The Economic Institutions of Water

Gary Libecap*

There is increasing concern about the availability of fresh water worldwide as demand grows and as supplies become more uncertain due to climate change.[1] With rising per capita incomes and growing populations, human consumption of water is rising while demands for water for agriculture, manufacturing, recreation, and the environment also are increasing.

More than other natural resources, water is allocated and used through an institutional framework that is important in analyzing "the economics of water." In the United States and elsewhere, property rights to water generally are not well defined because of the high resource costs involved and the political costs associated with equity and public goods' demands. Accordingly, markets are less active than one might expect for this critical and increasingly valuable asset.[2] Decisions about water often are made through judicial, legislative, and bureaucratic processes, without direct price and cost considerations, which results in waste and misallocation.

In my research I have examined water rights, exchange negotiations, markets, and regulation in the semi-arid U.S. West to better understand the institutional constraints that mold water distribution, use, and investment. In many cases there are important historical legacies that affect how those institutions have developed and operate today.

Limited Markets

Although the western U.S. has some of the most active water markets in the world, large price differences between agricultural water, where as much as 80% of annual consumption takes place, and urban water illustrate the potential for further

* Libecap is a Research Associate in the NBER's Programs on the Development of the American Economy and Environmental and Energy Economics. He is also a Professor of Corporate Environmental Management and Economics at the University of California, Santa Barbara. His profile appears later in this issue.

gains from trade. Additionally as Grafton, Landry, Libecap and O'Brien show, water markets are much more active in the Murray-Darling River Basin of south eastern Australia than in the U.S. West.[3] The question of interest then is what impedes the development of water markets?

As I indicated in a recent paper, price comparisons to gauge the potential for trade are difficult to assemble because of segmented, local markets, limited comparable observations of transactions within and across sectors, high shipping or conveyance costs, diverse regulatory regimes, and variation in quality.[4] Accordingly, examining available price data must be done with caution. Even so, the differences often are striking. For instance, in the Reno/Truckee Basin of Nevada the median price for 1,025 agriculture-to-urban water rights sales between 2002 and 2009 (2008 prices) was $17,685/AF as compared to $1,500/AF for 13 agriculture-to-agriculture sales.[5] In the South Platte Basin of Colorado the median price for agriculture-to-urban sales was $6,519/AF as compared to $5,309/AF for agriculture-to-agriculture sales.[6]

Aggregating transactions across markets and time can compensate for the limited number of similar transactions within local markets to further illustrate the potential gains from trade and to reveal how activity varies across the states and across time. Until the analysis of Brewer, Glennon, Ker, and Libecap, however, there had been no comprehensive examination of water rights, trading, and type of contracts used in the U.S. West.[7] They developed a data set of 3,232 water transactions (short- and long-term leases, sales) across 12 western states from 1987-2005. This data set subsequently has been updated through 2008 with 4,220 observations, of which 2,765 have price information.[8] This information reveals that median prices between 1987 and 2008 were $74/AF for agriculture-to-urban leases

as compared to $19/AF for agriculture-to-agriculture leases and median prices were $295/AF for agriculture-to-urban sales as compared to $144/AF for agriculture-to-agriculture sales.[9]

Every western state allows for water trading, but patterns vary sharply. Colorado dominates in terms of total market transactions, but California, Texas, Arizona, and Nevada also have active markets. Within California, the state's institutional and regulatory environment favors short-term leases. In all states, however, most trading involves informal exchanges among adjacent users within sectors (neighboring irrigators, for example), rather than trades across sectors, such as agriculture-to-urban, where price differences and associated efficiency gains from reallocation are the greatest. There is virtually no private water transacting across state boundaries. Despite apparent barriers, the total number of water transfers, however, is increasing as demand is shifting. Between 1987 and 2008 agriculture-to-urban and environmental trades have been significantly rising but agriculture-to-agriculture trades show no discernable trend. Analyzing the underlying institutions and transaction costs affecting these observed patterns is central to my research.

