Determinants of the Premium in Electricity Forward Contracts

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An empirical finding

- Market power increases forward premium

  ➔ Market monitoring implications

AGENDA

1. *Research background*
2. *Data*
3. *Multifactor Propositional Framework*
4. *Modelling the month-ahead forward premium*
5. *Conclusions*

(1) Research background: Introduction

- Trading volume significantly higher than physical demand
- Questions of ***efficiency and determinants*** of realised forward premia arise
- Resulting ***transaction costs*** (i.e. premia) may ***erode*** some ***potential benefits*** of forwards (market completeness, risk management, potential greater competitive behaviour on spots)
- Focus on electricity – characteristics render forward pricing special:
  - "Flow" rather than "stock" product – absence of 1:1 correspondence between forwards and spots; Premia complicated by averaging over extended delivery periods
  - Nonstorability precludes cost of carry equilibrium
  - Equilibrium in expectations and risk aversion (Keynes, 1930): $F_{t,T} = E(S_T) + FP_{t,T}$
    - ***Ex post forward premium*** key variable assessed in (empirical) literature:

$$F_{t,T} - S_T = \underbrace{F_{t,T} - E_t(S_T)}_{} + \underbrace{E_t(S_T) - S_T}_{} = {}^{e}FP_{t,T} + \varepsilon_{t,T}$$

    - Ex post premium equals ***ex ante premium*** plus ***random error*** of price forecast due to shocks between *t* and *T*
  - Derived commodity: Technologies using gas, coal or oil set price
    - How much of price of risk is due to electricity sector; How much is supply-chain transmission of underlying fuel premia?
  - Industry structure: Oligopoly pricing serious concern
    - Market concentration may induce additional market power effects in premium

(1) Research background: Theoretical literature

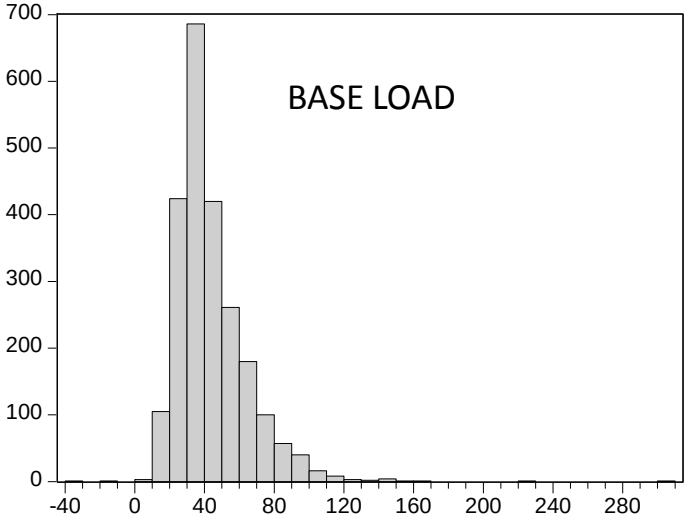
- Two streams of ***equilibrium modeling*** of forward markets:
  - Risk aversion in competitive environment; ***Bessembinder and Lemmon (2002)***: Result depends on utility function, price process, second order Taylor series expansion: VAR (-) and SKEW (+) determine forward premium;
  - Strategic effects of contracts in oligopolistic risk neutral environment; ***Allaz ('92), Allaz & Villa ('93)***: Cournot producers end up short on forward market; Prices decrease
    - Pro-competitive effect of forward markets
  - Both issues not resolved by empirical (and theoretical) literature

