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Reducing institutional barriers to water conservation

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Abstract

Significant increases in water demands, in conjunction with economic and population growth, stress already scarce water supplies in dry areas. This paper shows that the principle of confronting all water users with the opportunity cost of their actions can be applied to the design of institutions that reduce barriers to water conservation. We apply the principle to the case of temporary water transfers from agriculture to cities, in which the opportunity cost of water used for agriculture is what cities are willing to pay for the water. A significant institutional barrier that blocks temporary market transfers of water is the 'use it or lose it' principle of western US water law. Legislation that removes that institutional barrier to conservation by defining short-term water trading to be a beneficial use of water can promote greater total economic benefit from scarce water, if combined with measures for protecting third parties. By removing this barrier to the free flow of information on the opportunity cost of water used in agriculture, legislation can create a market for agricultural water and reduce the cost to cities of securing needed water.

1. Introduction

Significant growth in water demands in conjunction with economic and population growth stress already limited water supplies in dry places around the world. In these areas, designing institutions that promote water conservation means little unless these designs are based on

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economics. One definition for water conservation is "any decision that promotes a reduction in water use over time that pays for itself in human benefits gained" (Baumann, Boland & Sims, 1984).

In drought periods, reduced levels of streamflow, aquifers and reservoirs increase the economic value to all users of the remaining water. These reduced supplies typically require agriculture, cities, power utilities and environmental users to conserve and/or look for other sources of wet[1] water.

The aim of this paper is to illustrate how simple economic principles can be used to design institutions that reduce barriers to water conservation in dry regions and therefore lower economic damages produced by droughts. We illustrate how these economic principles can be applied by showing how economic costs of droughts can be reduced by removing legal barriers that block the effective flow of information on the opportunity cost of water used in irrigated agriculture.

2. Demand elasticities for cities and agriculture

Irrigated agriculture has produced food in dry places for thousands of years. By definition, irrigated agriculture is water-intensive. Therefore, where irrigation demand faces strong competition, such as from large cities or from cheap rain-fed food production, its demand for water is quite sensitive to its price.

The price elasticity of demand measures the percentage change in use of water from a given percentage change in its price. High-valued necessities such as drinking water typically have a low price elasticity while lower-valued, more water-intensive uses such as irrigated agriculture, possess higher price elasticities. A high price elasticity of demand for water means that a small percentage change in water's price causes a large percentage change in quantity used.

High price elasticities characterize water demands for irrigated agriculture compared to cities in most parts of the world. Depending on the crop, soil, climate, weather and period of adjustment, price elasticities for irrigated agriculture have been found to range from -1.0 to -3.0. A small percentage change in the price of water causes major impacts on water used in and incomes derived from agriculture. Herrington (1987) summarizes a number of earlier modeling studies on irrigation demand elasticity which show demand elasticities in agriculture to be relatively high, especially at higher water charges.

Irrigation farmers typically respond to increases in water prices by making one of three kinds of adjustments: (1) substituting between water and other inputs, (2) changing the crop

[1] Wet water, sometimes called 'real water', is water available for transfer to another use not derived at the expense of another legal water user. Two examples of wet water are (1) water savings resulting from not planting and irrigating a crop that would otherwise be used in irrigation; (2) an offer to release reservoir-stored water that would otherwise be stored behind the dam. The opposite of wet water is 'paper water', i.e. water proposed for transfer that only seems like an increase in supply, but creates no new water. An example is a proposal to market water under a water right not historically used. Paper water transfers often involve an offer to sell water that someone other than the seller would use without the proposed transfer. An example is farmer's offer to transfer return flows to a city historically used by a downstream farmer (California Department of Water Resources, 1993a).

mix on irrigated land and (3) reducing total irrigated area. Overall, the use of water in agriculture is considerably more price responsive than the use by cities.

Similarly, the price of water in cities is more responsive to shortages than is agriculture's. For example, based on the typical US$1 per quart price of designer bottled water, people pay about US$1.3 million per acre foot for drinking water. Cities typically charge their customers more than US$300 per acre foot. What this means is that cities are usually willing to pay considerably more to assure needed supplies during drought than is agriculture. Schneider and Whitlach (1991) presented a comprehensive water demand study and provided an extensive survey of the previous literature. They showed that almost all estimates of long-run price elasticity of residential water demand in the US seem to fall between −0.3 and −0.7.

The relatively low demand elasticity for city water means that city demands in periods of shortage could provide a ready market for temporary use of agricultural water. Irrigated areas that are located close to cities can use the elasticity concept to advantage by recognizing that cities are willing to pay much more for water than farmers lose in production by taking water out of agriculture[2].

3. Economic benefits of short term water transfers

In the US west, agriculture owns most of the rights to use water. Here farmers have an economic opportunity to increase profits in dry years by charging premium prices to cities and others who need wet surface water.

