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Can Farm Irrigation Technology Subsidies Affect Real Water Conservation?

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Can Farm Irrigation Technology Subsidies Affect *Real* Water Conservation?

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Introduction

In the western U.S., growing urban water demands and a rise in the values placed on instream flows have intensified the competition for limited water supplies. With irrigated agriculture being by far the largest and often lowest-valued water use, efforts are increasingly undertaken to encourage agricultural water conservation with the aim of transferring some water to higher-valued uses and improving the economic efficiency of water resource allocation. Adopting improved on-farm irrigation technologies is often cited as one potential approach for farmers to conserve water while maintaining yield levels with little or no loss of income.

Scholars and policymakers intent upon increasing the pace of irrigation technology transitions commonly focus on the provision of economic incentives, including instituting higher agricultural water prices or subsidizing investments in more efficient irrigation technologies (Weatherford 1982, Caswell et al. 1990, Huffaker and Whittlesey 2003). While in theory water price reform may appear to be more appropriate and efficacious, in real world applications—especially within the framework of the prior appropriation system—this policy tool may not be available. Another approach, that of subsidizing irrigation technology transitions, is therefore receiving increasing attention. The U.S. Department of Agriculture has long provided cost-share arrangements for upgrading irrigation systems. One of the priorities of the ongoing Environmental Quality Incentives Program is the conservation of ground and surface water resources, and eligible practices include the installation of improved irrigation technologies such as sprinklers (NRCS 2003). The U.S. Department of Interior under the Yakima River Basin Water Enhancement Project Act is also authorized to provide public financing for improvements in on-farm irrigation efficiency and to earmark the reduction in diversions to increase the reliability of the water supply for both instream flows and irrigation (Huffaker and Whittlesey 2000). In addition, expanding cities are increasingly called upon to help finance irrigation technology adoption in return for "saved" irrigation water, providing a supposed "win-win" solution for a knotty problem. For example, such proposals are currently being discussed to help solve the water needs of the fast-growing urban areas in the Front Range of Colorado.

A few analysts have questioned the conservation potential of improved irrigation technologies (Hornbaker and Mapp 1988, Caswell 1989, Whittlesey and Huffaker 1995, Smith et al. 1996, Huffaker and Whittlesey 2003). Their critiques rest on the distinctions among withdrawal (the amount of water diverted from a source), delivery (the amount of water delivered to the place of use) and consumption (the amount actually depleted via evapotranspiration), and in the observation that only if consumption is reduced will any basin-wide *real* conservation be achieved. Even if improved on-farm irrigation efficiency leads to reduced withdrawals and deliveries, consumptive use may not decrease—it may even increase, especially if the irrigated area can be expanded. In addition, at the river basin level the magnitude and/or timing of return flows may be changed, negatively impacting water users who depend on them. To date, however, no explicit empirical estimates of the effects of irrigation technology subsidies on withdrawals and, in particular, deliveries and consumptive use seem available.

The model we develop aims at analyzing the potential for real water conservation that might be generated by subsidizing on-farm irrigation technology improvements. Our estimates are based on a two-stage crop simulation/linear programming model that is applied to a representative irrigation water delivery organization in the South Platte Basin in northeastern Colorado. Flows from the South Platte River and its tributaries serve the state's most important agricultural region as well as the major urban-industrial centers. With more than 80% of the water withdrawals from the South Platte used for irrigation, there is increasing pressure to make some of that water available for growing non-agricultural demands by encouraging a faster adoption of improved irrigation technology. Currently farmers use mostly surface technologies, with open ditch with siphons distributing water on more than half of the irrigated area. The remaining area is served by gated and flexible pipes with and without surge, and by center-pivot sprinklers.