U.S. Water Rights

I have examined property rights to a variety of natural resources, including oil and gas; timber, agricultural, and range land; fish; and water; and among these water poses the greatest challenges in defining rights.[10] Water cannot be bounded or partitioned easily across claimants and uses. Fluidity, and in the case of groundwater an inability to observe it, also raise the costs of measuring a water right. Parties often sequentially access the same water, and amenity, riparian, and aquatic habitat values may be provided simultaneously. For these reasons, private and

public water uses are intertwined to an extent not found for other resources. In the eastern United States, where water traditionally has been less scarce than in the West, it typically is common property, with riparian rights held by land owners whose properties are appurtenant to water. Riparian rights holders have proportionate access for reasonable use, so long as their actions do not harm downstream claimants.

In the more arid western United States access to water historically has determined the location and economic viability of communities. Prior appropriation rights emerged in the nineteenth century to support mining and agriculture often remote from water sources.[11] Appropriative rights are not tied to the land, and the ability to move water led to investment in dams, storage reservoirs, and canal systems by the Bureau of Reclamation and other organizations largely in support of farming.[12] Hansen, Lowe, and Libecap construct a county-wide dataset of water supply infrastructure, topography, and agricultural output for 5 western states from 1900-2002. Using these data they show how critical this investment was for providing more constant water supplies for smoothing agricultural production in the face of climatic variability.[13]

Appropriative water rights grant diversion rights to a *fixed* quantity or flow of water from a highly variable stock, based on the date of the original claim. Those with the earliest claims or senior rights have the highest priority, and subsequent claimants have lower-priority or junior rights. Diversions are progressively rationed by priority of right, and during drought, junior diversions may be halted. Appropriative rights can be sold or leased for use elsewhere, creating a basis for water markets.

As I argue, markets are limited by incomplete water rights.[14] First, there is uncertainty as to the actual amount of water involved. In the past, when scarcity was

less of an issue, rights were not measured accurately nor were diversions monitored. Limited information about capacities resulted in many streams and aquifers being over-allocated. Second, fluctuating seasonal precipitation affects stream flow, reservoir size, and groundwater recharge, and hence, the amount of water available for individual diversion. Seasonal fluctuations, however, are generally predictable. Long-term droughts are more difficult to forecast and may be even more prevalent with climate change. Third, and perhaps most important, under prior appropriation there is a critical interdependence among diverters from the same water source with different access priorities. This situation complicates the definition of a water right and use of water markets because of the potential for third-party impairment from trade.

Because as much as 50 percent of the original diversion may flow back to the stream or percolate down to the aquifer, it is available for subsequent users. During times of drought when only senior appropriators may have their allotments fulfilled, junior appropriators are especially dependent upon these return flows. They bear most of the downside risk of shortfalls. Actions by senior rights holders that affect water consumption and hence influence the amount of water released downstream can directly impair junior parties. For example, sales by senior rights holders to urban areas may move water out of a basin so that it no longer is available for subsequent access by junior rights holders. Accordingly, they are more likely to protest, and often delay or block, otherwise economically-beneficial trades.[15] Additionally, if the sale or lease of surface water results in groundwater substitution, then third parties also can be affected as aquifers are depleted. Groundwater rights are even less well defined and monitored than are surface rights, and classic common-pool conditions can exist.[16]

Accordingly, interconnected water uses under appropriative water rights are the basis for state regulation of potential third-party impairment. Regulatory patterns vary across the states with important implications for the transaction costs of exchange and extent of market activity.

Water Regulation

In all western states, appropriative water rights are usufruct rights, conditional upon placing water into beneficial use, no-injury to third parties, and adherence to the public interest. Failure to comply can result in the loss of the right. Although irrigation was the dominant initial basis for diversion, the set of beneficial uses is expanded or contracted based on changing public values, judicial interpretations, and constituent group politics.

