Water Demand Elasticities: Selection Effects in Meta-Analysis

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Contribution

A meta-analysis of reported water demand elasticities shows that publication selection bias results in water demand estimates that overstate price elasticities.

The analysis uses panel data estimators to measure and adjust for publication bias. A random effects estimator is used to derive water demand elasticity estimates that are efficient and unbiased by selection effects. The sample mean elasticity for reported elasticities is -.37%. Once publication bias is removed, the mean elasticity estimate drops to -.08%. Indoor water demand is almost perfectly inelastic.

Water demands and their elasticities are heterogeneous in specific uses and locations. Water demand elasticities vary by location, water use type, econometric approach and publication bias.

Water use elasticities range up -1.48% for domestic irrigation demand in the southwestern US. Estimated elasticities are also higher when derived with discrete choice data and estimators.

Problem

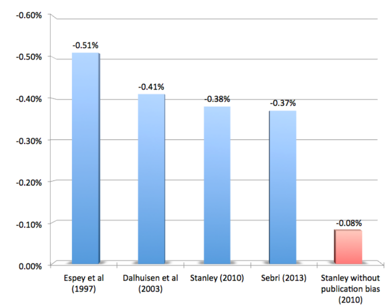
Hundreds of water demand elasticities are reported in the literature [Sebri, 2013]. Espey et al (1997) estimated a mean water demand elasticity of -.51 from a sample of 124 elasticities. Dalhuisen et al (2003) obtained a mean elasticity of -.41 after adding 172 observations to the Espey et al. Sebri (2013) obtained a mean elasticity of -.37 from a sample of 638 elasticities.

Water demand elasticity data pose special difficulties for obtaining good summary estimates. First, Stanley (2010) shows that the reported elasticities are subject to publication bias, leading to data that overstate average price responsiveness.

Stanley analyses a sample of 110 elasticities and finds that removing publication bias effects reduces the sample mean elasticity from -.38 to only -.08, an 80% reduction in price responsiveness—mean demand is almost perfectly inelastic.

Second, meta-analysis data have a panel structure since two or more—sometimes many more than two--elasticities are usually reported from a single original study. The panel data structure means that ordinary least squares estimates usually used in meta-analysis may be inefficient or even inconsistent depending on the panel error structure.

Water Demand Elasticities, Previous Research



Theory

Meta-analysis is based on sampling theory. Elasticity from original studies are random variables. Each is an estimate of an underlying true parameter. Sample means are unbiased estimate when sampling error is symmetric about the true mean.

Publication bias occurs when the sample of reported estimates is truncated so the sampling error is not symmetric. Truncation may occur due to well-accepted conventions.

Elasticity estimates may go unreported when they are not statistically different from zero. If so, mean and standard deviation estimates are likely to be correlated, rather than independent—to be statistically different from zero, small elasticity estimates require small standard error estimates.

Demand theory virtually requires elasticity estimates to be negative. Unfortunately, sampling theory suggests that a fraction of study estimates are correctly positive even when the true parameter is negative. Positive demand elasticity estimates are likely to end up filed away or rejected in the peer review process.

Funnel plots help detect the effects of publication bias. Funnel plots are scatter plots of an elasticity estimate and its precision as measured by the inverse standard error. Evidence of bias is absent when the plotted distribution is symmetric and there's no correlation between the estimate and its precision.

Data

Elasticity and covariate data were developed from the Dalhuisen et al (2003) data set. The original studies were reviewed to obtain additional estimates and covariates, especially a more complete set of elasticities paired with their standard errors. The final data set contained 238 observation from 51 studies.

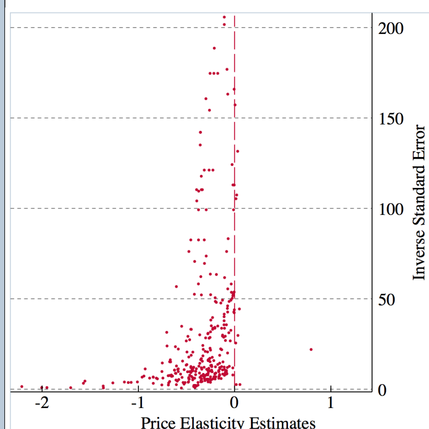
Evidence of Publication Bias

The funnel plot below shows strong evidence of publication bias. First, there is strong correlation between the absolute value of the elasticities and their precision. Precision increases markedly as elasticities. This implies that publication process tend to filter out elasticities that are not statistically different from zero.

Second, the funnel plot is asymmetric. Negative elasticities are more densely represented as they approach zero, but the density of observation drops off sharply for positive elasticities. Demand theory apparently exerts a strong effect on publication—reports of positive elasticity estimates are much more rare than implied by random sampling.

Hypothesis: publication bias results in an illusory degree of mean price responsiveness in water demand.

Funnel Plot

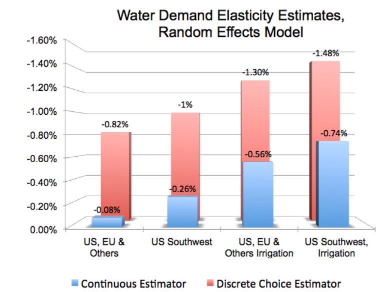


Econometric Analysis

Elasticities and covariates were analyzed using a multiple regression model developed by Doucouligos et al (2013). The model evaluates variation in the estimated elasticities as a function of their standard errors and independent variables. Independent variables used in this analysis are dummy variables for: short-run, outdoor irrigation, winter season, southwestern US location and discrete choice estimation method.

Fixed and random effects estimators were used. Hausman tests favored the the random effects estimate. All coefficients except those for season and length of run were statistically different from zero at the 5% level.

The mean baseline elasticity estimate was -.08% in the absence of publication bias--indoor water demand outside of the US southwest is essentially perfectly inelastic. However, water demand elasticities are as high as -1.48% for domestic irrigation in the US southwest when derived from a discrete choice estimator.



Conclusions

Reported water demand elasticities overstate water demand elasticities due to publication bias. Mean residential water demand is actually almost perfectly inelastic. The inelasticity of water demand means *large price increases are required to encourage water conservation.*

Water demand in domestic irrigation and in arid regions is much more elastic. Water demand heterogeneity means that *non-price rationing results in large and unnecessary welfare losses.*

Future research is needed understand why continuous and discrete estimators result in such different estimates.