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MICHIGAN STATE UNIVERSITY ■ INSTITUTE OF PUBLIC UTILITIES REGULATORY RESEARCH AND EDUCATION

DECLINING WATER SALES AND UTILITY REVENUES: A FRAMEWORK FOR UNDERSTANDING AND ADAPTING

JANUARY 2013 ▪ ipu.msu.edu

Aubuchon, C. P., and Roberson, J. A. (2012). Price perception and nonprice controls under conservation rate structures. *Journal American Water Works Association, 105*(11).

Abstract: "This research evaluates the effect of price and nonprice conservation controls on monthly water system demand and explores differences in rate design, education and outreach programs, population growth, and regional climate variables among a national cross section of utilities. Using the Shin price perception parameter, this study found that under conservation rate structures, aggregate demand was related to something other than marginal or average price. The price–demand response increases with higher levels of consumption for both the marginal price and the total bill, which may provide preliminary evidence that the price signal of the total bill matters for demand. Nonprice controls were not found to be statistically significant in the study sample. Income elasticities were positive and slightly larger in magnitude than price elasticities, suggesting that over the long term, utility managers may need to increase rates faster than regional income growth for effective demand management."

Beecher, J. A. (2010). The conservation conundrum: How declining demand affects water utilities. *Journal American Water Works Association, 102*(2), 78-80. [link]

Abstract: "This article discusses the significant financial challenge that utilities face in the rising infrastructure costs that must be recovered from a shrinking sales base. Fortunately, strategic coping methods are available such as forecasting, scenario-building, and planning. Utility plans should incorporate long-term goals and performance metrics as well as prudent investment strategies based on changing demand patterns. Cost recovery should recognize expenditures for cost-effective investments in efficiency, and regulators can provide additional incentives as appropriate. As long as costs and demand continue to shift, more frequent rate adjustments will help reduce lag and ensure that rates are properly aligned with costs. Forward- looking rates can be established by using a "future test year" for revenues. A demand-repression adjustment may be needed to recognize the effects of programs and prices on forecast use. Utilities will also need to examine rate-design options and assess whether they exacerbate or mitigate revenue volatility, uncertainty, and distributional consequences."

Beecher, J. A. (2012). The ironic economics and equity of water budget rates. *Journal American Water Works Association, 104*(2). [link]

Abstract: "Water budget rates are gaining attention in the water sector. Although clearly well-intended, the water budget approach to rates raises serious theoretical and practical issues familiar to applied regulatory economics. In essence, water budget rates exemplify "social rate-making," that is, a system of pricing that departs from traditional economic standards in the interest of serving social goals—in this case water conservation. The inherent problem with this particular rate structure, however, is not its good intentions but its disconcerting implications. The troubling irony of water budget rates appears to be lost in the deliberation.

Beecher, J. A., and Chestnut, T. W. (2012). Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting. *Alliance for Water Efficiency.*

Abstract: "The scenario is becoming all too familiar. Utility managers see falling water sales and falling revenues. Rates must be raised simply to maintain revenues, but rate increases are also needed to pay for the rising cost of infrastructure replacement and improvement. Higher rates might even induce a price response in the form of further declines in usage (shifts along the demand curve).[1] The effects of economic recession make matters worse, particularly for areas experiencing declines in service population and economic activity (shifts in the entire demand curve). As water price increases outstrip overall inflation, boards of directors and water customers alike are balking at successive and high rate increases. Promoting water conservation in this context seems illogical at best and self-destructive at worst. In a twist of distorted incentives, the water manager may even hope for drought. Infrastructure-intensive public utilities face a serious "conservation conundrum"[2]in that socially beneficial efficiency appears contrary to their financial self-interest, particularly in the short run. The combination of rising costs and falling sales is a potential recipe for revenue shortfalls and fiscal distress. What is a water manager or rate regulator to do?

A Summit on Declining Water Sales and Utility Revenues Summit in Racine, Wisconsin, convened by the Alliance for Water Efficiency, examined how this problem is manifested across the country. This white paper explores its root causes and offers potential utility and policy solutions."