(1) Research background: Aim and scope of analysis

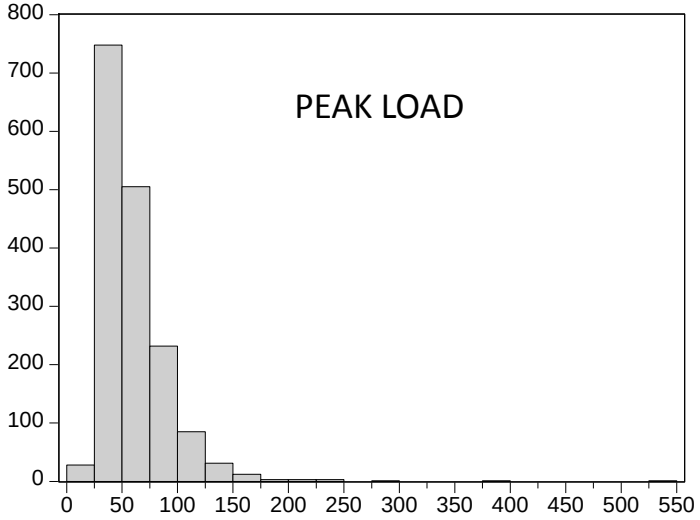
- Aim to ***provide more complete multi-factor analysis of empirical determinants of forward premium***
  - Literature focuses on risk aversion (variance, skewness) and shocks in generation (hydro) and demand
  - We assess forward pricing at biggest regional European power market: Western European power market; Leading power exchange: ***EEX***, Germany.
- Our ***analysis*** focuses on ***month-ahead futures***:
  - Most liquid contract and most price data available
  - Shorter and subsequent delivery period implies lowest forecast errors
  - Prices on the last trading day are considered
    - Monthly averaging of futures prices yields autocorrelation in residuals
    - Considering full price history of a specific contract: Results may not be robust due to the increased time to delivery – and lack of trading;
    - Lacking fundamental data on a daily basis (e.g. reserve margin)

(2) Data

- Distribution of daily spot prices at the EEX:



Series: BASE	
Sample 1/10/2003 31/01/2010	
Observations 2315	
Mean	44.08
Median	38.94
Maximum	301.54
Minimum	-35.57
Std. Dev.	20.78
Skewness	2.26
Kurtosis	17.55
Jarque-Bera	22397.59
Probability	0.00



Series: PEAK	
Sample 1/10/2003 31/01/2010	
Observations 1653	
Mean	60.71
Median	52.33
Maximum	543.72
Minimum	6.76
Std. Dev.	31.74
Skewness	4.21
Kurtosis	45.87
Jarque-Bera	131452.1
Probability	0.00

➔ Forecasting problem

➔ Incentive to reduce risk exposure

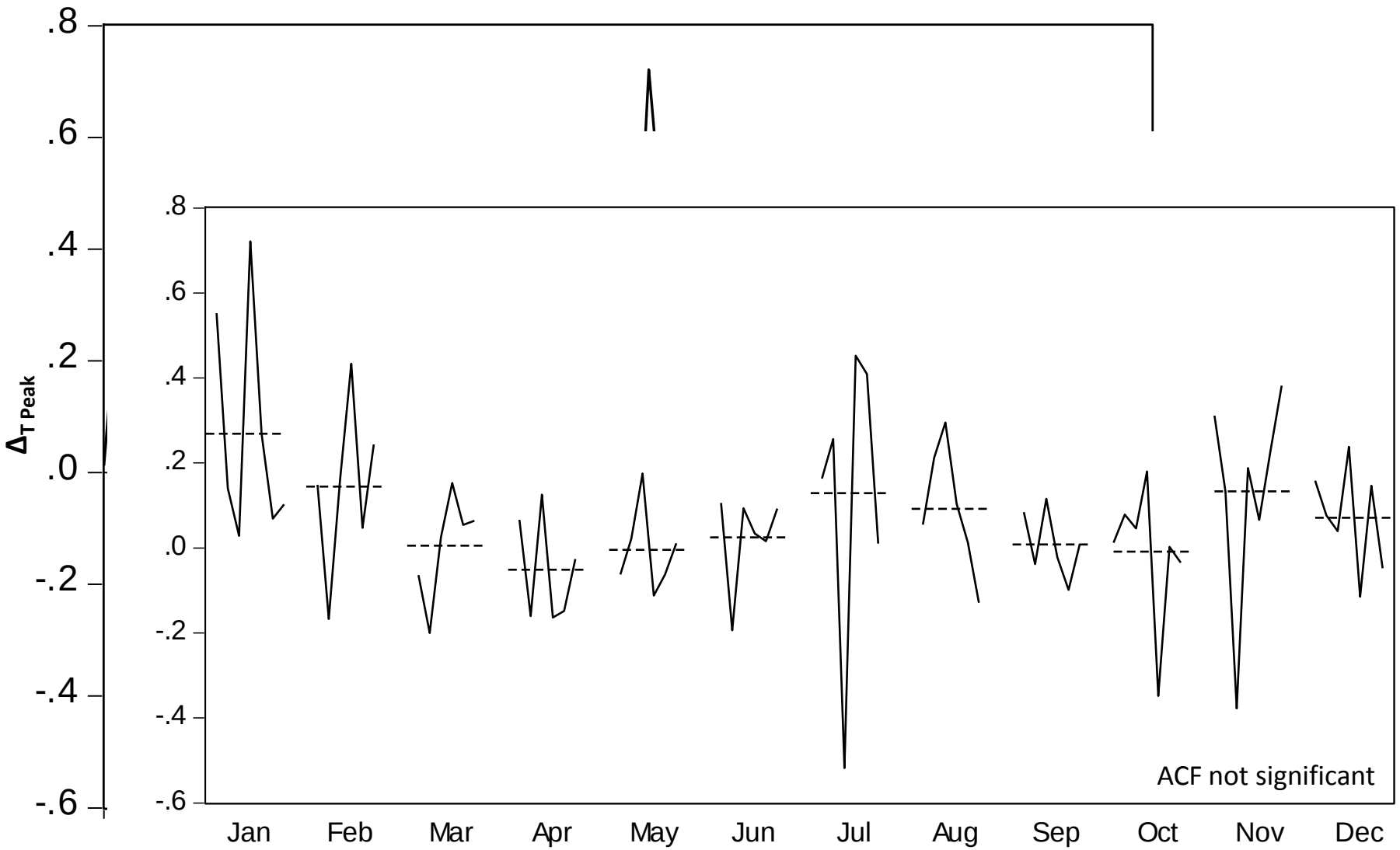
(2) Data: Realised month-ahead forward premia

