Electricity Price Prediction Equation

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DRAFT

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2 Method

3 Graph Result
   - Nominal Price Forecast
   - Real Price Forecast

4 Conclusion
The purpose of this project is to analyze the relationships between historical electricity portfolios and electricity prices across the contiguous United States to estimate the most-likely electricity price in a state with a portfolio and other conditions that the user has specified. We are trying to predict the price of electricity using portfolio data, and we can do it successfully 96% of the time.
In this energy database, we have 3647 observations from 1940 to 2010 of all 50 U.S. states. Each observation contains coal price, gas price, and all relevant variables. But most of the data are missing from 1940 to 1989. So, in this model we only use the 895 complete data from 1990 to 2009.
## Variable Description

<table>
<thead>
<tr>
<th>variable</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rate</td>
<td>the price of electricity</td>
</tr>
<tr>
<td>coal</td>
<td>the percentage of electricity generation that is from coal</td>
</tr>
<tr>
<td>hydro</td>
<td>the percentage of electricity generation that is from hydro</td>
</tr>
<tr>
<td>gas</td>
<td>the percentage of electricity generation that is from gas</td>
</tr>
<tr>
<td>nuke</td>
<td>the percentage of electricity generation that is from nuke</td>
</tr>
<tr>
<td>wind</td>
<td>the percentage of electricity generation that is from wind</td>
</tr>
<tr>
<td>biomass</td>
<td>the percent of electricity generation that is from biomass</td>
</tr>
<tr>
<td>ngeid</td>
<td>the price of gas</td>
</tr>
<tr>
<td>gas-ngeid</td>
<td>an interaction term of ngeid and gas</td>
</tr>
<tr>
<td>cleid</td>
<td>the price of coal in dollar per MMBTU in that state</td>
</tr>
<tr>
<td>estcp-pc</td>
<td>per capita electricity consumption in Gigawatt hours</td>
</tr>
</tbody>
</table>
Working Model

Random Coefficient model.

\[ Y_{ij} = X_i \times \beta + Z_i \times \gamma_i + \varepsilon_{ij} \]

Fixed Effect \hspace{1cm} Random Coefficient

with \( \varepsilon_{ij} \sim N(0, \sigma^2) \)
Fixed Effect

\[ X_i \times \beta = \text{int}_\beta + \beta_1 \times \text{year} + \beta_2 \times \text{coal} + \cdots + \beta_{11} \times \text{estcp_pcp} \]
Random Coefficient

\[ Z_i \times \gamma_i = \text{int}\gamma_i + \gamma_{1i} \times \text{coal} + \gamma_{2i} \times \text{ng eid} + \gamma_{3i} \times \text{cleid} \]

Without this part, this model will be the fixed effect model, which we used initially.
Of 895 historical estimates, 860 were within 1 penny of the observed value, which is approximately 96%. 891 were within 2 pennies of the observed value. No estimates are larger than 2.5 pennies away from the observed value. While for the fixed effect model, only about 837 were within 1 penny of the observed value.
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Histogram of National Residuals 1990-2010
Random Coefficient Model, Nominal Price

- Predicted vs. Observed Errors (Cents per kWh)
## Fixed Effect Estimation

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Estimation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-131.15</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>year</td>
<td>0.06761</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>coal</td>
<td>2.7068</td>
<td>0.0002</td>
</tr>
<tr>
<td>cleid</td>
<td>1.518</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>hydro</td>
<td>2.1837</td>
<td>0.0073</td>
</tr>
<tr>
<td>gas</td>
<td>2.4701</td>
<td>0.0005</td>
</tr>
<tr>
<td>ngeid</td>
<td>-0.02761</td>
<td>0.1796</td>
</tr>
<tr>
<td>gas_ngeid</td>
<td>0.5362</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>nuke</td>
<td>3.2372</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>wind</td>
<td>11.3215</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>biomass</td>
<td>16.2255</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>estcp_pc</td>
<td>-172.85</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Advantage of random coefficient model

- **Accuracy** Since this model is a subject specified model, it can cause less variation compared to fixed effect model.