Water transfers within agricultural regions is an old practice. For example, Maass and Anderson (1978) describe an effective water marketing arrangement that has been in effect in one area of Spain since the 15th century. There are also vast numbers of water trades among farmers throughout the western United States (Lund and Israel, 1995). The economic literature describing the merits of voluntary water transfers is huge (Milliman, 1959; Hartman and Seastone, 1970; Howe et al., 1986).

4. Institutional barriers to water transfers

In much of the mountain and desert US west, agricultural water right owners believe that investments in water conservation measures, such as lining ditches with concrete or depositing water into a water bank for cash, may cause them to forfeit their saved or deposited water, because it may be perceived as failure to demonstrate beneficial use. For example, New Mexico legislator Pauline Gubbels recently described a farmer in the Mesilla Valley who told the New Mexico Legislature's Water, Utilities and Natural Resources Committee "I would spill my water before I would try to conserve it, because I won't risk forfeiting any of my water rights" (Gubbels, 1998). This quote vividly illustrates the economic damages to everyone produced by information barriers on the real cost of spilling water. Namely, other water users in and out of

[2] A good example is Elephant Butte Irrigation District, New Mexico, 40 miles from El Paso, TX.

agriculture may be able to put that spilled water to an economically beneficial use. So by spilling water, the other beneficial use of water is lost along with the opportunity for the farmer to earn an income by marketing that water to the other user. Unfortunately if the farmer believes the market for that water is insecure, he perceives an opportunity cost of nearly zero[3].

The culprit blocking the information flow on the real cost of water use is the 'use it or lose it' element of the prior appropriation doctrine[4]. By creating risk associated with actions that reduce current water use, this barrier impedes water conservation acts such as temporary water transfers from agriculture and thus limits wet water available for cities in droughts. Legal barriers are especially important when a proposed transfer involves changes in conditions stipulated by the original water right, such as changes in type of use, place of use, or time of withdrawals. Fear of losing a water right is a serious obstacle to farmers who might otherwise conserve water by entering into a short-term voluntary water transfer[5].

Legislative bodies could remove this barrier that blocks effective information on the real cost of water use by promoting greater security of tenure of water rights[6]. They could do this by enacting laws that declare short-term water transfers from agriculture to be a beneficial use of water[7]. Such legislation could create a market condition by providing a profit incentive for farmers to conserve water in exchange for cash.

5. Agricultural adjustments

Temporary or permanent water transfers from agriculture typically produce one or more of the following responses: fallowing (not irrigating) fields, shifting to lower water-using crops, substitution of ground water for surface irrigation supplies, increased ground water pumping, conserving water, and releasing water from reservoir storage. Each response could produce cash for agriculture and by reducing usage in agriculture, free up some water for other uses.

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[3] But not exactly zero. The opportunity cost of the spill is X dollars of lost revenue if the other beneficial user would pay for the water. But the farmers current decision to spill is the outcome of a multiperiod decision. He spills because the cost of risking part of a water right loss for all future time far outweighs the X dollar one-shot income gain.

[4] Similar institutional barriers to water conservation were described nearly 100 years ago by Mead (1903), p. 380). He stated "The west needs, as never before, to study methods of social organization and to develop plans for co-operation".

[5] Another obstacle to transfers of water from agriculture to cities is a lack of adequate infrastructure to divert water. For example, Albuquerque, NM and many other western US cities currently have no infrastructure to divert water from rivers, since they rely completely on groundwater (Daves, 1997). Similar fears of water right losses are also critical in almost all international water negotiations, as illustrated by the history of efforts between Palestine and Israel. The fear of losing a water right also motivates considerable effort to recapture water rights that were thought to be taken, as in the case of the Palestinians and many native American tribes.

[6] Ciriacy-Wantrup (1956) discussed several dimensions of security of tenure in water rights.

[7] The California legislature essentially did this during the 1986-1992 California drought. The Water Banking Law included specific legal assurance that depositing water into the bank would not change farmers' permanent water right. This legislation was cheap, easy, and because it reduced farmers' uncertainty, was effective.

6. Institutional adjustments

Several kinds of water transfer arrangements would provide an economic opportunity for agriculture to mitigate the economic cost of drought (Lund and Israel, 1995). We discuss contingent transfers/dry-year options; spot market transfers; water banks; transfer of reclaimed, conserved and surplus water and water wheeling or water exchanges.

6.1. Contingent transfers/dry-year options

Sometimes potential water buyers are less interested in acquiring permanent water supplies than in increasing the predictability of their water supply system during droughts. For both buyers and sellers, temporary transfers that are contingent on water shortages may produce an economic payoff. The buyer could pay agriculture a sum of money for the privilege of exercising the right to use water in an emergency situation. The buyer might also arrange to pay agriculture an extra sum if that right is actually exercised. Advantages of contingent transfers for agriculture are the immediate acquisition of cash when the contract is made and additional revenues if the contingent transfer option is called. The advantage to the buyer is access to wet water when most needed.