Chesnutt, T. W., Fiske, G., Beecher, J. A., and Pekelney, D. M. (2007). Water Efficiency Programs for Integrated Water Management. *Water Research Foundation.* [link]

Executive Summary: "Water utilities have increasingly come to appreciate the value of water use efficiency (WUE) for accomplishing their long-term mission of providing a safe and reliable potable water supply. The importance of water efficiency goes well beyond the short-term measures invoked to respond to drought emergencies, and is much broader in scope. Improved water-use efficiency is seen as a viable complement to – and in some instances, a substitute for – investments in long-term water supplies and infrastructure. This understanding of water efficiency includes outdoor as well as indoor WUE, nonresidential water customers as well as residential customers, and utility delivery efficiency as well as end use efficiency. At the heart of the new understanding of water efficiency is an economic standard: a good WUE program produces a level of benefits that exceed the costs required to undertake the program."

Coomes, P., Rockaway, T., Rivard, J., and Kornstein, B. (2009). North America Residential Water Usage Trends Since 1992. *Water Research Foundation.* [link]

Conclusion: "This research documents a pervasive trend toward lower water usage per household. The magnitude of the decline is consistent across North American utilities and is confirmed by more detailed data provided by the study's 11 partner utilities, although there were annual variations due to regional factors. The results of the study' statistical models identify the magnitude of both positive and negative forces affecting water usage. The decline in number of residents per household is clearly an important factor in falling water consumption per residential customer. However, the negative consequences of smaller households appears to be more than offset by the positive consequences of higher household incomes. Higher incomes have led to larger homes, with more water-using appliances, and more landscape irrigation. Thus, the net decline in water usage per household appears to be due to the steady penetration of low-flow appliances over the past 20 years. The end-use study found that low-flow appliances and changing household demographics accounted for a 16 percent reduction in average household water use in 2007, as compared to 1990… The steady decline in usage per household has important financial-planning consequences for water utility companies, as infrastructure is spread over more housing units using less water than before. The data compiled in this research are intended to assist utilities in developing realistic

management plans that take into account the primary causes of declining residential water usage. The data provide a tool for projecting residential water usage in light of utility-specific trends. Utilities serving communities with growth in single-occupant households are likely to see erosion in revenues per household. Additionally, new federal regulations governing water-conserving appliances and fixtures further indicate that residential water usage will continue to decline as newer homes make up a larger component of the housing stock. Utilities may find it useful to track persons per household in addition to number of households as they plan infrastructure and set rates… Although the rate of decline may slow, there is no indication that national household-size trends will reverse. Also, new and existing federal regulations will prompt further penetration of water-conserving appliances.

Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F., and Nijkamp, P. (2003). Price and Income Elasticities of Residential Water Demand: A Meta-Analysis. *Land Economics, 79*(2), 292-308. [link]

Abstract: "This article presents a meta-analysis of variations in price and income elasticities of residential water demand. Meta-analysis constitutes an adequate tool to synthesize research results by means of an analysis of the variation in empirical estimates reported in the literature. We link the variation in estimated elasticities to differences in theoretical microeconomic choice approaches, differences in spatial and temporal dynamics, as well as differences in research design of the underlying studies. The occurrence of increasing or decreasing block rate systems turns out to be important. With respect to price elasticities, the use of the discrete-continuous choice approach is relevant in explaining observed differences."

Danielson, L. E. (1979). An Analysis of Residential Demand for Water Using Micro Time-Series Data. *Water Resources Research, 15*(4), 763-767. [Link]

Abstract: "Residential water demand is estimated as a function of temperature, rainfall, house value, water price, and household size using monthly cross-section and time-series meter readings from 261 residential households in Raleigh, North Carolina, between May 1969 and December 1974. Tests for validity of assumptions are made, and a methodological approach is used that provides unbiased estimates of parameters and standard errors with data that exhibit serially correlated residuals. Demand relations are estimated for total residential, winter, and sprinkling demands. Sprinkling use per period per customer for each year is estimated by subtracting winter (November–April) from summer (May–October) use. Household size explained the largest proportion of the variation in the data. Estimated sprinkling demand was found to be highly responsive to changes in water price and the level of the climatic variables, while total residential demand and winter demand were less responsive to price changes."

Fenrick, Steven A., and Getachew, L. (2012). Estimation of the Effects of Price and Billing Frequency on Household Water Demand Using a Panel of Wisconsin Municipalities. *Applied Economics Letters, 19*(14), 1373-1380. [link]

Abstract: "A demand function of residential water consumption is developed from a 1997 to 2006 panel of 200 Wisconsin water utilities. A double-log functional form is assumed and parameters are estimated using a random effects model. The results suggest that the price is inelastic yet negative and statistically significant and this elasticity response grows stronger as the marginal price level is increased. Additionally, the model reveals water savings due to monthly billing and also the annual water savings from technology adoption."

