Spotted: How varying fuel prices affected British electricity wholesale prices.

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Liliana Nowakowska - Imperial College Business School, London
Agenda

- Goals and motivation
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UK energy market- background
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- Merit Order Effect
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- UK energy market - background
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- Methodology
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- Results
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This research: the ex-post study of British day-ahead spot prices for almost a decade.

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In fact, the out-turn prices are highly dependent on energy demand and other factors.
Modelling electricity prices

The main difference between electricity market and others - commodity is not storable. It gets more complicated: consider different types of generators in one pool - renewables are fairly cheap but not always available contrary to fossil fuels (expensive and not flexible but more reliable in general).
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All papers are based on direct fuel prices - mainly on gas and this approach, given the rapidly changing capacity mix may be subject to an upgrade.
Higher cost stations are on the margin, producing less but setting the price in the spot market.
Fuel Prices incl. carbon price and share of thermal output

Data source: National grid & BEIS
Output of different energy sources as a share of total yearly generation in %.

Data source: National grid
Methodology

We capture this effect by constructing variables not for the variable costs of gas generation and of coal generation per se, but for whichever plant type is cheaper, and whichever is more expensive. Additionally, we introduce the nonlinear relationship between demand and electricity prices by using polynomials.
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Data:

- The focus is placed on the day-ahead market in UK encompassing half-hourly data from years 2009-2017.
- Sources include ENTSOE, BEIS, Ofgem, Bloomberg (for Gas price) and Investing.com (for Coal price).
Why not linear?

Complex relationship of demand towards price.

Firstly, to check if our assumptions of non-linearity is correct we run the model without interaction effects with demand to see clearly the relationship.

Coefficients of demand squared and demand cubed are statistically significant.

The positive sign for demand and negative sign for demand squared suggest a monotonic increasing function of price by demand until a turning point is reached and then it very slightly turns upward.
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<th>Day-ahead electricity price</th>
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<tr>
<td>Demand</td>
<td>GW</td>
<td>Actual Total Load</td>
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<td>Renewable Gen.</td>
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<th>GasPrice</th>
<th>£/MWh</th>
<th>(Gas price + UKCarbon)/ thermal eff</th>
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<tr>
<td>CoalPrice</td>
<td>£/MWh</td>
<td>(Carbon price + UKCarbon)/ thermal eff + delivery cost</td>
</tr>
<tr>
<td>CheaperFuel</td>
<td>£/MWh</td>
<td>(The cheaper of Gas and Coal incl. fuel price + carbon cost) / thermal eff.</td>
</tr>
<tr>
<td>CostlierFuel</td>
<td>£/MWh</td>
<td>(The more expensive of Gas and Coal incl. fuel price + carbon cost)/ thermal eff.</td>
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Costlier Demand | GW | Net Demand which is not satisfied with the CheapFuel Capacity Formula: (Demand-Renewable Gen.-Nuclear Gen.)-0.8*CheapCapacity. if <0 then set to 0 |

CheapCapacity | GW | Capacity of CheapFuel |

PeakHours | binary | Dummy for peak hour=1, off-peak=0 Peak period: 8 am - 8 pm on weekdays |

Note: 0.8 in Costlier Demand definition means that generators do not run at full capacity and based on previous research they usually use 80% of their overall capacity for optimal efficiency.
Two approaches:

\[ P_t = \alpha_t + \beta \cdot Dem_t + \gamma \cdot Renewables_t + \gamma_1 \cdot PeakHours_t + \delta_1 \cdot GasPrice_t + \delta_2 \cdot CoalPrice_t + \Theta \cdot V_t + \epsilon_t \] (1)
Two approaches:

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2

\[ P_t = \alpha_t + \beta \cdot Dem_t + \beta_1 \cdot Dem_t^2 + \beta_2 \cdot Dem_t^3 + \gamma \cdot Renewables_t + \gamma_1 \cdot PeakHours_t + \delta_1 \cdot CheaperFuel_t + \delta_2 \cdot CostlierFuel_t + \delta_3 \cdot CostlierDemand_t + \Theta \cdot V_t + \epsilon_t \quad (2) \]
<table>
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<th>Variable</th>
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<tr>
<td>DemandGW</td>
<td>-10.851***</td>
</tr>
<tr>
<td>I(DemandGW^2)</td>
<td>0.375***</td>
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<tr>
<td>I(DemandGW^3)</td>
<td>-0.004***</td>
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<tr>
<td>Renewables</td>
<td>-1.056***</td>
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<tr>
<td>CheaperFuel</td>
<td>0.412</td>
</tr>
<tr>
<td>CostlierFuel</td>
<td>-4.390***</td>
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<tr>
<td>PeakHours</td>
<td>2.753***</td>
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<tr>
<td>CostlierDemand</td>
<td>0.954***</td>
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<td>DemandGW:CheaperFuel</td>
<td>0.061**</td>
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<td>I(DemandGW^2):CheaperFuel</td>
<td>-0.003***</td>
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<td>0.0001***</td>
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<td>0.00004***</td>
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<tr>
<td>Constant</td>
<td>101.175***</td>
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| Observations                                 | 157,672     |
Marginal impact of fuels on power prices in polynomial model

Direct fuels approach

Switching fuels approach
How prices changed from 2009 to 2017

£/MWh

2009 Actual: 36.88
Demand: -3.81
Renewables: -6.08
Capacity: -0.13
Fuel prices: 7.43
Carbon: ETS: 9.94
Carbon: CPS: 5.32
Residual: 44.72
2017 Actual
What-if analysis for year 2017

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<td>Gas:30 £/MWh,</td>
<td>Gas:32 £/MWh</td>
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<td>Coal:21.6 £/MWh</td>
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*carbon level stays for 2017*
Conclusions

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3. Carbon and fuel prices which increased in this period (particularly carbon price) triggered increase of electricity price by around 16 £/MWh.
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