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Valor Público

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Nota de política

Abril 2024

N. 1

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Notas de política 2024
Edición No. 1
Edición digital
Abril del 2024

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Notas de política de Valor Público EAFIT

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Welfare implications of a tax on electricity: A semi-parametric specification of the incomplete EASI demand system

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Abstract

We perform a welfare analysis due to a tax on electricity consumption based on the incomplete exact affine Stone index (EASI) model using a novel data set in the Colombian economy. We provide a novel inferential framework based on a non-parametric specification of the stochastic errors using Dirichlet processes mixtures that allows handling non-normal errors, gaining efficiency, and taking into account, microeconomic restrictions, censoring, simultaneous endogeneity and non-linearity. We find that there is a 95% probability that the equivalent variation of the representative household is between US cent 34.1 and US cent 34.3, given an approximately 0.8% tariff increase (US cent 0.12 per kWh). In addition, we observe that the welfare loss of the representative household of the lowest socioeconomic characteristics is approximately twice the loss of the representative household of the highest socioeconomic characteristics.

Ex ante welfare analysis of new taxes should be a basic economic practice. Thus, policy makers have a baseline framework to make decisions that potentially minimize welfare losses due to tax distortions. Consumer response to changes in prices is instrumental for any assessment of the welfare consequences of taxation, and demand models play an essential role in assessing these consequences. Particularly, we analyze the welfare implications of an approximately 0.8% electricity consumption tax rate on middle to high income households in Colombia using the incomplete exact affine Stone index (EASI) demand system. This electricity demand tax was implemented by the national Colombian government in July 2019 to subsidize the recovery of the electricity system in the north-western Colombian region following the bankruptcy of its former provider. The former provider had attended about one third of the total residential subscribers in Colombia (i.e., 2.4 million users), most of whom belonged to the poorest segment (about 84% of its total subscribers).[1]

We perform this welfare analysis based on utilities demand, particularly electricity, gas, water, and sewerage. These goods are approximately 5% and 5.9% of household budget share in developed and developing countries, respectively.

To perform our analysis, we built a new micro-level data set that integrates household and provider data from four administrative sources: the Colombian national household budget survey, the utilities information system (SUI), and the regulation councils of energy and gas, and water and sewerage.

Our specification is based on an extension of the EASI demand system. This system satisfies the axioms of choice, such that additivity, homogeneity, and symmetry restrictions can easily be imposed in a simple setting to perform estimation. In addition, the rank in the function space spanned by the Engel curves is flexible (i.e., it can be more than three), which allows the Engel curves to take arbitrary shapes. Moreover, the stochastic errors can be interpreted as unobserved consumer heterogeneity. These are nice features that other well known demand systems do not take into account, such as the almost ideal demand system or quadratic AIDS. These properties are particularly relevant in our case as we work with micro-level data where the variation in expenditure is not smoothed out by aggregation and much of the demand variation may not be explained by observable variables.

This paper studies the potential welfare implications of a consumption tax on electricity based on a novel framework to perform inference in the EASI model. Our proposal uses an econometric framework that is based on a non-parametric specification of the stochastic perturbations in the EASI incomplete demand system. In particular, we use a Dirichlet process mixture (DPM) to handle unobserved preference heterogeneity. We extend the inferential approach of Ramirez (2021/JAE) to an incomplete demand system in a semi-parametric specification, and the proposals of (Conley, et al., 2008/JoE and Jensen, 2014/JoE) to a high-dimensional system of simultaneous equations with cross-equation restrictions. Our approach easily allows us to check and impose symmetry, strict cost monotonicity and concavity, and perform inference of the equivalent variation, which is our measure of welfare impact, as a by-product of the posterior chains.

[1] In December 2020, this tax was declined by order of the Colombian National Constitutional Court because \href{https://www.eltiempo.com/justicia/cortes/las-razones-de-la-corte-para-tumbar-sobretasa-de-energia-en-estratos-4-5-y-6-para-electricaribe-553358.

In particular, modelling the joint distribution of the stochastic errors of the structural and reduced form equations by an infinite mixture of distributions (DPMs) attempts to uncover and exploit structure in the data. Therefore, if the errors are non-normal, our proposal would fit this distribution, and may provide efficiency gains, particularly in presence of weak instruments, compared to instrumental variables, three stage least squares, generalized method of moments or parametric Bayesian approaches. In addition, observations which could reasonably correspond to the same error distribution are grouped together, thus taking unobserved preference heterogeneity into account. We are the first proposing a semi-parametric specification of the EASI incomplete demand system as this gives correct welfare change measures without invoking the weak separability assumption and the exogeneity of group expenditures.

Our results show that electricity, water, gas and sewerage are price-inelastic normal services, and the Engel curves of utilities in our application are non-linear. There is a 95% probability that the equivalent variation of the representative household is between US cent 34.1 and US cent 34.3 given an approximately 0.8% electricity tariff increase (US cent 0.12 per kWh). In addition, the average equivalent variations equal to US cent 45.3, US cent 22.5 and US cent 25.9 for the representative households of strata 4, 5, and 6. This means that the welfare loss of the representative household of stratum 4 is approximately twice the loss of strata 5 and 6. This result highlights the notable welfare implications of tariff increases of price-inelastic goods, and as a consequence, policy makers should take this implication into account prior to set a tax on electricity consumption, and explore multiple tariff structures to minimize welfare losses considering socioeconomic conditions.

Full paper available at

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