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Evaluating the Effectiveness of Conservation Water-Pricing Programs: Comment

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In their July 1998 article, Huffaker et al. call into question the common conception that price-induced water conservation will always enhance western stream flow levels. Utilizing a simple model of homogeneous farms covering a rectangular river basin of uniform hydrology, the authors claim to identify conditions under which an opposite result can emerge. The purpose of this comment is to offer two corrections, one of interpretation and one of analysis.

The primary goal of Huffaker et al.'s paper is to formulate a theory examining the potential stream flow consequences of irrigation district water pricing. Because the theory's water price variable, P, is introduced along with the profit-maximizing input choice condition [the authors' equation (2)],

$$P_Y F_C(C) = P,$$

and because the input choice pertains to water consumption, C, the water price variable identifies the price of consumed water rather than the price of delivered water (as claimed or implied throughout the paper). As a consequence, the theory's results do not provide transparent implications for the linkage between contemporary irrigation district pricing policy and instream flows. In contemporary settings, some irrigation districts have abandoned acreage-based pricing systems in favor of the volumetric pricing of water deliveries, but district attempts to volumetrically price water consumption remain novel. The distinction is crucial. Delivery pricing does not motivate the same modes of conservation behavior as does consumption pricing. While it can be argued that evolving district policy may eventually embrace consumption pricing and add relevance for the Huffaker et al. theory, the transaction costs of measuring or estimating water consumption present a major obstacle.

The analytical error of Huffaker et al. is more crucial. As noted, the analysis focuses on the impact of volumetric pricing on instream flow levels. The highlighted finding is that heightened water price may positively or negatively influence instream flows ($\partial W_x/\partial P > 0$, or $\partial W_x/\partial P \le 0$). This conclusion is incorrect within the authors' assumptive base.

Inspecting the polar case of full return flow, $\delta = 1$, which is the situation argued to be most conducive to a negative $\partial W_x/\partial P$, the authors' equation (12) is basically as follows:

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$$\frac{\partial W_x}{\partial P} = -\frac{C}{P}\left(\varepsilon_{Q,P} + \varepsilon_{E,P}\right)\alpha x.$$

Because C, P, α, and x are everywhere positive, $\partial W_x/\partial P$ has a sign opposite to that of $\varepsilon_{Q,P} + \varepsilon_{E,P}$. The authors contend that this elasticity sum may be positive in some circumstances. However, a revision of their equation (8) provides:

$$\varepsilon_{Q,P} + \varepsilon_{E,P} = \frac{P}{P_Y F_{CC} C},$$

which quite clearly indicates that the sum of the two elasticity measures is negative. This infers that $\partial W_x/\partial P$ must be positive in the polar case of $\delta = 1$, just as it is for the opposite case of $\delta = 0$ (no irrigation return flow).

While not undertaken by Huffaker et al., their assumptions also can be used to sign $\partial W_x/\partial P$ for intermediate cases of δ. Rewriting their equation (4) after dropping implied arguments and subscripts, one obtains:

$$W = W_0 + \alpha x[(\delta - 1)Q - \delta C].$$

Taking this equation's derivative with respect to P yields:

$$\frac{\partial W}{\partial P} = \alpha x\left[(\delta - 1)\frac{\partial Q}{\partial P} - \delta\frac{\partial C}{\partial P}\right].$$

Signs of the constants on the right-hand side are readily apparent: $\alpha > 0$, $x > 0$, $\delta - 1 \leq 0$, and $\delta \geq 0$. According to the authors' equation (7), $\partial C/\partial P < 0$. Moreover, if $\partial E/\partial P > 0$, as Huffaker et al. argue,[1] their equation (5) demonstrates that $\partial Q/\partial P < 0$. Together, this information implies that $\partial W/\partial P > 0$ for $\delta \in [0, 1]$. That is, rises in the price of consumed irrigation water must increase instream flow for the entire range of possible return flow ratios.

This analysis can be modified for examining changes in water delivery pricing (P_Q). According to the farm input structure used by Huffaker et al., E and Q are substitutable intermediate inputs from which the primary input, C, is derived. If C is not explicitly priced, but E and Q are costly inputs, then rises in P_Q will motivate farms to substitute added E for reduced Q. Hence, $\partial E/\partial P_Q > 0$, and $\partial Q/\partial P_Q < 0$. Moreover, because rising P_Q increases the effective price of C (which has declining marginal product in crop production), we can expect $\partial C/\partial P_Q < 0$. Utilizing this information within

$$\frac{\partial W}{\partial P_Q} = \alpha x\left[(\delta - 1)\frac{\partial Q}{\partial P_Q} - \delta\frac{\partial C}{\partial P_Q}\right]$$

yields a demonstrable positive sign for $\partial W/\partial P_Q$ across the interval where $\delta \in [0, 1]$.

[1] This argument appears to depend partially on experiences relating to the pricing of delivered water rather than consumed water.

The upshot is that price-induced conservation cannot decrease stream flow within the static and homogeneous modeling framework established by Huffaker et al. While contrary observations may emerge in isolated, real-world conditions, suitable modeling requires attention to particularized, heterogeneous facts, especially with regard to spatial or dynamic aspects of the hydrologic setting. If water conservation is to have negative implications for instream flow, then the explanation must be rooted in a temporal shifting of flows or a disjoint hydrology. Either of these situations can only be local phenomena in a dynamic or spatial sense, because their global existence would oppose the first law of thermodynamics. Such situations can occur locally, however, and appropriate modeling constitutes an important challenge for both hydrologists and economists. An important consequence of such modeling will be that single-dimensioned policy instruments—be they prices, incentives, regulations, or edicts—are not fully satisfactory tools for achieving economic efficiency in water allocation.

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Reference

Huffaker, R., N. Whittlesey, A. Michelsen, R. Taylor, and T. McGuckin. "Evaluating the Effectiveness of Conservation Water-Pricing Programs." *J. Agr. and Resour. Econ.* 23(July 1998):12–19.