This presentation premiered at WaterSmart Innovations

watersmartinnovations.com

Basic Questions to be Addressed

- **What impact does the price of water have on the amount of water used?**

- **What effects do various pricing structures have on the reaction of water users to changes in the price of water?**

- **Through this link the impact of pricing structures on water use can be evaluated using individual water use and price data.**

Impact of the Price of Water on Use

- **The impact of the price of water on use can be evaluated using price elasticity of demand from estimated demand curves**
  - **The price elasticity of demand is a measure of the change in the quantity demanded resulting from a change in price.**
  - **The price elasticity of demand in previous studies have consistently been inelastic, meaning that the percentage change in quantity of water used is less than the percentage increase in price.**

RECLAMATION

What effects do various pricing structures have on the reaction of water users to the price of water?

- **The effect of different water structures can be evaluated using the price elasticity results in a second phase analysis.**

- **The second phase analysis evaluates the effect of price structures on estimated elasticities. This is called meta-analysis.**

- **Water bill format characteristics can also be included in the meta-analysis to explain variation in elasticity.**

Modeling Water Demand - Data

- **10 Years of data were obtained from 11 suppliers**
  - **Contra Costa Water District**
  - **Eastern Municipal Water District**
  - **Irvine Ranch Water District**
  - **Los Angeles Department of Water and Power**
  - **City of Henderson**
  - **Otay Water District**
  - **East Bay Municipal Utility District**
  - **Las Vegas Water District**
  - **Western Municipal Water District**
  - **Carlsbad Municipal Water District**
  - **San Juan Capistrano**

Modeling Water Demand - Data

- **Over 600,000 total observations for single family residences**
- **Over 150 zip codes represented**
- **Monthly use per connection**
- **Customer water rates per unit of use by tier**
- **Other charges and fees applied to bill**
- **Days included in billing period**
- **Service location/Zip Code**

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Modeling Water Demand

- **Important water demand variables include:**
  - **Price of water – Used to estimate elasticity**
  - **Household income**
  - **Household size**
  - **Lot size**
  - **Size of home and other characteristics of home**
  - **Climatic variables: precipitation, temperature, ET**
  - **Seasonality**
  - **Education level**
  - **Unemployment**
  - **Age**

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Modeling Water Demand

- **Specific variables used in the models**
  - Water use – Use per household in gallons per day
  - Lagged Price of water – Average real price per gallon used from previous billing period
  - Real median household income
  - Household size
  - Average monthly precipitation and temperature
  - Annual unemployment rate
  - Educational attainment, % with B.S. or higher

Modeling Water Demand

- **Specific variables used in the models (continued)**
  - Lot size or landscape acreage when available
  - Proxy for lot size, percentage of homes that are detached
  - Seasonality variable – Seasonal sinusoids were used in final models.

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Some potential issues in estimating water demand curves and elasticities

- **Increasing block rates**
  - Consumer can influence price through their consumption decision. So, price and quantity can be determined simultaneously.

- **What is the relevant price that consumers react to?**
  - Economic theory says marginal price is the relevant price that influences consumer behavior.
  - However, in the case of municipal and industrial water supplies households may not be well informed about the marginal price and may react to average price or total water bill.

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Additional considerations in estimating water demand curves and elasticities

- **Effect of the Recession on water use**
  - Concern that effects from the recession could attribute some change in water use over the 2000 to 2010 period to changes in the price of water
  - Attempt to account for recession by dividing data sets into pre-recession (2000 to 2007) and recession (2008 to 2010) time periods.
  - Importance of the appearance of the water bill on use – What information is reflected and how does it influence behavior?

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Summary of modeling results

- **Modeling results are presented in the following two slides to show the range of results in terms of elasticities and significance of variables without identifying individual agencies.**

- **Many different iterations were run with combinations of variables. It should be noted that the individual elasticity estimates were very stable and consistent.**

- **Income, lot size, also precipitation variables were also consistent.**

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Summary of modeling results

Elasticity estimate	Adjusted R^2 - Measure of explained variance	Precipitation (coefficient sign)	Household size (sign)	Income (sign)
-0.265	.37	(-)	(+)	(+)
-0.433	.35	Not sig	(+)	(+)
-0.839	.39	(-)	(+)	(+)
-0.821	.39	(-)	Not sig	(+)
-0.670	.32	(-)	Not sig	(+)
-0.846	.33	(-)	(+)	(+)
-0.634	.29	(-)	Not sig	(+)
-0.753	.41	(-)	(+)	(+)
-0.229	.28	(-)	(+)	(+)
-0.554	.20	(-)	(+)	(+)
-0.855	.36	(-)	(+)	Not sig