- Relative ex-post difference between forward prices in the trading period and spot prices in the delivery period (%-forward premia):

$$\Delta_T = \frac{F_{T-1,T} - S_T}{S_T}$$

(10/'03 to 1/'10)	EEX			
	Base load		Peak load	
	Monthly average	Last trading day	Monthly average	Last trading day
Mean	9%	5%	12%	7%
Standard dev.	21%	15%	26%	20%
Minimum	-38%	-38%	-50%	-50%
Maximum	87%	65%	98%	72%
Skewness	0.79	0.47	0.58	0.24
Kurtosis	4.88	5.47	3.98	4.80
t-statistic	3.66*	2.96*	4.04*	3.16*

(2) Data: Realised month-ahead forward premia



(3) Multifactor Propositional Framework

- (Realised) forward premia affected by market assessment and corresponding risk behaviour
  - Stochastics of spot price (caused by convex supply function and inelastic demand)
  - Fundamentals (electricity derived commodity)
    - Fuel prices (and corresponding hedging decisions)
    - Scarcity in supply system
  - Behavioural biases (e.g. adaptive heuristics, anchoring)
  - Market power in forward premium (highly concentrated industry)
  - Shocks (Distinction between effects on forward price and shocks to spot drivers)

- Taxonomy of forward premia determinants:
  - Fundamental influences
  - Behavioral effects
  - Market conduct
  - Dynamic effects
  - Shock effects

(3) Multifactor Propositional Framework

- ***Taxonomy*** of forward premia determinants and corresponding ***propositions***:

Observable for market participants on forward trading day

- ***Fundamental influences:***
  - Fuels and their risk premia (gas): *Increases in gas premia increase electricity premia*
  - *Scarcity*: *Negative relationship between observed margin and forward premium*
- ***Behavioural effects:***
  - *We postulate adaptive/myopic adjustment w.r.t. risk/market assessments*
  - Higher moments: *VAR(+)/SKEW(+)/KURT(+) are of importance for risk assessment of market actors*
  - Spikes: *Forward premium increases due to spikes in the spot market*
  - Oil market volatility: *Oil market volatility increases electricity premium*
- ***Market conduct:***
  - Market power: *Exercise of spot market power positively affects premium*
- ***Dynamic effects:***
  - Basis: *Increasing basis increases forward premium*

Not observable on forward trading day

- ***Shock effects:*** *Margin shocks positively influence forward premium*

(3) Multifactor Propositional Framework

- Summary of forward premia determinants:

	Effect on forward premium	Proxy variable
*Fundamentals**		
Premia in fuels	+	Month ahead gas forward premium
Scarcity	-	Reserve margin: Ratio generation/consumption in the regional market
*Behavioural effects**		
Variance	+	Coefficient of variation of spot price
Skewness	+	Skewness of spot price
Kurtosis	+	Kurtosis of spot price
Spikes	+	Count spikes outside 1, 1.5, 2, 2.5, 3 standard deviations of mean spot
Oil volatility	+	Coefficient of variation of Brent oil spot price
*Conduct**		
Spot market power	+	Fundamental cost mark up estimate for regional spot market
*Dynamics**		
Basis	+	Difference of forward price and spot price average in trading month
Shocks		
Margin shocks	+	Change in supply margin during delivery month

