AN EXPERIMENT OF OWN-PRICE ELASTICITY ESTIMATION: NON-RESIDENTIAL DEMANDS FOR ELECTRICITY AND NATURAL GAS IN THE UNITED STATES

Kang-Hua Cao, Hong Kong Baptist University
Steffan Qi, Shenzhen University
Raymond Li, University of Canberra
Chi-Keung Woo, Education University of Hong Kong
Asher Tishler, Tel Aviv University
Jay Zarnikau, University of Texas at Austin

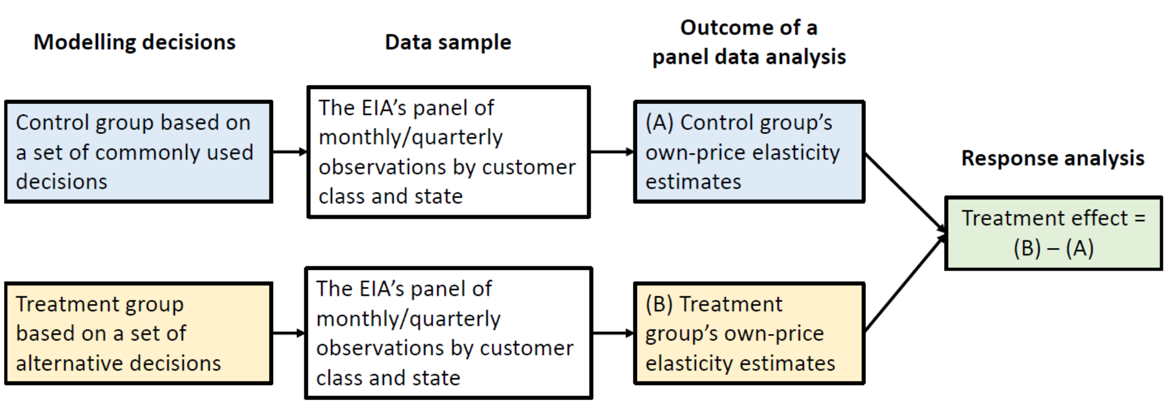
Overview

Accurate price elasticity estimates of energy demands are necessary for applications such as policy modelling, resource planning, supply procurement, demand management and energy pricing. However, elasticity estimates found by extant studies of the US commercial and industrial demands for electricity and natural gas are highly diverse, complicating the development of reasonable elasticity assumptions for these applications.

This paper presents an experiment of own-price elasticity estimation to answer the substantive question of what modelling decisions significantly move the elasticity estimates of non-residential demands for electricity and natural gas in the US. Using ~350,000 panel data analyses of the US Energy Information Administration's 10,944 monthly observations by state for 2001-2019, the experiment documents that non-residential elasticity estimates are most affected by decisions on parametric specification, estimation method, and treatment of cross-section dependence.

Methods

Shown in the figure below, a control group is based on a set of plausible modelling decisions that shape a panel analysis of the EIA data. An electricity example of such decisions comprises (1) sample period: 2001 – 2019; (2) geographic coverage: lower 48 states; (3) data frequency: monthly; (4) non-electric prices: natural gas and fuel oil; (5) specification: double-log; (6) partial adjustment: no; (7) estimation method: non-IV; (8) cross-section dependence: yes; and (9) fixed effects of states: yes. Performing the panel data analysis shaped by (1) to (9) yields the control group's static elasticity estimate.



A treatment group is based on a set of alternative modelling decisions. An example of a single treatment corresponding to (8) above is (8') cross-section dependence: no. Performing the panel data analysis shaped by (1) to (8') and (9) yields the treatment group's static elasticity estimate. The treatment effect is the difference between the elasticity estimates of the two groups. If the difference is statistically significant, the decision to ignore cross-section dependence is said to alter commercial electricity demand's estimated price responsiveness.

Results

For the control group characterized by the full panel and appropriately estimated double-log specification, the static, short-run, and long-run elasticity estimates respectively are: (a) -0.089, -0.095 and -0.124 for commercial electricity demand; (b) -0.161, -0.143 and -0.204 for commercial natural gas demand; (c) -0.103, -0.094 and -0.150 for industrial electricity demand; and (d) -0.062, -0.056 and -0.116 for industrial natural gas demand. Hence, the US non-residential energy demands are price inelastic, implying that absent large and persistent price escalation (e.g., over 5% per year), price-induced conservation is likely modest (i.e., under 1% per year).

The key findings of the elasticity experiments are summarized below:

- **Elasticity effects of parametric specification.** For commercial electricity demand, the linear and CES specifications tend to yield smaller elasticity estimates. However, the same cannot be said about the GL and TL specifications. For commercial natural gas demand, double-log's elasticity estimates tend to be larger than those found under the other specifications. For industrial electricity demand, the CES specification tends to yield the smallest elasticity estimates. The linear, GL and TL specifications, however, likely result in moderately larger estimates than those found using the double-log specification. For industrial natural gas demand, the CES specification tends to yield the smallest elasticity estimates. The linear specification likely results in modestly larger estimates than the double-log specification. However, the elasticity effects of the GL and TL specifications are mixed.
- **Elasticity effect of sample period selection.** Elasticity estimates based on the full sample tend to be slightly larger than those based on the 10-year rolling samples. This makes sense because the full sample's 19-year period reflects a non-residential customer's greater responses to energy price variations over a longer period.
- **Time trend of elasticity estimates.** The US non-residential demands for electricity and natural gas have been changing slowly over time. The corresponding change in the size of elasticity estimates is under 0.11, implying that the US non-residential demands have almost flat time trends in the 2001-2019 period.
- **Elasticity effects of controlling for cross-section dependence.** The elasticity estimates can be significantly biased upwards or downwards when cross-section dependence is not controlled for. Thus, controlling for cross-section dependence matters greatly when estimating elasticities.
- **Elasticity effects of data frequency.** Using monthly data tends to slightly alter the elasticity estimates for the US non-residential demands for electricity and natural gas.
- **Elasticity effects of using IV-estimation when appropriate.** IV-estimation can alter elasticity estimates, even though it effects are mostly small, less than 0.1 in size.

Conclusions

Emerged from the preceding results are the following policy implications. First, they inform participants in a regulatory proceeding – or in any other deliberation where an elasticity estimate must be selected – on why own-price elasticity estimates are highly diverse and how alternative modelling decisions can lead to vastly different estimates. Hence, they aid assessment of plausibility and reasonableness of elasticity assumptions recommended by the proceeding's participants.

Second, they show that the US non-residential demands for electricity and natural gas can become more price responsive in the very long run, as evidenced by the elasticity estimates produced by the BE estimator. However, these demands are unlikely to become sufficiently price responsive in the immediate future to make price-induced conservation highly effective in achieving deep decarbonization.

Finally, they lend support to continued policy support, at least in the immediate future, for energy efficiency standards and demand side management for achieving deep decarbonization. That said, the US low-carbon future also requires large-scale development of renewable resources aided by expanded carbon trading, flexible capacity development (including storage), easy transmission access, and expedited siting approval.