Summary of modeling results

Lot size data available (sign)	Proxy used in place of lot size (sign)	Unemployment (sign)
Yes (+)	NA	(-)
Yes(+)	NA	NA
No	% detached (+)	(-)
Yes(+)	NA	NA
No	% detached (Not sig)	NA
No	% detached (Not sig)	NA
Yes(+)	NA	NA
Yes(+)	NA	(-)
Yes(+)	NA	(-)
Yes(+)	NA	NA
No	% detached (+)	NA

Summary of modeling results

- **All of the price elasticities of demand are inelastic (absolute value of coefficient is less than one).**

- **There is considerable variation in price elasticity of demand.**

- **Results were very good in terms of expected signs and significance.**

- **A large portion of variation in quantity of water demanded is not explained by the model (As reflected by R^2). However, equations are statistically significant.**

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Additional Results

- **Separate models were run for each agency, pre-recession (2000 to 2007) and recession (2008 to 2010) time periods.**

- **Models were compared using a Chow test, can be used to test if coefficients in two different regressions are statistically different. This can be used to test for structural differences between two time periods**

Additional Results - Continued

- **Effect of recession on elasticities**
    - **Very mixed results depending on agency.**
    - **Inconsistent effect of recession on elasticity.**
    - **In most cases (but not all) there was a significant difference between pre-recession and recession based data models.**
    - **Possible reasons for inconsistent results**
        - **Recession coincided with other events such as drought, changes in rate structure, other.**
        - **Water is a relatively small portion, so factors other than recession have a greater influence.**

Additional Results - Continued

- **Importance of the appearance of the water bill on use – What information is reflected and how does it influence behavior?**
  - Two small groups were provided example water bills to evaluate clarity of information on:
    - Use
    - Price paid
    - Current use relative to historical use
    - Pricing structure
  - The results were used to provide additional justification for use of average price, lagged water bill, meta-analysis variables.

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Additional Results - Continued

Some results of "focus group" and comments that were made:

- Only 1 person could answer the marginal cost question for all bills (A maximum of five minutes was allowed on each bill, most took much less)
- All but two could answer average cost.
- The tier information was "interesting," but the total bill was consistently the main focus.
- Having sewer on the bill confused two on total cost.

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Summary of modeling results: Meta-Analysis

- **Meta-analysis is a method for quantitatively combining the results of different analyses to find patterns or consistencies that can be generally applied to various situations.**

- **The estimated elasticities from the modeling results shown previously are combined with data representing variables that characterize the various water agencies to evaluate factors that may influence elasticity.**

Summary of modeling results: Meta-Analysis

- **Model estimation:**

  Elasticity = f(variables that influence responsiveness to price changes)

- **Variables considered to include in the Meta-analysis:**
  - Average cost of water per gallon
  - Average water bill
  - Median household income
  - Number of price tiers and "width" of price tiers
  - Service population
  - Bill characteristics – From small group evaluation
  - Region

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Summary of modeling results: Meta-Analysis

E_d = f(avg bill, service pop, conservation bill, southern area, #tiers, multi bill)

– Average bill, significant +.011645

– Service population (1,000's) coefficient of -.000101 and significant

– Conservation bill type, significant +.061175

– # of tiers, highly correlated with average bill (not significant)

– Multiple charges on bill (e.g. sewer included), not significant

– Adjusted R^2 = .55

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Summary of modeling results: Meta-Analysis

- **Some water agencies had changes in pricing structure during period of analysis. These agencies were characterized for longest period of time during analysis.**
- **The total water bill appears to have the greatest impact on elasticity.**
- **Number of tiers affects elasticity through the impact on water bill.**
- **Southern areas have lower elasticity**
- **Greater service population has lower elasticity**

Summary

- **Estimated models for the 11 water suppliers evaluated in the analysis indicate the price elasticity of demand is inelastic, but there is considerable variation.**

- **Estimated elasticities ranged from -0.23 to -0.85.**

- **The relevant price was lagged average price (real prices were used).**

- **The primary effect of tiers appears to be the impact on total water bill.**