6.2. Spot market transfers

Spot market transfers are short-term transfers, typically agreed to and carried out within a single year. These transfers typically set up a bidding process, often with some of the conditions for transfer, such as price or quantity, being fixed. The advantage of a spot market transfer for agriculture is the immediate infusion of cash when the transfer takes place.

6.3. Water banks

Water banks are a special form of a spot market that is organized and operated by a central banker, such as the state or perhaps a group of water utilities. The bank is a mechanism for willing owners of water to lease water to the bank for release to renters on a short-term basis (Pratt, 1994). The banker is responsible for organizing the lease and for keeping track of the supply and demand for money and water. A water bank is characterized by flexible, temporary transfers of water without ownership changes. Bank participants may differ by year.

The California Drought Emergency Water Banks of 1991 and 1992 are good examples of cases in which the terms and price of transfer were essentially fixed, with the State of California acting as a banker (California Department of Water Resources, 1992, 1993, 1993a, 1993b; Rich, 1994; Jercich, 1997).

The state acquired water in three ways: by paying farmers for water they would have used to irrigate their fields resulting in unused water flowing past their farms, by purchasing surplus water from local irrigation districts, and by paying farmers or irrigation districts to use ground water instead of surface water (Rich, 1994). In both physical and financial terms, the 1991 California Drought Water Bank was the largest set of regional water trades to occur so far in the United States (Howitt, 1994).

The 1991 Water Bank taught water managers a number of important lessons (Dziegielewski et al., 1993): (1) water markets, even when they are severely controlled and constrained, will work; (2) water has a high value for many buyers and there are many willing sellers; (3) very large amounts of water can be found if money is put on the table and (4) third-party interests in market transactions can be protected.

6.4. Water wheeling and exchanges

In the power industry, electricity is often wheeled through the transmission system between power companies and generation plants to reduce the cost of power and to get it to where it is most needed at the right time. Water could be similarly wheeled or exchanged through water conveyance and storage facilities to improve the performance of the system[8]. An example is the use of a parallel lined canal owned by somebody else to deliver water rather than incurring considerable water losses by using one's own unlined canal, a common feature in the US west.

Seasonal wheeling of water is common in agricultural regions in which different areas have complementary demands for water over time. For example the City of El Paso, TX needs wet surface water flows from the Rio Grande in the winter while the Elephant Butte Irrigation District has limited need for its channel capacity in winter, when there is no irrigation. So seasonal wheeling may provide opportunities for cities like El Paso to exchange water with irrigation districts during low-flow irrigation demand periods. Repayment could come in the form of added water and/or cash during the high-demand irrigation season.

By allowing water-buyers to pay farmers to not use water, the water not used in agriculture becomes available for non-agricultural uses. The use of wheeling to meet environmental uses could involve the use of storage facilities to release water for instream flows when desired. A good example of this policy would be releases by the Middle Rio Grande Conservancy District in central New Mexico from its upstream storage facility at El Vado Lake that could produce streamflows needed by the silvery minnow, an endangered species.

6.5. Transfer of reclaimed, conserved and surplus water

The purchase of water made available by reclamation or reductions in water demands is a form of a water transfer. Recently the Metropolitan Water District of California set up a 35 year contract to pay the Imperial Irrigation District (IID) several million dollars for canal lining and other system improvements in exchange for the water conserved. Israel and Lund (1995) report estimated savings at 100,000 acre feet per year from IID's Colorado River water

[8] It is important to point out that water infrastructure, i.e. a plumbing system, is needed to make markets work effectively. This infrastructure is needed to give adaptability and flexibility to the system. Otherwise water cannot be moved around. Another important part of the water infrastructure needed is a sophisticated water accounting system for tracking water. These requirements are often lost in the debates where people propose banking and other forms of marketing, but often forget the importance of infrastructure. Also water trading is often proposed as solutions in places that lack effective capacity to connect water, say from agriculture to cities. We thank Dr. Delli Priscoli for these insights.

supplies. This similar potential for a mutually beneficial trade exists between cities and agriculture in dry areas around the world.

7. Issues needing resolution

Designing institutions that reduce barriers to free flow of information on the opportunity cost of water promotes economically effective conservation. Still, for water transfers to play a meaningful role in effectively coping with drought in dry regions, a number of scientific and policy issues must be squarely dealt with. We pose several questions to challenge innovators who wish to craft institutions for coping with water shortages.