Grafton, R. Q., Ward, M. B., To, H., and Kompas, T. (2011). Determinants Of Residential Water Consumption: Evidence and Analysis from a 10-Country Household Survey. *Water Resources Research, 47*. [link]

Abstract: "Household survey data for 10 countries are used to quantify and test the importance of price and nonprice factors on residential water demand and investigate complementarities between household water-saving behaviors and the average volumetric price of water. Results show (1) the average volumetric price of water is an important predictor of differences in residential consumption in models that include household characteristics, water-saving devices, attitudinal characteristics and environmental concerns as explanatory variables; (2) of all water-saving devices, only a low volume/dual-flush toilet has a statistically significant and negative effect on water consumption; and(3) environmental concerns have a statistically significant effect on some self-reported water-saving behaviors. While price-based approaches are espoused to promote economic efficiency, our findings stress that volumetric water pricing is also one of the most effective policy levers available to regulate household water consumption."

- House-Peters, L. A., and Chang, H. (2011). Urban Water Demand Modeling: Review of Concepts, Methods, And Organizing Principles. *Water Resources Research, 47*(5). [link]

  Abstract: "In this paper, we use a theoretical framework of coupled human and natural systems to review the methodological advances in urban water demand modeling over the past 3 decades. The goal of this review is to quantify the capacity of increasingly complex modeling techniques to account for complex human and natural processes, uncertainty, and resilience across spatial and temporal scales. This review begins with coupled human and natural systems theory and situates urban water demand within this framework. The second section reviews urban water demand literature and summarizes methodological advances in relation to four central themes: (1) interactions within and across multiple spatial and temporal scales, (2) acknowledgment and quantification of uncertainty, (3) identification of thresholds, nonlinear system response, and the consequences for resilience, and Alliance for Water Efficiency 20 (4) the transition from simple statistical modeling to fully integrated dynamic modeling. This review will show that increasingly effective models have resulted from technological advances in spatial science and innovations in statistical methods. These models provide unbiased, accurate estimates of the determinants of urban water demand at increasingly fine spatial and temporal resolution. Dynamic models capable of incorporating alternative future scenarios and local stochastic analysis are leading a trend away from deterministic prediction."

- Hunter, M., Donmoyer, K., Chelius, J., and Naumick, G. (2011). Declining Water Use Presents Challenges, Opportunities. *American Water Works Association Opflow.* [link]

  Abstract: "For many North American utilities, residential water use has declined steadily for the last 20 years. In many locations, the trend has accelerated in the last decade. Several factors appear to contribute to declining household water use. The long-term trend could significantly affect the way utilities conduct their business and operations."

- Krause, K., Chermak, J. M., and Brookshire, D. S. (2003). The Demand for Water: Consumer Response to Scarcity. *Journal of Regulatory Economics, 23*(2), 167-91. [link]

  Abstract: "Provision of water raises several issues for municipal utility companies and other suppliers, including reliability of supply in and regions or during droughts, equity issues that arise because water is literally a necessity, and heterogeneity in consumer response to regulatory policy. We combine experimental and survey responses to investigate demand for water. The experiments simulate water consumption from a potentially exhaustible source, revealing heterogeneous demand for water. We estimate econometrically water demand for different consumer groups. A regulator could use estimates of disaggregated demand to attain conservation goals by designing an incentive compatible pricing system. The example given achieves a conservation goal while minimizing enforcement costs and welfare loss."

Mayer, P., DeOreo, W., Chesnutt, T., Pekelney, D., and Summers, L. (2008). Water Budgets and Rate Structures: Innovative Management Tools. *Journal American Water Works Association, 100*(5).

Abstract: "Water budgets, volumetric allotments of water to customers based on customer-specific characteristics and conservative resource standards, are an innovative means of improving water-use efficiency. Once thought to be impractical because of technological constraints, water budgets linked with an increasing-block rate structure have been implemented successfully by more than 20 utilities. Key issues identified in this examination of water budgets and their potential value to North American water utilities include: different practical approaches to water budget rate structures; the benefits and challenges of these approaches; the potential uses of water budgets during drought; and, important steps in the water budget implementation process."

Mehan III, G. T., and Kline, I. (2012). Pricing as a Demand-Side Management Tool: Implications for Water Policy and Governance. *Journal American Water Works Association, 104*(2). [link]

Abstract: "Full-value or -cost pricing and conservation pricing as demand-side management tools are examined along with the benefits of maintaining responsive and transparent government and the benefits realized as a result of such practices."

