. For instance, the Júcar basin public water bank that was operational during the 2005–2008 drought reduced conflicts between two states (Castilla-La Mancha and Valencia) that have been embroiled in protracted legal battles over water allocation (De Stefano and Hernández-Mora, [this issue](#)).

In the *Western USA*, water markets and associated institutional reforms have been shaped by three phases of interstate and multi-level coordination challenges and institutional responses: interstate water apportionment, federal and tribal roles in water markets and interstate ‘water marketing arrangements’. In the first half of the twentieth century, states sharing interstate rivers entered into ‘compacts’ to apportion water between themselves, creating bulk water allocations for each

state within the basin. These interstate compacts, such as the 1922 Colorado River Compact and the 1938 Rio Grande compact, apportion water based on fixed volumes or proportional shares of the water available. Historically, the Supreme Court has been the primary venue for resolving interstate disputes over compliance with the compact, illustrated vividly by the 40-year Supreme Court case on the Colorado River. In this context, water trading across state borders has historically been viewed with suspicion as a threat to the certainty achieved through hard-fought water sharing agreements. For example, a proposal for interstate trade in the Colorado River in the 1980s was critiqued as ‘illegal, immoral, and dangerous to the current comity among the states [that share the Colorado River]’ (Kenney 2013). More recently, ‘marketing arrangements’ (US Bureau of Reclamation 2016: 3) have developed in the Lower Colorado River as a means of introducing flexibility and risk sharing, building on the legal and institutional frameworks established by interstate compacts.

The role of the federal government in water markets has expanded, underscoring the importance of effective coordination between the federal and state governments, particularly associated with federal water storage projects. The US Bureau of Reclamation is a federal agency that operates 337 reservoirs with a total storage capacity of 245 million acre feet (302,203 Mm³), providing water for 10 million acres of irrigated agriculture supporting

60% of the country's vegetable production. Seven of the eight trading regions classified as 'high activity' by WestWater Research (2016) are located in regions with a federal water project and interstate water compact, demonstrating the need for both interstate and multi-level coordination institutions (US Bureau of Reclamation 2016).⁵ Tribal nations are also emerging as an important influence on water trading in regions where their water rights are quantified. Vertical coordination between water users, states and state and federal governments has occurred through the planning and operation of federal water storage projects, adjudication processes or statewide planning efforts where higher levels of governments participate on behalf of federal or tribal water rightsholders.

Water markets in Australia's Murray-Darling Basin are some of the most active in the world and depend on cooperation and conflict resolution between the states and the federal government. River basin institutions have evolved over a century of intense political negotiations among the states and the Commonwealth government, marked by intergovernmental agreements for water market-oriented reforms since the 1992 Murray-Darling Basin Agreement (Connell 2007; Guest 2017). There are three primary coordination challenges: establishing a cap, ensuring compatible water plans and entitlement frameworks and recovering water for the environment. Intergovernmental coordination efforts have relied on the Council of Australian Governments and the Murray-Darling Basin Ministerial Council to facilitate negotiation, and implementation of these agreements has been audited by the National Water Commission (2004–2014, now undertaken by the Productivity Commission).

First, the 'cap' on water diversions has presented a persistent coordination challenge for states and the Commonwealth government (Heinmiller 2007). The 1995 recommendation to establish an interim cap required 2 years for final approval, and its implementation and revision have remained a chronic source of disputes, with states taking several years to comply (Queensland being the last, in 2010). The Commonwealth Water Act 2007 and its amendments established new federal authority and a mandate to establish sustainable diversion limits, and set trading rules, overcoming significant resistance and bargaining by the states (Kildea and Williams 2011). Although no lawsuits have been filed, the states have demonstrated willingness to cut their funding contributions to joint water resource management programs as a negotiating tactic, underscoring the tensions between governments across multiple scales (Bettles 2013; MDBA

2014). The high stakes of the negotiation can also be an important coordinating factor, keeping all the state and federal governments at the negotiating table.