What is the best way to deal with the possibility that short-term water transfers such as banking may stimulate water use that would not otherwise take place? If farmers believe they will be paid in the future to reduce water use, some may start using as much water as possible to establish a higher historical level of use. Where this occurs, the expectation that markets will be established for promoting water conservation may do just the opposite. This is a serious problem in parts of the world where streams are not adjudicated[9].

Problems may arise from failing to account for the interrelationship of surface and ground water. Market transfers of surface water may later increase the seller's groundwater pumping. This action may take groundwater, and through hydrologic connections, surface water away from other users. Where this occurs, the buyer fails to face the full cost of the transferred water, resulting in the risk that society loses by having water move from a higher- to lower-valued end use.

Typically, two-party transfers between agriculture and another water user can affect several third parties, such as other farmers, local communities, water-based recreation and environmental interests. Some institutional mechanism, such as requirement of notice to possible objectors, combined with compensation requirements, is needed to assure that all interests are protected by proposed transfer[10]. Successful design of such a mechanism is required for each potential water buyer to face all costs of his water use. Opportunity costs of the transfer include the seller's lost income from current water use, administrative costs, and costs imposed on third parties. Failure to design institutions that protect third parties with some combination of money and water produces one of two undesirable outcomes: (1) either

[9] River basin adjudication is expensive and slow, because it requires setting up and carrying out a rational method to define the complex pattern of who owns the right to use how much water under widely varying conditions of water supplies. Adjudication takes place under intense public scrutiny. It requires setting up a formula, typically spelled out in a court decree, that states which water users suffer what percent of the total shortage under various levels of reduced streamflow compared to 'normal' flows. Wherever streams are not adjudicated, like in most of New Mexico, policymakers are advised to design market-transfer institutions, like water banking, with great caution. The lack of clear titles that exist in nonadjudicated river basins creates huge claims for water that are many times larger than normal streamflows-which is the current (1998) situation in New Mexico. It also greatly magnifies current water uses and freezes current water use patterns, both of which damage efforts to attract new high-paying jobs to the affected area, since prospective new employers cannot always be assured of reliable water.

[10] Trelease (1956, 1974), in two engaging law review articles, discussed several institutions for protecting the public interest in the face of proposed water transfers.

these parties will block implementation of the proposed transfer or (2) if they fail to block it in spite of their losses, society loses because the transfer moves water from a higher- to lower-valued use.

Market-based transfers are likely to work better in places that have extensive systems of conveyance and storage facilities and with well-coordinated operations. The importance of having these facilities should not be understated. Locations with poorly developed storage and conveyance facilities or poor river basin accounting procedures are likely to have considerably less potential for making water transfers work.

Fears motivated by the uncertainty of water allocations that will emerge from future market activity for coping with water shortages may inhibit current rational solutions[11]. For example, before and during the 1986–1992 California drought, the three major water users who negotiated, consisting of cities, farmers and environmentalists, failed to reach an agreement, even though collaboration was an obvious solution on paper. Each group had a different hammer. Cities had the money, farmers had state law, and environmentalists had federal law and the courts. The fight cost a California senator his job and led to a federal law that gave more water to the environment[12].

8. Conclusions

Water conservation can be defined as any action, such as a new institution, that promotes a reduction in water use over time that pays for itself in human benefits gained. One way to promote water-conserving decisions is to design institutions that remove barriers to communicating economic information on the opportunity cost of current water use patterns.

Considerable differences in the price elasticities of demand for water in agriculture versus cities creates an opportunity for designing legal institutions that reduce barriers to market transfers. Water used in irrigated agriculture is typically more responsive to price changes than water used by cities. Owners of agricultural water rights could use this price responsiveness to advantage by renting or leasing their water to cities in periods of drought with no change in water right ownership.

Without explicit legislative action, the 'use it or lose it' tenet of the prior appropriation doctrine poses a barrier to temporary water transfers because in many parts of the US west, trading is not considered a beneficial use of water. Where there is water infrastructure to store and move traded water, legislation that defines water trading to be a beneficial use of water removes this institutional barrier to water conservation. Such legislation, if drafted with guarantees to protect third parties, confronts water sellers with the full cost of continued

[11] Nearly 500 years ago Machiavelli (1505) described people's fear of change; his observations are still timely in the realm of proposed new water institutions. There is nothing more difficult to take in hand, more perilous to conduct or more uncertain of its success, than to take the lead in the introduction of new order of things; the framers of the new institution face as enemies all who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.

[12] We thank an anonymous reviewer for much of this paragraph. This reviewer also observed that the preponderance of much of the problem and solution space may lie outside technical or institutional fixes that seem logical.

current water uses. In so doing, it opens a market for agricultural water and increases profits to agricultural users who choose to rent their water to cities in a dry year. It also reduces the cost to cities of securing needed water.

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