

Modeling & Forecasting US Electricity Consumption

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Overview

This paper looks to model the dynamics of the US electricity market at the sectoral level on a monthly basis. By incorporating multiple sectors of demand at once and using high-frequency data, the model provides robust feedbacks between electricity markets as well as the larger macroeconomy. Estimation uses a sequence of single-equation sectoral-level models; the sectoral specification includes macroeconomic variables that influence demand at the monthly frequency. These sectoral models are then linked together to create a single large, cross-sector model. With this robust specification, several different scenarios and simulations are tested empirically in order to further understanding of the US electricity market. These insights will be useful in future analysis of the electricity market as energy demand continues to evolve over the coming decades, particularly with regards to higher-frequency macroeconomic variables.

Methods

In order to overcome the dimensionality problem that comes from specifying even a simple reduced-form model of several electricity and macro sectors simultaneously, this paper simplifies the model specification through structural and sectoral linkages between labor, income, and energy prices. These relationships are then shared with other sectoral models, aiding in identification of the between-sector relationships.

By specifying several conditional dynamic models independently as single-equation models, the complex interactions between electricity markets and the broader economy can be more easily and better isolated through data-driven linkages. This avoids the problematic identification issues that arise from the high dimensionality of using so many variables in a dynamics-driven model. These dynamics-driven equations are then combined, and further linkages are identified using the General-to-Specific (GTS) approach.

I begin by specifying the single-equation sectoral models. The sectoral models are demand equations for the quantity of electricity consumed, and include the price of electricity and electricity substitutes, as well as the relevant macroeconomic variables (elements of income and expenditure for the sector), and other explanatory variables that influence demand. A detailed description of the variables used in these models can be found in the paper.

With the initial sectoral models specified, the next step is to link the models. This involves paring down the initial specifications for robustness and parsimony, identifying shared long-run relationships, and then estimating the linked models simultaneously. These three steps are accomplished using the VAR/VECM framework.

The first step, paring down the models, relies on the GTS approach. As discussed in the Literature Review, the GTS approach relies on a battery of parameter and residual diagnostics to assess the most parsimonious and robust specification of a family of models. The initial sectoral specifications serve as the starting point of the analysis, with each equation undergoing the process. This produces the slimmed-down models single-equation models, including dropping insignificant variables and lagged terms. These models are then combined into a modified VAR.

For the VAR framework, I begin by describing the system in general. The VAR equations are identified by first specifying the sectoral subsystems as demand equations, which are combined into a single, multi-sector VAR. Using this framework, the multi-sector model is specified. This large, single model is then re-subjected to the GTS algorithm. This better captures the dynamic linkages that feedback between the electricity markets while also aiding in identification. This larger simultaneously-estimated model is then be subjected to a forecasting exercise using the

most recent vintage of data. This model forecasts electricity markets using perfect foresight of macroeconomic data, generating a series of 1-step, 3-step, 6-step, 12-step, and a 24-step forecast.

Conclusion

The initial, single-equation models provide strong amounts of explanatory power, describing the demand behaviour of each equation. The Residential and Commercial models both provided stable parameter estimates, while the Industrial model potential suffers from a small structural break in 1999. The reduced versions of these equations, relying on the Autometrics algorithm, highlighted several key factors across the models. Each demand equation was significantly influenced by macroeconomic factors in both the short- and long-run. Each model had a seasonal component that required dummy saturation in order to properly model. Each model had significant own-price and substitution price elasticities. The forecasting exercise also showed both that the macroeconomic data inform the forecasts, but also that the models are not exceptional at finding economic turning points.

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