PRICE ELASTICITY OF RESIDENTIAL ELECTRICITY DEMAND: EVIDENCE FROM SOUTH AFRICA

Yuxiang Ye
University of the Witwatersrand
yuxiang.ye@wits.ac.za

Overview

Understanding responsiveness of residential electricity demand to price changes is of great importance to utilities and regulators in policy decision-making process for the purposes of affordability and/or energy conservations. Previous studies in estimating demand elasticities mostly use time-series or aggregated data, while few focuses on micro-level household survey data, due to lack of electricity price information, especially in developing countries. This study uses household survey data and regulator approved tariff data from a developing country to estimate residential price response and further investigate the heterogeneous effects across different groups. A log-log functional form regression and an instrument variables approach are employed for the estimation. This study contributes to the literature in several ways: 1) use publicly available household survey data merged with regulated tariffs to estimate price elasticity in a developing country context; 2) adopt an instrument variables estimation to address endogenous average price; 3) examine heterogeneity in price response of different household groups; 4) offer insightful policy implications.

Methods

We focus on a log-log function form as it is prevalent in prior studies (e.g. Miller and Alberini, 2016; Ye et al., 2018; Boogen et al., 2021). Some benefits of using a log-log specification include directly deriving elasticities and reducing the potential influence of outliers. When estimating price elasticity of residential electricity demand, one needs to figure out which price households respond to, marginal price or average price. Standard economic theory assumes customers respond to marginal price to maximise their utility. However, literature suggests that consumers respond to average price because it is easy to calculate from electricity bills. Recent evidence (e.g. Ito, 2014) also suggests customers respond to average prices rather than marginal prices when making electricity consumption decisions. For this reason, we use average price of electricity in estimating price elasticities.

Estimating electricity demand may suffer endogeneity issues which arise from the simultaneous determination of price and electricity consumption. For instance, for a given household facing increasing block tariff, the more electricity the household consumes, the marginal electricity price will be higher, and the average price will also change as the increase of electricity usage. To address the endogeneity of average price in our study, an instrument variable approach is considered. More specifically, we use average neighbour price as the instrument for the average electricity price faced by the households (e.g. Miller and Alberini, 2016; Boogen et al., 2021). The average neighbor price for a household is the average electricity price of all the households but the household itself located in the same municipality. For a given household, the average neighbor price is exogenous to its electricity consumption, however, representative of the average electricity price in the municipality. Therefore, the constructed instrument satisfies both the relevance and exclusion criteria. In other words, the instrument is corelated with the average price a household facing, but only affects the household's electricity consumption through its effect on the average price.

Data

The data used for this study source from South Africa Living Conditions Survey (LCS) 2014/2015, the most recently available national representative survey. We use LCS 2014/2015 data set because it contains rich information related to household energy demand, including household electricity consumption expenditure, payment type (prepaid or postpaid meter), receipt of free basic electricity (a policy to support the basic energy needs of poor households), as well as household socio-economic characteristics, asset stocks and dwelling characteristics. After tidying the data, 17104 observations remain for our empirical analysis.

The LCS 2014/2015 data set does not contain electricity price data. For the purpose of our research, we collect regulator approved municipality-level tariff and merge with each household in the LCS 2014/2015 by their tariff

types. The average price for each household is calculated as the total electricity consumption expenditure (net of fixed charges) divided by the quantity of electricity consumption.

Results

The results show that short-run price elasticity is -0.84, which is higher than previous studies in magnitude (-0.305). Controlling for household characteristics, season, housing characteristic and receipt of free basic electricity has small effects on the price elasticity. It is noting that income elasticity (0.25) has decreased by 40% after controlling for appliance assets, indicating that higher income households are more likely to have more appliances which will increase electricity consumption. By spitting the observations by median of electricity monthly usage, we find that lower electricity usage group is more responsive to price change than higher usage households, with price elasticity as -0.67 and -0.51 respectively. This heterogeneity in price responses with respect to electricity consumption is consistent with some of the literature.

Conclusions

We estimated price elasticity of residential electricity demand using household survey data and regulator approved tariff data from South Africa. The merged data set provided a unique opportunity to examine responsiveness of residential electricity demand to price change. We employed a standard log-log functional form for the estimation and an instrument variable estimation to explore the extent of endogeneity bias. The results suggest that our estimated price elasticity is higher than previous studies using older data. Further, we investigated the heterogeneity in price response of residential electricity demand. We also found that addressing the endogeneity of average price with instrument variables has noticeable effect on the price elasticities. Our results have important policy implications for the utilities and regulators.

References

Boogen, N., Datta, S., Filippini, M., 2021. Estimating residential electricity demand: New empirical evidence. Energy Policy 158, 112561. doi: 10.1016/j.enpol.2021.112561.

Ito, K., 2014. Do consumers respond to marginal or average price? Evidence from nonlinear electricity pricing. American Economic Review 104, 537–563. doi:10.1257/aer.104.2.537.

Miller, M., Alberini, A., 2016. Sensitivity of price elasticity of demand to aggregation, unobserved heterogeneity, price trends, and price endogeneity: Evidence from U.S. data. Energy Policy 97, 235–249. doi: 10.1016/j.enpol.2016.07.031.

Ye, Y., Koch, S.F., Zhang, J., 2018. Determinants of household electricity consumption in South Africa. Energy Economics 75, 120–133. doi: 10.1016/j.eneco.2018.08.005.