The second coordination challenge relates to ensuring compatibility of water planning and water access entitlement frameworks across states. One of the success stories of the water market in the MDB is its ability to transfer water between uses and locations quickly and relatively cheaply (Productivity Commission 2010). Although the federal-state relationships remain a source of tension, water markets have provided an alternative to intergovernmental conflict over water. Renegotiating the distribution of water between the states would have been extremely difficult politically, but water markets have facilitated this redistribution to the highest value use of the water by supporting high volumes of allocation trade; during the Millennium drought, for example, a net export of 550 Mm³ moved water from river valleys in New South Wales to Victoria and South Australia (Kirby et al. 2014). Like the USA, the final coordination challenge is associated with recovering and delivering water for the environment. Water markets have enabled significant and rapid water recovery for the environment, totalling a long-term average annual yield of approximately 1166 Mm³ as of 31 December 2016. Despite initial support from irrigators (National Farmers' Federation 2010), by 2015, irrigators were concerned that the Australian government department was acquiring too much water for the environment and limiting the water available to irrigators. In response, the Australian government amended the *Water Act 2007* in 2015 to place a limit of 1500 Mm³ on the total volume of water access entitlements that the Commonwealth Environmental Water Holder could acquire from the market (just over half of the total water recovery target of 2750 Mm³ in the MDB).

Discussion

The comparative analysis demonstrates how water markets are affected by the federal system of water allocation and governance.

How has the distribution of authority affected the goals of water markets?

Water markets have been associated with multiple policy goals in each of the case studies analysed, including allocating water efficiently, building resilience to drought, recovering water for the environment, sustaining agricultural communities, reducing the likelihood of or resolving conflicts and creating flexibility in the water allocation system. Allocative efficiency is one of the primary goals of the water markets in all

⁵ High market activity is noted by WestWater (2016) in the Central Valley of California, Southern California, Southern Nevada, Phoenix of Arizona, Northern Front Range of Colorado, Middle Rio Grande of New Mexico, Edwards Aquifer of Texas and Lower Rio Grande (also Texas). All but the Edwards Aquifer are beneficiaries of federal water projects.

three countries. Intensified competition for water between irrigation, cities and the environment, as well as periodic droughts, has prompted reallocation efforts to maximise the economic value of water use. Beyond this fundamental similarity, the policy goals vary markedly across and within the three countries, and these differences are partially explained by variations in the (de)centralization of the federal system of water governance. These differences have important implications for defining success and assessing the performance of institutional reforms.

Centralised development of water markets involves setting overarching policy goals and enacting the relevant legal and regulatory reforms to achieve these goals. Decentralised development of water markets involves the emergence of water trading in response to localised pressure and incremental institutional reforms. The centralised reforms in the Spanish case represent one end of the spectrum, with the main legal reform enacted by the central government in 1999. Motivated by drought experiences in the 1990s, the 1999 law introduced formal water market mechanisms as a means of ‘enhancing efficiency or optimising the social utility of a scarce resource’ (Casado-Perez 2015: 181). These were originally limited and highly regulated to overcome political resistance from irrigators, left-wing political parties and environmentalists that opposed the idea of treating water as a commodity (De Stefano 2005; Del Moral et al. 2000; Casado-Pérez 2015).

Water markets in the Western USA are highly decentralised by comparison, involving a more ad hoc set of reforms and local ‘emergence’ of water trading, constrained by state-level regulations to limit negative third party impacts. By contrast with Spain, the policy goals are much more diverse as a reflection of the more decentralised approach to reform and the local values and interests involved. As a consequence, the goals attached to water markets are sometimes incompatible with one another, such as recovering water for the environment and sustaining agricultural communities (US Bureau of Reclamation 2016).

