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## Evaluating the Effectiveness of Conservation Water-Pricing Programs: Reply

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The comment offered by Griffin is correct in asserting that equation (2) in our paper measures the derived demand for consumptive water use, and that its use in our model produces a positive relationship between streamflows and increased consumptive water rates. A slight modification to equation (2) produces a derived demand for delivered water that is consistent with the ambiguous relationship between streamflows and increased water delivery rates that we demonstrate in equation (12). The modified equation is:

$$(2') \quad P_Y F_C(C)E = P,$$

where

$$\frac{\partial Y}{\partial Q} = F_C(C) \frac{dC}{dQ} = F_C(C)E$$

is the marginal product of delivered water. The implicit derivative of (2') with respect to  $P$  is:

$$P_Y F_{CC} \frac{\partial C}{\partial P} E + P_Y F_C \frac{\partial E}{\partial P} = 1,$$

or, in elasticity form:

$$(9') \quad |\varepsilon_{Q,P}| - \varepsilon_{E,P} = \frac{1}{cF_{CC}} \left[ F_c \varepsilon_{E,P} - \frac{P}{P_Y E} \right],$$

where  $\varepsilon_{Q,P} = (P/Q)\partial Q/\partial P$  is the price elasticity of demand for water deliveries, and  $\varepsilon_{E,P} = (P/E)\partial E/\partial P$  is the elasticity of demand for investment in improved on-farm irrigation efficiency with respect to the price of delivered water. The sign of the term  $|\varepsilon_{Q,P}| - \varepsilon_{E,P}$  is ambiguous since it is greater (less) than zero, as  $\varepsilon_{E,P}$  is less (greater) than critical value  $P/(P_Y F_C E)$ . This ambiguous term determines the sign of the partial derivative

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measuring the marginal impact on streamflow of an incremental increase in the price of delivered water in the absence of irretrievable water losses:

$$(12) \quad \frac{\partial W_x}{\partial P} = \frac{C(P_1)}{P_1} (|\varepsilon_{Q,P}| - \varepsilon_{E,P}) \alpha x.$$

Hence, the sign of  $\partial W_x / \partial P$  also must be ambiguous. Consequently, equations (2'), (9'), and (12) support the major result of our paper that, in the presence of irrigation return flows, increasing block rates on delivered water have an ambiguous impact on streamflows, and thus can be an unreliable policy tool for generating agricultural water conservation. This is a general result produced by a relatively simple hydroeconomic model. Contrary to the comment's concluding remarks, it is not a narrow result reliant on "local phenomena" reflecting "a temporary shifting of flows or a disjoint hydrology."

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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.