Previous Literature on Irrigation Technology Choice

Improved irrigation technologies are known to be able to significantly increase on-farm irrigation efficiencies and, thus, reduce delivery (and withdrawal) requirements. They also improve irrigation uniformity, and reduce deep percolation and runoff. Output produced with a given amount of water is increased, but this improvement involves higher equipment costs (and, in the case of a switch to sprinklers, energy costs). Research on the adoption of improved irrigation technologies is relatively new, but it is based on a well-established adoption literature in both development economics and industrial organization (Caswell 1991). Since the 1980s both normative and positive models have been developed. The normative literature includes conceptual models as well as empirical work that is usually based on an engineering approach (see especially Caswell and Zilberman 1986, Hornbaker and Mapp 1988, Caswell et al. 1990, Letey et al. 1990, Carey and Zilberman 2002). The positive models are based on empirical data to test hypotheses using econometric techniques (Caswell and Zilberman 1985, Nieswiadomy 1988, Lichtenberg 1989, Negri and Brooks 1990, Schaible et al. 1991, Green et al. 1996).

The literature on irrigation technology adoption has identified numerous variables affecting farmers' technology choice, including economic, environmental, and institutional factors. Economic factors include commodity prices, costs of inputs, and the costs of the irrigation technology. Environmental factors comprise climate, topography and land quality. Among the institutional factors are tenurial and water rights arrangements. Although the results from different studies differ in the weight given to particular factors, it seems that improved irrigation technologies are more likely to be adopted on lower quality land, when crop and input prices are high, and when the cost of switching technologies is low. In the case of the South Platte River Basin, with mostly high-quality agricultural land, the availability of secure and cheap water sources for agriculture, and low real crop price increases, it is not surprising that the transition to improved irrigation technologies is relatively slow. This means, in the absence of policy-induced changes, relatively small quantities can be expected to be available in the future to meet increasing nonagricultural demands.

Modeling Procedure

In order to analyze the impact of hypothetical subsidies for farm irrigation technology adoption on water deliveries and consumptive use, we develop a linear programming model to simulate crop production decisions and irrigation technology and management options available to farmers in the representative irrigation water delivery organization (for details on the economic model, see Scheierling et al. 2003). The delivery organization has senior water rights for river flow, but also uses reservoir water and groundwater from the unconfined shallow alluvial aquifer along the South Platte River for irrigation. The main crops are corn grain, alfalfa, edible dry beans, corn silage, and sugar beets.

To carefully reflect the yield effects of changing water inputs, the linear programming model incorporates water-crop production functions computed with a complex discrete-input simulation model (for details on the crop simulation model, see Scheierling et al. 1997). The linear program calculates the net income-maximizing choice of irrigation technologies and deliveries in response to a subsidy, as well as the related consumptive use. Examining scenarios reflecting varying proportions of annual irrigation system improvement capital costs paid by a public agency from zero to 100%, we estimate the effects on deliveries and consumptive use. Different scenarios allow a range of possible on-farm adjustments in irrigation technologies, cropping mix, irrigated acreage, and the number and timing of irrigations. Based on the related changes in agricultural net income and costs to the public agency, net social costs per additional acre foot of water instream and downstream are calculated as well as distributive impacts analyzed.

Results and Implications

We find that the higher the subsidy level, the more probable it is that improved farm irrigation technologies are adopted and deliveries reduced. However, since subsidies do not provide any incentive to decrease the number of irrigations, shift to less water-consuming crops, or reduce the acreage irrigated, subsidies appear unlikely to diminish consumptive use under all scenarios. In fact, consumptive use may rise—even without an accompanying expansion in irrigated area—, when yield levels can be profitably increased by applying additional numbers of irrigations. Thus, in a basinwide context the subsidy approach is limited in its real water conservation potential. In some cases, the results may be the opposite of what was intended with downstream water users having less water available than before at the times that they need it. Yet capital investment is encouraged, labor inputs reduced, and agricultural net income increased with the use of public funds. The overall conclusion is that the net social (public budget) cost per unit of real water conserved by a subsidy program would be quite high.

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