Observable for market participants on forward trading day

Not observable on forward trading day

(4) Modelling the month-ahead forward premium

- Base load:

$$F_{t,T} - S_T = b_1 + b_2 c_v(S_t) + b_3 c_v(Brent_t) + b_4 FP_{Gas,t-1,t} + b_5 Margin_t + b_6 Basis_t + b_7 Margin_T + \varepsilon_{t,T}$$

*, **, *** denotes significance on the 10%, 5% and 1%-level

Coefficient	Variable	Baseload	Elasticity	Response of 1SD rise
b_1	Constant	9.06 (.18)		
b_2	Coeff. of var. ($Spot_t$)	26.77 (5.00)***	4	3
b_3	Coeff. of var. ($Brent_t$)	97.47 (3.54)***	2.4	2
b_4	Forward premium gas t	0.26 (1.51)		1
b_5	Margin t	-238.73 (-2.60)**		
b_6	Basis t	0.39 (2.77)***	0.4	
b_7	Margin T	220.92 (2.89)***		
R^2 (R^2_{corr})		0.30 (0.23)		
DW		1.99		
F-statistic		4.73		
Serial correlation	χ^2_{12} (p-value)	0.231		
Functional form	χ^2_1 (p-value)	0.691		
Normality	JB (p-value)	0.000		
Heteroscedasticity	χ^2_6 (p-value)	0.361		
Observations		74; 11/03-12/09		

(4) Modelling the month-ahead forward premium

- Peak load:

$$F_{t,T} - S_T = b_1 + b_2 Skew(S_t) + b_3 Spike_{2sd,t} + b_4 FP_{Gas,t-1,t} + b_5 Marketpower_t + b_6 Basis_t + b_7 Basis_t + b_8 Margin_T + \varepsilon_{t,T}$$

*, **, *** denotes significance on the 10%, 5% and 1%-level

Coefficient	Variable	Peak load	Elasticity	Response of 1SD rise
b_1	Constant	86.00 (0.44)		
b_2	Skew spot t	2.84 (2.11)**	0.4	3.6
b_3	Spike spot 2sd t	-4.98 (-2.06)**		
b_4	Forward premium gas t	1.18 (3.02)***	0.15	4
b_5	Market power spot t	20.99 (3.86)***	0.9	6
b_6	Margin t	-459.33 (-2.62)**		
b_7	Basis t	0.39 (2.87)***	0.3	
b_8	Margin T	379.38 (2.89)***		
R^2 (R^2_{corr})		0.25 (0.17)		
DW		1.96		
F-statistic		3.18		
Serial correlation	χ^2_{12} (p-value)	0.483		
Functional form	χ^2_1 (p-value)	0.285		
Normality	JB (p-value)	0.000		
Heteroscedasticity	χ^2_7 (p-value)	0.668		
Observations		74; 11/03-12/09		

(5) Conclusions

- Multifactor analysis of electricity forward premia determinants shows several new effects:
  - Ex post nature of analysis is controlled by (significant) margin shock
  - As derived commodity electricity translates fair amount of underlying fuel's market price of risk
  - As part of energy commodity bundle, oil sentiments spill over
  - Market concentration has double effect on prices
    - Besides potential effect on spot prices it increases forward premium
    - Forward may make spot more competitive – though compensated through premium
  - Significant effects of scarcity, spot vola and skewness ➔ Consistent with risk aversion
- Premium ***complex function*** of fundamental, behavioural, dynamic, market conduct, shock components
  - Analysis in terms of stochastic properties of spots is oversimplification
- Market concentration translates market power effects into premium
  - ***Market monitoring*** implications since forwards have been considered procompetitive
- Reserve ***margin*** plays crucial role ➔ Reduction implies double hit for consumers
- Forward premia should be considered key elements of transaction cost analysis of market efficiency
  - Transparency initiatives indicated (market data availability, short/long positions)
  - EC proposed regulation on energy market integrity and transparency

Thank you for your attention!

For questions / remarks etc. …

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