Fundamental and Speculative Shocks – Structural Analysis of Electricity Markets.

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Why are electricity prices difficult to forecast?

- unknown generation mix (RES),
- unknown demand,
- speculations.

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  - price variance: Ketter (2014).
- How influence the forecast accuracy?

SVAR analysis

SVAR (Structural VAR) models allow for decomposition of forecast errors into structural shocks, which:

- have economic interpretation,
- are uncorrelated,
- enable disentangling forecast error variances.

SVAR in electricity markets

Literature:

- Fezzi C, Bunn D (2009): PJM market; electricity prices and demand (hypothesis of inelastic demand),
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No supply or RES shocks included!!!

Agenda

- Introduction
- GARCH-SVAR model
- Structural analysis of UK market
- Conclusions

SVAR model

Reduced form VAR model:

$$y_t = \Phi x_t + \sum_{i=1}^{p} A_i y_{t-i} + e_t$$

Structural form SVAR model (B-type)

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Shocks:

- structural shocks $u_t \sim N(0, \Lambda)$, $\Lambda = diag([\sigma^2_{1t}, ..., \sigma^2_{Kt}])$,
- forecast errors: $e_t = Bu_t \sim N(0, \Sigma)$,
- $\Sigma = B\Lambda B'$

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  - other $K(K-1)/2$ restrictions.
- Popular restrictions:
  - contemporaneous restrictions (on matrix B),
  - long run restrictions,
  - IR restrictions.
  - ...

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- Lanne, Lütkepohl (2008), Lanne, Maciejowska, Lütkepohl (2010) - regime switching in variance
- Lütkepohl, Netsunajev (2014) - Sooth transition of variances
- Milunovich, Yang (2013) - ARCH effect

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Advantages:

- Control for heteroscedasticity - important in variance analysis.
- Typical restrictions are testable (also shocks interpretation).

Identification via heteroscedasticity

In the literature regime switching models are used - there exist two states characterized by different variances of structural shocks: Λ_1 and Λ_2. Then

$$\Sigma_i = B'\Lambda_i B$$

Lanne, Lütkepohl (2008) showed that if:

- $\Lambda_1 = I_K$
- For any pair (i, j): $\Lambda_{2,i} \neq \Lambda_{2,j}$ - change of relative variance

Remark: conditions difficult to test since under the null model is not identifiable (Wald approach applicable - need of calculation of the variance-covariance matrix of parameter estimates)

EGARCH-SVAR model

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where

- z_t a vector of exogenous variables: (K_z): for example expected wind, expected demand etc.

Identification via GARCH(1,0)

SVAR model is identifiable if for any pair (i, j) at least one of the conditions hold:

- $\rho_i \neq 0$
- $\rho_j \neq 0$
- $\beta_i \neq \beta_j$

Remark: restrictions can be tested separately hence under the null model may be still identifiable (enables usage of LR test)

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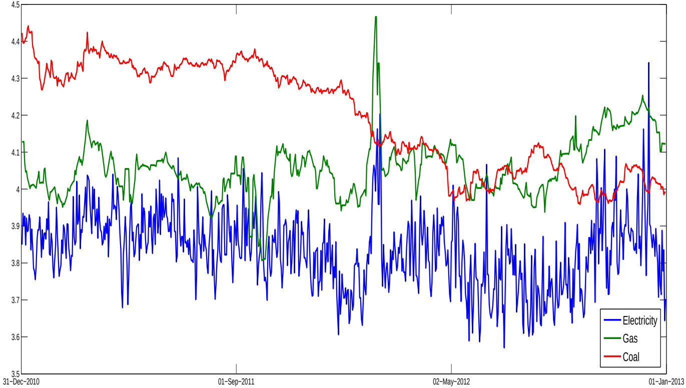
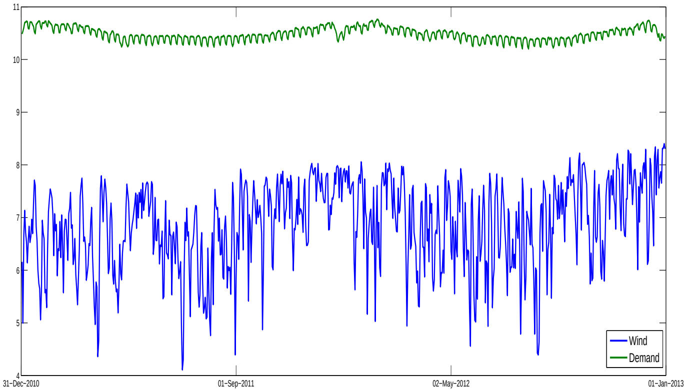
Data

- Data for UK market (APX): from 01.01.2011 to 31.12.2012.
- Endogenous variables (logarithms) $y_t' = [W_t, D_t, P_t]$:
  - W_t: wind generation ,
  - D_t: total demand,
  - P_t: electricity price.
- Exogenous variables(logarithms):
  $x_t = [1, WD_t, EW_t, ED_t, G_t, C_t, CO2_t]$ and $z_t = [EW_t, ED_t, t]$
  - EW_t, ED_t: expected wind generation and demand,
  - $G_t, C_t, CO2_t$: fuel prices.

Electricity and fuel prices (logarithms)



Total demand and wind generation (logarithms)



GARCH-SVAR model

Identification restrictions (can be tested)

- wind generation shock: affects only wind generation and prices,
- demand shock: affects only demand and prices,
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$$B = \begin{bmatrix} * & 0 & 0 \\ 0 & * & 0 \\ * & * & * \end{bmatrix}$$

Restrictions are testable due to heteroscedasticity property.

Results - average daily quantities

	Model 1 (Unrestricted)			Model 2 (Restricted)		
B	0.189	0.000	-0.004	0.186	0	0
	-0.006	0.012	0.005	0	0.012	0
	-0.036	0.002	0.060	-0.047	0.002	0.061
β	-0.774	-0.018	-0.256	-0.810	0	-0.245
	0.012	0.046	0.142	0	0.050	0.140
	0.272	0.022	0.432	0.292	0.020	0.447
ρ	0.071	0.901	0.047	0	0.879	0
LogL	5345.3			5343.4		
LR	3.826					
p-value	0.872					

Identification conditions

	LogL		LR	
	Unrestricted	Restricted	Test	p-value
$\rho_1 = 0$	5343.7	5343.4	0.710	0.399
$\rho_2 = 0$	5343.7	5332.8	21.82	0.000
$\rho_3 = 0$	5343.7	5343.7	0.005	0.944
$\beta_{2,1} = \beta_{2,3}$	5343.7	5340.7	6.191	0.012

Results indicate that

- $\rho_2 \neq 0$,
- $\beta_{2,1} \neq \beta_{2,3}$,
- ... model is identifiable.

Variance input

	u_{1t}	u_{2t}	u_{3t}
Daily	38.2%	0.1%	61.6%
Peak	27.8%	0.1%	72.0%
Off-peak	46.1%	0.2%	53.7%

- wind share of variance is much larger that the RES share of generation mix.

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Conclusions

- There are three structural shocks: wind generation, demand and speculative shocks
- wind generation affects:
  - level of prices
  - variance of prices
- only demand shock exhibits GARCH effect
- major sources of price variation are: wind generation shock (38.2%) and speculative shocks (60%).