As I describe, beneficial use is a vague concept that can shift, adding uncertainty to a water right. Historically, physical diversion and complete use of diverted water were deemed sufficient to maintain a water right—the so-called use-it-or-lose-it mandate. Not surprisingly, this requirement motivates irrigators to place marginal water into low-valued applications, even though its use in urban settings has much higher values. This marginal water offers the greatest opportunity for gains from trade. It also suggests that any indirect effects of water exchange, such as reduction in demand for farm labor and related declines in local commercial activity would be small.[17]

Nevertheless, concerns about the impact of agricultural-to-urban water trades on regional economies are major sources of opposition to expanded water markets. A common reference is the infamous Owens Valley-to-Los Angeles water transfer largely negotiated during 1916-34 between farmers and the Los Angeles Department

of Water and Power (LADWP). This added water supply delivered via the Los Angeles Aqueduct made the rapid growth of Los Angeles possible. The received view is that the LADWP used its monopsony power to extract the rents and essentially, “stole” the valley’s water leaving it an economic wasteland. The episode was the basis for the 1974 movie *Chinatown*, and the anecdote is repeated often in contemporary water policy discussions.

Because of its notoriety I collected data on 869 farms purchased by the city, the prices paid for land and water rights, and the bargaining pools formed by farmers. My analysis reveals that contrary to conventional wisdom, farmers did much better by selling than if they had remained in agriculture. Further, the more cohesive the pool, the higher the sale price received. Nevertheless, comparing the prices paid with what the LADWD might have been willing to pay (the cost of alternative water) reveals that the city captured most of the surplus. Although there were clear gains from trade for both parties, the imbalance in the outcome fuels equity concerns that loom large in rural areas today.[18]

The prospect of both direct and indirect third-party impairment has led states to implement judicial or administrative procedures that must be followed before water applications can be altered or water rights transferred. The burden of proof of no-harm from a transfer rests with the applicant. The procedures vary by state, but those with a broad definition of both pecuniary and technological injury and a wide range of standing for objection have higher transaction costs for water trade.[19]

Other institutions also affect the transaction costs of water exchange. Irrigation districts are the most common type of agricultural water supply organization, and many use tremendous amounts of water. One of the country’s largest is the Imperial Irrigation District of Southern California (IID) that annually

diverts 2.8 million AF of Colorado River water, nearly two-thirds of California's legal share of the river. In some irrigation districts individual water rights are only vaguely defined and instead are held in trust by the district as common property. In those cases, the voting rule by which the district governing board is selected plays an important role in the costs of water transactions. Where the board is elected by community-wide votes, the many heterogeneous interests involved, including non-farmers, tenant farmers, and land owners, make water negotiations with urban areas more complex and contentious than in the case where the board is selected by only by farm owners. As I argue, in light of the high prices offered for urban water there is potential for opportunism as additional claimants attempt to secure a portion of the rents. These differential patterns of water regulation and governance affect water market activity. [20]

Alternative Water Institutions

Although my research focus has been on the U.S. West, similar conditions exist in other semi-arid regions where increased fresh water scarcity is raising pressures for more efficient water use and distribution. Grafton, et al, July 2010 compare water institutions and market activity in parts of Australia, Chile, China, South Africa, and the U.S. with respect to four components of integrated water resource management: institutional underpinnings, economic efficiency, equity, and environmental sustainability. Australia has the earliest and most developed water market and administrative management structure. The U.S. is more fragmented with considerable institutional diversity and innovation as well as an expanding water market. Chile has well defined water rights similar to those in Australia. South African water rights are short term and the country relies more on central planning and less

on water markets and hence, has few formal trades. Chinese institutions are the least well developed so that some river basins and reservoirs are effectively informal open access.

Overall, my research reveals the importance of water institutions. There are important path dependencies and efficiency and equity objectives for water often conflict.

