Energy Policy
Volume 200, May 2025, 114537

Assessing price elasticity in US residential electricity consumption: A comparison of monthly and annual data with recession implications

panelJamal Mamkhezri

Introduction

In 2022, electricity consumption in the US was approximated at 4.05 trillion kilowatt hours (kWh), the highest amount ever recorded, with the major sectors: residential, commercial, and industrial consuming about 38.4%, 35.4%, and 26% of the total share of electricity respectively (EIA, 2023b). As more than half of the electricity generation in the US comes from fossil fuels, concerns over global climate change and greenhouse gas emissions have encouraged lawmakers to implement policies and programs aimed at reducing and improving efficient energy usage. Gauging the potential as well as actual effectiveness of certain strategies, like pricing policies, to promote reduction and conservation depends on quality estimations of the price elasticity of electricity demand.

Throughout the years, studies have been conducted on all three sectors of the US electricity market to see how consumers respond to changes in the price of electricity. Most of the literature have used annual frequency data for their estimations (e.g., Azevedo et al., 2011; Dergiades and Tsoulfidis, 2008; Garcia-Cerrutti, 2000; Ros, 2017; Salari and Javid, 2016), overlooking monthly data's ability to account for seasonal behavioral changes. There are a few exceptions that use monthly data (Cao et al., 2023; Deryugina et al., 2020; Fell et al., 2014; R. Li et al., 2021, 2022; R. Li and Woo, 2022; Woo et al., 2017, 2018) or, in a rare case, quarterly data (Nakajima and Hamori, 2010), but these are few and only a more recent phenomenon. These studies have a diverse set of price elasticity estimates which is expected, but is a potential issue when it comes to evaluating policy decisions.

The price elasticity of electricity demand in the residential sector has been studied the most out of all three sectors in the U.S. To measure consumer responses to changes in the price of electricity, a wide range of models, methodologies, time periods, data types (panel, time series, or cross sectional), and geographical locations across the United States, spanning from single states to the entire continental U.S., have been used to quantify electricity price elasticity. In the residential literature alone, price elasticity ranges from −1.07 to −0.05 in the long-run, −0.74 to 0.07 in the short-run, and −0.86 to −0.06 using static models across the sector (see Table A1 of the appendix). Separating elasticities by data frequency, however, we get elasticity

estimates for annual (monthly) data from −1.07 to −0.18 (−0.35 to −0.05) in the long-run, −0.74 to 0.07 (−0.09 to −0.004) in the short-run, and −0.86 to −0.17 (−0.06) using static models. It is clear that separating elasticity estimates by what data frequency the researchers used in their study shows a drastic difference between estimation results.

Of course, data frequency may not be the only answer to these mixed elasticities. Other decisions regarding estimation techniques and data aggregation levels (Miller and Alberini, 2016) or even accounting for cross sectional dependence (CSD) presence and usage of a between estimator (Cao et al., 2023) can significantly change price elasticity results. Depending on the data source, Miller and Alberini (2016) have shown that state-level data can produce lower elasticity results than household-level data (American Housing Survey data) or can produce higher elasticity results than utility-level data (EIA Forms 861). Controlling for CSD presence has been shown to matter when estimating price elasticities and the utilization of a between estimator can increase elasticity results (Cao et al., 2023). Data frequency (monthly vs. quarterly) was also looked at by Cao et al. (2023), with results showing that monthly data can slightly alter estimates, however, they did not look at monthly vs. annual data, which we believe may produce more significant differences in estimates.

Motivated by this mixed set of elasticities in the residential literature, this paper focuses on the price elasticity of electricity in the US residential sector. Despite all the various ways elasticity has been quantified, there is a lack of research concerning how economic business cycles, such as recessions, influence residential electricity consumption. Viscio (1983) studies the effects of price and recession on energy demand and finds that in the short term, recessions have an impact, but the impact of price becomes more significant over time due to lagged effects. Recessions can also reshape energy markets through tightening reforms (Bettarelli et al., 2024), which could potentially impact energy prices and consumer behavior. Other papers that assess how energy demand is affected during financial downturns find that energy use declines during recessions (Kilian, 2008; Ali Bekhet and Yasmin, 2014; Deb et al., 2023; Yasmeen et al., 2022). For example, Kilian (2008) highlights that during recessions, lower incomes and greater uncertainty about future often lead households to cut back on electricity use, delay buying energy-intensive durables, and altering consumption patterns altogether. However, Deb et al. (2023) note that these effects are temporary and growth rates eventually return to normal. Additionally, studies have shown that an economic crisis can lead to a decrease in consumption (Dagoumas and Kitsios, 2014; Soava et al., 2021), though more so for non-residential electricity consumption. This difference highlights the need to assess how economic cycles impact residential electricity consumption.

Since 2000, the US has faced three significant recessions: the Dot-Bomb Recession, the Great Recession, and COVID-19 Recession. During recessions, economic activity declines and consumer behavior may change. Though brief in nature, it may take time for an economy to fully return to its previous state, implying that consumer behavior will have to adjust for months after a recession has occurred (NBER, 2022). This has great implications for the estimation of price elasticity of electricity within the last two decades. Therefore, two research questions emerge: 1) Does an economic business cycle impact electricity consumption? 2) Does the frequency of data collection affect the estimation of the price elasticity of electricity consumption? This paper aims to provide the most up-to-date price elasticity of electricity demand in the US residential sector using various state-of-the-art panel static and dynamic modeling approaches.

To fill the gaps in the literature and answer our research questions, we compiled two datasets encompassing both monthly and annual consumption data in the US from 2001 to 2022. Employing various panel static and dynamic empirical approaches, we controlled for common variables associated with electricity consumption, as well as recession months experienced since 2001. Our approach allows us to compare how the results differ between the two data frequencies. Our key results after running more than one thousand regressions are as follows: first, our long-run elasticity results for monthly data (−0.93 to −0.83) are approximately five to thirteen times more elastic than our long-run results for annual data (−0.18 to −0.07), an outcome that contradicts the recent literature's inclination that annual data produces higher elasticity results than monthly data. Second, our recession variable is highly significant for most specifications under monthly results, indicating that consumers reduce electricity consumption during times of economic strife. Finally, we find that using a between estimator yields similar static elasticity results for our monthly (−1.10) and annual (−1.06) datasets.

This paper extends the literature in two ways. First, we performed a panel data analysis on monthly and annual data, differentiating between elasticity results and showcasing that the type of data that a study uses can significantly impact elasticity estimations. Second, we estimated the price elasticity of electricity by accounting for economic shocks, seeking to illustrate the intricate relationship between electricity consumption, pricing elasticity, and economic fluctuations.

This paper is structured as follows: Section 2 outlines the data used in this study, its sources, theoretical framework, methodology, and empirical estimation methods; Section 3 covers the results and discussion; and Section 4 concludes the study and provides policy implications for stakeholders.