CONSERVATION PRICING OF HOUSEHOLD WATER USE IN RURAL COMMUNITIES

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Abstract. Rising concerns about water conservation have led to increased interest in conservation pricing policies on the part of Georgia environmental policy makers. Conservation pricing has been discussed frequently during the on-going development of Georgia's statewide water plan. It is important to quantify the impact of such policies in order to determine that they will achieve their objectives. For conservation pricing, understanding the relationship between price increases and revenues, as reflected in price elasticity, is critical in designing successful policies.

Although a number of studies have estimated the price - quantity relationship for water use, these studies have generally used data from large urban areas. This paper provides new estimates of the price elasticity of demand for water for residential consumers in small, rural communities. Residential consumers in rural areas might react differently to conservation pricing, in part because customers in these areas typically are more homogeneous and have lower household incomes than urban households. Our empirical results, based on data from water systems in rural Georgia, confirm that the demand for water is relatively price-inelastic. However, our point estimates of elasticity are somewhat higher than in previous studies, suggesting that residential water demand in small, rural communities may be significantly more responsive to price changes relative to that observed in larger cities. These results demonstrate that the effectiveness of this conservation tool might be different in rural and urban areas of Georgia and emphasize the importance of considering price elasticity in designing conservation pricing strategies.

INTRODUCTION

An impressive literature exists that focuses on estimates for the demand for water, especially the demand for water by households (see Arbuès *et al.*, 2003). The "demand" for water refers to the relationship between prices charged for water and the amount of water use by households. Virtually all of the existing studies of residential water demand have (to our knowledge) focused on water systems serving large populations -- service populations well in excess of 100,000 (see Renwick and Green, 2000). The focus on large urban areas is understandable, particularly in light of the difficulties encountered in efforts to acquire data from small systems. Over the last decade or so, however, small, typically rural public water supply systems have become interested in the character of household demand for water. Many times (such as in the State of Georgia) this interest results from pressures from state water managing agencies to conserve water in general, and to consider conservation water pricing in particular.

Rising concerns about water conservation have led to increased interest in conservation pricing policies on the part of Georgia environmental policy makers. Conservation pricing has been discussed frequently during the ongoing development of Georgia's statewide water plan. It is important to quantify the impact of such policies in order to determine that they will achieve their objectives. For conservation pricing, understanding the relationship between price increases and revenues, as reflected in price elasticity, is critical in designing successful policies.

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CONSERVATION PRICING AND ESTIMATION OF THE ELASTICITY OF DEMAND FOR WATER

The basic notion underlying conservation water pricing is the inverse relationship between price and water use that has been repeatedly demonstrated in empirical studies — i.e., water use declines as water prices rise. An important measure in the water demand relationship is the *price elasticity of demand* (or simply "elasticity"). The price elasticity of demand is measured by the ratio of the percentage change in a households' water use divided by a percentage change in water costs. If this ratio is greater than 1 (the percentage change in use exceeds the percentage change in price), demand is described as "elastic." If the ratio is less than 1 (the percentage change in use is *less* than the percentage change in price), demand is described as inelastic. Whether demand is elastic or inelastic can be of critical importance for water planners regardless of the service population. If demand is elastic, increases in prices will *reduce* system revenues. If demand is price inelastic, increases in prices will not only reduce use, but will result in an *increase* in system revenues.

In general, economists consider demand for a commodity to be relatively unresponsive to price changes (price inelastic) if one or more of the following conditions are met: the commodity in question has few substitutes; expenditure on the commodity in question is a small portion of the consumer's budget; and the time period under analysis is short enough that the consumer cannot make-large adjustments or find alternatives to the commodity in question. Residential water use is typically characterized by all of these conditions.

Results from existing studies on relatively large water supply systems indicate considerable controversy concerning demand elasticity. This controversy centers on issues such as the extent to which consumers have access to easily understandable price-quantity information and whether or not consumers are even aware of what they pay for water, given that water expenditures are usually a small portion of income (for an overview of this issue, see Arbuès *et al.*, 2003).

Our understanding of these issues in the context of small, rural water systems is virtually nil, however. We have reason to think that small, rural communities might be "different" in terms of the dominance of home-owners in small towns who are highly motivated to protect real estate values (see Fischel, 2001). Furthermore, there are arguments suggesting that small size may make local governments more responsive to the public (see Oates, 1972). However, we find little in the literature that addresses whether price-quantity relationships (elasticity) for water will differ between small and large communities. The observation that may be most compelling in terms of expecting a difference in price-response relationships is made by Arbués, *et al* (2003) who note that cross-sectional analyses of consumers in large communities indicate that the socioeconomic characteristics of the different groups analyzed are very relevant and the elasticities estimated are supposed to represent their long-term values. It is reasonable to expect that small communities would be more homogeneous in terms of socioeconomic characteristics relative to large cities, in which case dominant socioeconomic characteristics in small towns may yield different elasticities than those observed in larger, more heterogeneous urban centers.

Economic theory does not provide a definitive basis for believing that household behavior, as it relates to demand elasticity, will differ in small communities relative to large urban areas. Water prices are typically lower in rural communities ($0.0027/gallon in the six communities used in this study, compared with $0.0047/gallon in five of the eight systems for which data are available in the Renwick and Green study), which might lead one to expect water demand to be more inelastic in small communities than in large ones. On the other hand, incomes in small, rural communities are likely to be lower than in large urban areas (average per capita income is $15,298 in our six small communities, $37,066 in the systems included in the Renwick and Green study), which could imply that water costs are relatively higher as a proportion of the household budget, suggesting in turn that demand may be more elastic.