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[2] J. Brewer, R. Glennon, A. Ker, and G. D. Libecap, "Water Markets in the West: Prices, Trading, and Contractual Forms," NBER Working Paper No. 13002, March 2007, and *Economic Inquiry*, 46(2): pp. 91-112; Q. R. Grafton, C. Landry, G. D. Libecap, S. McGlennon, and R. O'Brien, "An Integrated Assessment of Water Markets: Australia, Chile, China, South Africa, and the USA," NBER Working Paper No. 16203, July 2010, forthcoming in *Review of Environmental Economics and Policy*; Q. R. Grafton, C. Landry, G. D. Libecap, and R.O'Brien, "Water Markets: Australia's Murray-Darling Basin and the US Southwest," NBER Working Paper No.15797, March 2010; and T. Anderson and R. Watson, *Tapping Water Markets*, manuscript, Bozeman, MT: Property and Environment Research Center, 2010.

[3] Grafton et al, March 2010.

[4] G. D. Libecap, “Institutional Path Dependence in Climate Adaptation: Coman’s ‘Some Unsettled Problems of Irrigation,’” NBER Working Paper No. 16324, September 2010, forthcoming *American Economic Review* 101 (1) (2011), pp. 1-19.

[5] Transactions are in terms of acre feet (AF). An acre foot is 325,852 gallons, about enough to meet the needs of 4 people for a year.

[6] As reported in G. D. Libecap, “Institutional Path Dependence in Climate Adaptation…"

[7] Brewer et al, March 2007.

[8] See G. D. Libecap, “Water Rights and Markets in the U.S. Semi-Arid West: Efficiency and Equity Issues, forthcoming in *Evolution of Property Rights Related to Land and Natural Resources*, D. H. Cole and E. Ostrom, eds., Cambridge: Lincoln Institute, 2010.

[9] See Brewer et al 2007; G. D. Libecap, “Water Rights and Markets in the U.S. Semi-Arid West..."

[10] G.D. Libecap and J.L. Smith, “The Self-Enforcing Provisions of Oil and Gas Unit Operating Agreements: Theory and Evidence,” NBER Working Paper No. 7142, May 1999, *Journal of Law, Economics and Organization* 15(2): 526-48; G.D. Libecap, “The Assignment of Property Rights on the Western Frontier: Lessons for Contemporary Environmental and Resource Policy,” NBER Working Paper No. 12598, October 2006, in *Journal of Economic History* 67(2): 257-9; T. L. Anderson, R. Arnason, and G.D. Libecap, “Efficiency Advantages of Grandfathering in Rights-Based Fisheries Management,” NBER Working Paper No. 16519, November 2010, forthcoming *Annual Review of Environment and Resource Economics.*

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[12] See G. D. Libecap, “Institutional Path Dependence in Climate Adaptation…"

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[15] See G. D. Libecap, “Institutional Path Dependence in Climate Adaptation…"

[16] G. D. Libecap, “Water Rights and Markets in the U.S. Semi-Arid West…”; R. Hornbeck and P. Keskin, “Farming the Ogallala Aquifer: Short and Long-run Impacts of Groundwater Access, working paper, Economics Department, Harvard University, 2010.

[17] G. D. Libecap, “Water Rights and Markets in the U.S. Semi-Arid West…”;

[18] G. D. Libecap, “Transaction Costs: Valuation Disputes, Bi-Lateral Monopoly Bargaining and Third-Party Effects in Water Rights Exchanges. The Owens Valley Transfer to Los Angeles,” NBER Working Paper No.10801, September 2004, later published as, “Chinatown Revisited: Owens Valley and Los Angeles—Bargaining Costs and Fairness Perceptions of the First Major Water Rights Exchange,” *Journal of Law, Economics and Organization* 25 (2) (2008), pp. 311-38 and G. D. Libecap, *Owens Valley Revisited: A Reassessment of the West’s First Great Water Transfer*, Palo Alto: Stanford University Press, 2007.

[19] G. D. Libecap, “Water Rights and Markets in the U.S. Semi-Arid West…”;

[20] See G. D. Libecap, “Institutional Path Dependence in Climate Adaptation…"