- **Data-Driven** All of the coefficients in this model were derived from historical Federal data using statistical procedures.

- **Validation** This model has been validated using historical data from the contiguous United States. If things continue as they have over the past twenty years, then these results are very likely.
Disadvantage of random coefficient model

- **Complexity** This model involves advanced mathematical procedures and is more difficult to communicate or understand.

- **No New Technologies** Since the model uses historical observations, it cannot simulate experimental or theoretical electricity generating technologies, where data is not yet available.
Predicted vs. Observed Electricity Price, 1990-2009
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Electricity Price, 1990-2009

Random Coefficient Model

Observed Values (Cents per kWh) vs. Predicted Values (Cents per kWh)

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Electricity Price, 1990-2009
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Electricity Price, 1990-2009
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Nominal Electricity Prices by State, 1990-2010

Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
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Kentucky Predicted vs. Observed Electricity Prices, 1990-2010
Random Coefficient Model

Nominal Cents per kWh

Kentucky Energy Database, EEC-DEDI, 2011
New York Predicted vs. Observed Electricity Prices, 1990-2010
Random Coefficient Model

Nominal Cents per kWh

Year
Kentucky Energy Database, EEC-DEDI, 2011

Observed Predicted
Electricity Price Prediction Equation

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Ohio Predicted vs. Observed Electricity Prices, 1990-2010
Random Coefficient Model

Nominal Cents per kWh

Year

Kentucky Energy Database, EEC-DEDI, 2011

- observed
- predicted
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Tennessee Predicted vs. Observed Electricity Prices, 1990-2010
Random Coefficient Model

Nominal Cents per kWh

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Real Electricity Price, 1990-2009
Random Coefficient Model

Observed Real Values (Cents per kWh)

Predicted Real Values (Cents per kWh)

Kentucky Energy Database, EEC-DEDI, 2011
Electricity Price Prediction Equation

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Predicted vs. Observed Real Electricity Price, 1990-2009
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Real Electricity Price, 1990-2009
Random Coefficient Model

Observed Real Values (Cents per kWh) vs. Predicted Real Values (Cents per kWh)
Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Real Electricity Price, 1990-2009
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Histogram of National Residuals 1990-2010

Random Coefficient Model, Real Price

Kentucky Energy Database, EEC-DEDI, 2011
Predicted vs. Observed Real Electricity Prices by State, 1990-2010
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Kentucky Predicted vs. Observed Real Electricity Prices, 1990-2010

Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
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New York Predicted vs. Observed Real Electricity Prices, 1990-2010
Random Coefficient Model

Kentucky Energy Database, EEC-DEEI, 2011
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Indiana Predicted vs. Observed Real Electricity Prices, 1990-2010
Random Coefficient Model

Kentucky Energy Database, EEC-DEDI, 2011
Ohio Predicted vs. Observed Real Electricity Prices, 1990-2010
Random Coefficient Model

Real Cents per kWh

Year


Kentucky Energy Database, EEC-DEDI, 2011
Tennessee Predicted vs. Observed Real Electricity Prices, 1990-2010
Random Coefficient Model

Real Cents per kWh

Year
Kentucky Energy Database, EEC-DEDI, 2011

Observed
Predicted
### Fixed Effect Estimation for Real Price

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Parameter</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>136.92</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>year</td>
<td>-0.06556</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>coal</td>
<td>2.5845</td>
<td>0.006</td>
</tr>
<tr>
<td>cleid_r</td>
<td>1.4891</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>hydro</td>
<td>1.1695</td>
<td>0.2776</td>
</tr>
<tr>
<td>gas</td>
<td>2.0658</td>
<td>0.0299</td>
</tr>
<tr>
<td>ngeid_r</td>
<td>-0.03606</td>
<td>0.2017</td>
</tr>
<tr>
<td>GAS_NG_EID_R</td>
<td>0.4899</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>nuke</td>
<td>3.9876</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>wind</td>
<td>13.9024</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>biomass</td>
<td>18.436</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>estcp_pc</td>
<td>-198.3</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Random Coefficient Model produces predictions that match the observations consistently well for most states including Kentucky.
Thank You!