The bottom line, of course, is that we have no compelling evidence one way or another as to how the elasticity of demand for residential water use in small rural communities compares with that observed in larger cities. The purpose of this paper is to take the first steps to fill this void with a case study of six rural communities in the State of Georgia.

METHODS AND RESULTS

Our exploration of household demand for water was initiated during 2003 with a survey of 148 Georgia communities (Cummings *et al*., 2004). Data were obtained for quantities of water used by households during January and July of 2002, average household income in each community, and each community's pricing structure which allowed for the calculation of average and marginal prices paid for water. Results from the double-log demand functions that were estimated suggested elasticity measures for January of -.59 when price was used as the independent variable (R^2 = .43) and -.49 when marginal price was the independent variable (R^2 = .11). For July, elasticity measures were -.65 using price (R^2 = .50) and -.40 using marginal price (R^2 = .11). Note the low R^2 measures when marginal price is the independent variable (and, arguably, the appropriate measure of price to be used for these purposes). High values for t-statistics associated with all relevant variables allowed us to suggest reasonably strong evidence for price-inelastic household demand for water, although the elasticity measures derived seemed quite large in absolute values relative to those seen in the literature where elasticity measures for household water use in large cities were estimated (see Arbuès *et al.*, 2003).

Based on our experiences with this exploratory study, we made an effort during 2004-05 to conduct a more extensive study of the demand for household water use in Georgia's rural communities (Cummings and Walker, 2006). A combined cross-sectional and time series data set was established for seven communities. Following, somewhat, the procedures used in the seminal work by Renwick and Green (2000) for each community, over the period 1990 to 2003, *annual* data were obtained for: household water use; marginal price paid for water; rainfall, and whether or not the community had in place demand-management programs. Based on the panel data, we estimated linear, log-linear and double-log models of the demand for water, using marginal prices along with summer rainfall and demand management policies as covariates.

Our empirical results were quite robust, indicating that, similar to previous studies, the household demand for water in rural communities is relatively price-inelastic. However, as in our earlier study, our point estimates of elasticity are considerably higher than in previous studies focused on water use in larger cities, suggesting that the range of prices (marginal prices) over which demand is inelastic may be much more limited in small, rural, communities than in larger cities. Thus, a utility manager's expectations for revenue effects from an increase in prices should reflect careful consideration of current price levels in the community.

As an aside, we wish to comment briefly on the many problems encountered in efforts to obtain historical price-use data from small communities. Such problems reflect, in the main, the fact that many small public utility systems do not keep records for more than a year or two, and limited administrative budgets that make the maintenance and access to such data extraordinarily difficult. Thus, as will be noted later in this paper, *complete* data sets for our target period 1990-2004 were obtained from very few of our communities. Despite these problems, our results yield surprisingly robust parameter estimates, t-statistics and R^2 values that compare nicely with those obtained in the much more "data rich" study conducted by Renwick and Green (2000).

DISCUSSION

Our results differ somewhat from those previously found in the literature in that we find that our computed price elasticities are rather high. We found that marginal prices of water are approaching levels that will cause demand to become price elastic, rather than inelastic. This result suggests that conservation pricing strategies that raise prices only slightly could have substantial impacts on water use in these areas.

Our results suggest several avenues for useful future research. Among these are three particularly interesting lines of inquiry. First, do rural-metropolitan differences in price responses observed in Georgia communities extend to small, rural communities in other parts of the U.S., especially in the more arid West? Second, we have used "small" and "large" communities very loosely, defining "small" communities arbitrarily as communities with a service population well under 100,000. If results obtained in this study hold up in applications in other parts of the U.S., it will be very useful to develop better understanding as to the service population where behavior systematically switches from less to more elastic responses to price changes.

Third, and finally, we note the dearth of literature that addresses behavioral differences in large and small communities. Indeed, this gap in the state of the art motivated the present work. Persistent findings of differing price-responsive behavior in large vs. small communities should then excite interest in lines of research designed to attempt to *explain* such differences.

We should note that our results can only be viewed as a first step in understanding this issue. In particular, for example, they are limited by the fact that there is no basis for assuming that small communities in one state are characteristic or representative of behavior that might be expected in other regions of the U.S. However, this study demonstrates the need for this type of analysis to ensure effective policy design when implementing conservation pricing across a range of heterogeneous communities.

CONCLUSION

Although a number of studies have estimated the price - quantity relationship for water use, these studies have generally used data from large urban areas. Our empirical results, based on data from water systems in rural Georgia, confirm that the demand for water is relatively price-inelastic. However, our point estimates of elasticity are somewhat higher than in previous studies, suggesting that residential water demand in small, rural communities may be significantly more responsive to price changes relative to that observed in larger cities. These results demonstrate that the effectiveness of conservation pricing might be different in rural and urban areas of Georgia. For conservation pricing, understanding the relationship between price increases and revenues, as reflected in price elasticity, is critical in designing successful policies. In general, these results emphasize the importance of quantifying the impact of water conservation policies such as conservation pricing in order to determine that they will achieve their objectives.

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