Merrett, S. (2004). The Demand for Water: Four Interpretations. *Water International, 29*(1), 27-29.

Abstract: "The management of water resources draws on a wide range of disciplines and one of the most frequent terms used among these disciplines is the "demand" for water. In fact, this single word can have at least four quite distinct meanings: the use of water, the consumption of water, the need for water, or the economic demand for water. Each of these four separate terms is carefully defined in the paper in the context of the hydrosocial balance of a region. The paper recommends precisely defining these four terms (use, consumption, need, economic demand) is necessary to avoid the ambiguities and confusion in water resources management that can arise from the catch-all term "demand." It is also indicated that to regard supply-side activities to reduce leakage and evaporation as a form of demand management is mistaken."

Mieno, T., and Braden, J. B. (2011). Residential Demand for Water in the Chicago Metropolitan Area. *Journal of the American Water Resources Association, 47*(4), 713-23. [link]

Abstract: "This paper provides the first contemporary analysis of residential water demand in humid Northeastern Illinois, in the vicinity of Chicago, and explores seasonal and income-based differentials in the responsiveness of water use to water prices. Using a panel of system-level data for eight watersystems and controlling for seasons, weather, incomes, and community characteristics, the analysis yields low estimates of price elasticity of demand for water in line with other studies. Furthermore, price response is greater in summer and less in higher income communities. We suggest that use of seasonal pricing can help mitigate equity issues arising from differential income elasticities while taking advantage of the greater price responsiveness of summertime water use."

Olmstead, S. M., and Stavins, R. N. (2007). Managing Water Demand: Price vs. NonPrice Conservation Programs. *Pioneer Institute.* [link]

Excerpt from conclusion: "Water management in the United States has typically been approached as an engineering problem, not an economic one. Water supply managers are often reluctant to use price increases as water conservation tools, instead relying on non-price demand management techniques. These include requirements for the adoption of specific technologies (such as lowflow fixtures) and restrictions on particular uses (such as lawn watering)… This paper has offered an analysis of the relative merits of price and non-price approaches to water conservation. On average, in the United States, a ten percent increase in the marginal price of water can be expected to diminish demand in the urban residential sector by about 3 to 4 percent. For the purpose of comparison, this average of hundreds of published water demand studies since 1960 is similar to averages reported for residential electricity and gasoline demand… Estimates of the water savings attributable to non-price demand management policies such as watering restrictions and low-flow fixture subsidies vary from zero to significant savings. These programs vary tremendously in nature and scope. More stringent mandatory policies (when well-enforced) tend to have stronger effects than voluntary policies and education programs."

- Rockaway, T. D., Coomes, P. A., Rivard, J., and Kornstein, B. (2011). Residential Water Use Trends in North America. *Journal American Water Works Association, 103*(2), 76-89. [link]

  Conclusion: "This research investigated trends in household water use in North America. When controlling for weather and other variables, the evident decline in residential use was pervasive among the national and regional components of the study. A household in the 2008 billing year used 11,678 gallons less water annually than an identical household did in 1978… To investigate the causes of this decline, a local study of statistically representative households of the LWC was conducted in Alliance for Water Efficiency 22 Louisville. Adjusting for weather, water use per LWC customer fell from 208 to 187 gpd between 1990 and 2007, a decline of 21 gallons. Data-logging devices were installed at participating homes, and the data were incorporated into statistical models to examine possible causes and the relationships among socioeconomic factors, demographic factors, water-using appliances, behavior patterns, significant water features and types of irrigation, and residential water consumption. Demographic factors can account for a decline of 5 gallons, whereas income-related factors suggest an increase of about 5.4 gallons. This study attributes the remaining estimated net decline, about 19 gpd, to the increased installation of low-flow appliances in the Louisville market."

- Standard & Poor's (2012). From Droughts to Conservation: Water Can Have Big Effects on U.S. Municipal Utility Credit Quality. *Standard & Poor's.* [link]

  Overview: "Intense competition for potable water means that while water in most of the U.S. is not yet priced like a commodity, it could be, and sooner than many might think. Although conservation efforts affect utility financial risk profiles, they can be beneficial. Making the most of increasingly scarce federal funds for infrastructure renewal and prudent risk management, including raising rates as needed, will be vital for utilities to maintain credit quality."