Australia’s mixed approach, combining states’ rights and increasing federal coordination, has led to a progressive shift in the policy goals from the interests of individual states to limit trading outside their borders, to national competition policy reforms promoting allocative efficiency at a basin-wide level in the Murray-Darling. Cap-and-trade regulatory reforms in Australia have involved a dynamic tension between these national commitments and state water resource planning. Intergovernmental agreements have provided a key means of reconciling these goals, facilitated by the intergovernmental coordination institutions provided by the Council of Australian Governments and basin organisations.

In all three cases, the policy goals have evolved over time, through the changing balance of state and federal leadership in the institutional reform process and in response to changing political priorities and evolving power

balances among different regions and interest groups. In the case of Australia, the boundaries of markets have narrowed and sharpened their focus on allocative efficiency even as the national government has used the market to address environmental water recovery objectives. In the USA, irrigation districts and states remain the dominant level for defining the goals of water markets and establishing boundaries or restrictions on their development in the public interest. The national government, and particularly the Department of Interior, has asserted itself in an increasing role using funding, information, studies and infrastructure modernisation and operations to promote ‘water marketing strategies’ for an expanding range of policy goals associated with water markets (US Bureau of Reclamation 2016). In the case of Spain, successive national regulatory reforms, most recently in 2013, have eroded the original goals and restrictions on water trades that were designed to limit third party effects (Hernández-Mora and Del Moral 2015). These reforms have so far had limited impact on market activity and have largely been enacted to satisfy specific interest groups, not to meet broader policy goals, such as improving allocative efficiency, achieving environmental gains or promoting the public interest.

Institutional responses to coordination challenges associated with water markets

The three countries illustrate that water markets involve both intergovernmental (i.e. horizontal) and multi-level governance (i.e. vertical) coordination issues. Although a formal evaluation of the effectiveness of intergovernmental coordination institutions is beyond the scope of this paper, we can identify and compare institutional arrangements across the three countries to identify their broad types and characteristics.

Three coordination institutions have been relevant in all three countries, albeit in different forms and to different degrees: (i) national or basin-wide coordination institutions (councils, basin organisations), (ii) conflict resolution venues (particularly courts) and (iii) venues for negotiating and implementing intergovernmental agreements (and their associated financing). In Australia and Spain, RBAs have played a fundamental role (Fig. 2). In Australia, the Murray-Darling Basin Commission and its successor, the Murray-Darling Basin Authority, have played an important coordination role in establishing and updating the cap, as well as the development of trading rules. In Spain, RBAs play a direct role in administering and approving trades associated with intra-basin public water banks and intra-basin trades, whether within a state or between states in the same basin. In the USA, interstate compacts and their implementing bodies, either the Bureau of Reclamation in the Colorado River or the river basin compact commissions in most other interstate rivers, play a more indirect role, illustrated by the inclusion of water

markets and related management options in basin-wide assessments of supply and demand trends under basin studies program of the Secure Water Act. Interstate apportionment agreements also create a de facto cap on water supplies and an initial allocation of rights across states, which provide an enabling condition for water markets and has even led to experimentation with interstate water marketing arrangements.

Strong basin-wide institutions include mechanisms for dispute resolution, including conflicts related to water trading. Courts, or the threat of court action, have played a role in all three countries. In the USA, ongoing court cases have hindered the development of water markets in two ways. First, adjudications have struggled to quantify water rights, requiring decades in most instances with uneven success integrating federal and tribal reserved water rights. Second, interstate disputes have festered and created legal uncertainty, particularly disputes regarding the impacts of groundwater use on surface water deliveries (e.g. Texas versus New Mexico). In Spain, courts have been a venue for raising grievances associated with interstate and interbasin trades with limited success. In Australia, reliance on courts has been limited, but threats of High Court challenges have occurred and been used for bargaining by the states (Williams and Webster 2010). The three cases not only illustrate the power of court action, but also show that over-reliance on courts is a symptom of deficiencies in coordination institutions.

