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Technical Briefing Paper (8): Water Demand Impacts and Utility Responses

Synopsis Future urban water demand will be affected by climate change, but other variables, encompassing changes in land use, technology, household structure and social determinants of demand will play major roles too. Utilities can influence water use through pricing design and demand management programs, but the responsiveness of demand to such incentives will likely diminish as average per capita demand declines with the elimination of non-essential types of water use.

Explanation Household-level water demand varies considerably across different urban settings, with climate, property size, demographic variables and pricing structure all playing major roles in influencing use patterns. In addition, within any given city there are large seasonal differences in water use, driven largely by outdoor irrigation during the summer months. As cities plan for adaptation to climate change, they need to consider how water demand may change in the future in response to underlying trends in non-climate variables, as well as the direct effects of climate on water use patterns. They also will need to be able to reliably estimate the impacts of water pricing and other demand management policies.

Estimating water demand reliably is difficult, even in the near term due to: 1) the inherent non-linearity of water demand functions; 2) complex pricing structures (e.g., a mix of fixed and per-unit price components, discontinuities arising from block-rate pricing, and cases in which per-unit metering is lacking); 3) incomplete data on the social factors that drive changes in per capita water consumption; and 4) an imperfect understanding of the effects of climate and weather on demand. However, there is a growing literature on water demand estimation aimed at addressing these issues.

To estimate future water demand functions it will be important to distinguish between the short run and long run effects of changes in the determinants of demand. With regard to the effects of climate, caution must be exercised in extrapolating from observed responses to recent droughts or other climatic extremes. A well established proposition in price theory is that the price elasticity of demand tends to increase as a market moves from short-run to long-run adjustments to a price change. This could be exemplified in the context of urban water demand by consumers gradually reacting to a price increase through a sequence of purchases of water saving appliances and landscaping changes. Changes in climatic variables would likely lead to similar lagged responses – for example, with a long-term change to drier conditions leading to larger (and different) changes in household water demand than a short-term drought.

In addition, water industry professionals frequently express concerns about “demand-hardening,” a phenomenon whereby investments in water conservation eliminate the slack in the market, thus reducing flexibility for demand-side management during future drought emergencies. One way to view this phenomenon is simply as a reflection of the inherent non-linearity of water demand. In other words, water uses that are viewed as essential are much less responsive to price increases (or other equivalent incentives) than are uses that are considered to be discretionary. Thus, when conservation programs reduce discretionary demand, further water use reductions would be increasingly painful, and would require larger incentives to obtain.

Application A number of demand assessments have attempted to isolate the influence of climate variables on urban water demand. The results indicate significant differences in climate sensitivity across different seasons and customer classes, with summer residential demand being the most sensitive to variations in temperature and precipitation. For example, a study of water use in Albuquerque, New Mexico, found that while population growth was the major determinant of long-term trends in residential water use, summer precipitation and maximum daily temperatures accounted for inter-annual variations in per-capita water use, with precipitation emerging as the most significant

predictor. Furthermore, the study found that a water conservation program, encompassing educational efforts, direct incentives and price increases, led to a significant reduction in average residential water consumption, but the sensitivity of water use to the climate variables actually increased.

Other single-city studies have confirmed the sensitivity of residential water demand to weather variations, with the unsurprising result that use increases with temperature and diminishes with precipitation. Cross-city comparisons present challenges for teasing out the effects of climate due to many differences in pricing structure, other incentive programs, and household characteristics. However, when controlling for those factors, there is evidence that water demand increases as a function of daily maximum temperature and moisture deficit.

Case Study Residential water demand management in Aurora, Colorado

Aurora is a rapidly expanding suburban community located near Denver, Colorado. The city's water utility faces limited water availability, especially during drought years, and it must provide service to a growing population. During the drought of 2002, which was one of the worst on record, the utility implemented a suite of demand management measures in order to avoid severe shortages. These measures included restrictions on outdoor water use, incentive programs, and a sequence of changes in billing structures and rates, which led ultimately to the adoption of an increasing block rate (IRB) pricing structure in which the block widths are individually tailored according to the water consumption habits of each household. This aggressive demand management program proved to be effective, but a full analysis of the determinants of demand was needed in order to understand which elements of the program were most important in inducing conservation.

A study was carried out to evaluate the effects of two categories of variables: those within the utility's control (such as prices and watering restrictions), and those outside of the utility's control (such as weather, and seasonal effects). The study found considerable heterogeneity across households in average water use, and in the sensitivity of water use to price structure and other demand management tools, especially during the outdoor irrigation season. Outdoor irrigation is a major component of water demand in Aurora, with water use increasing by 30 percent during the irrigation season regardless of temperature or precipitation. The weather variables have further significant effects on water use. The study found that when pricing is used in the absence of watering restrictions, high water-use households are much more responsive to price increases than are households in the low use category. Similarly, they are more responsive to watering restrictions, when they are used alone. However, when restrictions and price increases are used simultaneously, each tool mutes the impact of the other. It was concluded that policies do not have additive effects and that policy outcomes vary considerably among users, with ramifications for equity and revenue generation.

Supporting materials and links

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