All three countries have relied increasingly on the central government to provide political leadership, financial resources, and, in Australia and Spain, legal and regulatory reform. Australia's 2004 National Water Initiative, 2007 Commonwealth Water Act and 2012 statutory Basin Plan are the clearest example of this trend. In Spain, the central government has played a critical role in both initially regulating markets and then removing restrictions to water trades to achieve other policy goals or in response to pressures from specific interest groups (Hernández-Mora and Del Moral 2015). In the USA, the management and operations of federal water storage projects have created an important opening for national influence, which has grown with the Secure Water Act of 2009 and recent federal initiatives aimed at stimulating water marketing strategies as a solutions to drought.

Finally, the ongoing legitimacy of these coordination institutions associated with water markets in federal political systems depends on demonstrating accountability, and ensuring water trading and the institutional responses to associated coordination challenges is in line with the public interest. Australia's water market is noteworthy for its efforts to establish accountability mechanisms based on robust water market information. In Spain, the RBAs hold information on water rights and intra-basin trades, and the central government on interbasin trading, but while any trades have to be inscribed in the water registries,

public reporting is not required and data is not easily or publicly available. In the USA, the situation is more complex. Information on water rights and transfers is available and reported in publicly available databases, and restrictions to avoid negative third party impacts are higher than the other two countries. However, the complexity of the water rights system and inconsistencies within and across states mean that existing information is inaccessible and insufficient to build legitimacy. Australia's experience suggests that the central government and basin-wide coordination institutions have a key role to play in establishing the data architecture and the reporting platforms to enhance transparency on trading patterns and their social, economic and environmental impacts. The lack of transparency in Spain and interstate coordination of data and reporting in the USA have exacerbated inter-governmental governance challenges.

Conclusions

This paper has filled a gap in our understanding of water markets, illustrating the coordination challenges and institutional responses associated with the development of water markets in federal political systems. It focused on two characteristics of federal systems of water governance that affect the goals, design and evolution of water markets: the distribution of powers and functions in water allocation and the intergovernmental coordination challenges and institutional responses associated with water markets. The diverse experiences of the three countries demonstrate that coordination institutions must be well developed for water markets to achieve their goals. Accountability mechanisms are essential for the legitimacy of water markets, ensuring accessible information about trading activity and impacts of trading activity on other local and national policy objectives related to equitable water allocation.

The three cases illustrate that context matters, specifically the influence of (de)centralization and the goals of the water market on the distribution of authority across levels of governance. Nevertheless, despite contrasting approaches to institutional reform, the comparison offers clear lessons about the importance of regional politics and coordination institutions for effective and equitable water markets in federal political systems regardless of the level of centralization and the associated differences in policy goals. For water markets to achieve their intended goals and limit unintended or negative consequences, their performance may depend upon effective intergovernmental coordination institutions, underpinned by robust and transparent information systems. Markets may emerge informally and address their intended local objectives with limited coordination across sectors and scales; however, water trading across sectoral, jurisdictional or basin borders relies on formal water markets with strong coordination institutions. This paper demonstrates the need to

update the conventional wisdom about water markets as a response to regulatory failure. Effective markets go hand in hand with effective governance and strong institutions, whether formal, informal or some blend of the two.

Future research should consider the impact of water markets and associated institutional reforms on the broader goals of the federation, such as representing diverse interests, enhancing legitimacy and ensuring accountability. In other words, efforts to foster democratic governance through federal political systems may introduce institutional safeguards that can both enable and constrain essential interstate and intergovernmental coordination for regulation, monitoring and enforcement as water moves longer distances. Further comparative institutional analysis of water markets can shed light on the relationship between federalism and water markets by the following: (i) identifying principles, such as the subsidiarity principle ('assigning tasks at the lowest level capable'), to guide the division of powers and functions in different institutional contexts; (ii) developing in-depth studies of water markets and their structure and performance using common frameworks, concepts and metrics to aid comparison; and (iii) constructing and apply common metrics for evaluation across cases and over time. In so doing, comparative research can inform the development and implementation of context-sensitive pathways of institutional development for sharing water across sectors and scales.

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