Perspectives on risk premiums in electricity forward prices

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Ronald Huisman
Erasmus University Rotterdam
rhuisman@ese.eur.nl

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Topics

Discussion on risk premiums based on recent results from the following working papers.

R. Huisman and M. Kilic, 2010, Is Power Production Flexibility a Substitute for Storability? Evidence from Electricity Futures Prices.

R. Huisman, R.A.F. Maliepaard, and R.C.J. Zwinkels, 2010, Heterogeneous Agents in Electricity Forward Markets.

R. Huisman and Y.T.A. ter Huurne, 2010, Electricity Market Design and the Effects on Uncertainty.

Time Varying Risk Premiums and Indirect Storage

R. Huisman and M. Kilic 2010

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Information embedded in futures

Theory of storage

Applicable to storable assets (partially applicable to gas, depending on installed storage capacity, transportation capacity and flexibility).

$$F(T,t) - s(t) = I(T,t) + W(T,t) - C(T,t)$$

$I(T,t)$ = interest rate forgone, $W(T,t)$ = storage costs, $C(T,t)$ = convenience yield

Expectations theory

$$F(T,t) = E_t\{s(T)\} + p(T,t)$$

$p(T,t)$ is the risk premium

Note: risk premium may account for uncertainty in storage costs and convenience yields.

Retrieving information from futures

Fama and French (1987)

$F(T,t) = E_t\{s(T)\} + p(T,t)$

<=>

$F(T,t) - s(t) = E_t\{s(T)\} - s(t) + p(T,t)$

<=>

$F(T,t) - s(t) =$

$E_t\{s(T)\} - s(t) + F(T,t) - E_t\{s(T)\}$

Fama and French propose to do two regressions.

$s(T) - s(t) = \alpha 1 + \beta 1(F(T,t) - s(t)) + \varepsilon(t)$

$F(T,t) - s(T) = \alpha 2 + \beta 2(F(T,t) - s(t)) + \varepsilon(t)$

$\beta 1$ tells to what extent the basis reflects information on future prices

$\beta 2$ tells to what extent the basis reflects the risk premium

For perfectly storable assets, $\beta 1 = 0$.

Fama and French outcomes

No reliable evidence for time-varying risk premiums for

- broilers, eggs, hogs, and oats (at every maturity), cattle, pork bellies, soybeans, and soy meal (some maturities)
- bulk and perishability imply high storage costs (relative to value)
- basis shows seasonals

Reliable evidence for time-varying risk premiums for

- soy oil, lumber (at every maturity), cocoa, corn and wheat (some maturities)

Forecast power and expected premiums for

- orange juice and plywood (forecast power at longer maturities and risk premiums at shorter maturities)

Neither for

- coffee, copper, and cotton (weak), gold, platinum, and silver (unclear)

Risk premiums in electricity

Huisman and Kilic 2010 examine time varying risk premiums in electricity forward prices and the influence of the fuel mix.

Based on 2007 numbers:

NordPool - 53% hydro, 22% nuclear, 11% coal, 5% gas, 9% other

Belgium - 54% nuclear, 2% hydro, 9% coal, 29% gas, 11% other

NL - 4% nuclear, 0% hydro, 28% coal, 57% gas, 11% other

Germany - 22% nuclear, 4% hydro, 49% coal, 11% gas, 13% other

Indirect electricity storage

- hydropower: conversion and uncertain storage (depending on weather conditions)
- fossil fuels: conversion and storage of fuels (coal, gas)

We expect no time-varying risk premiums in NordPool forwards and mixed effects for the fossil fuel markets.

Data

Forwards/futures

Monthly baseload contracts sampled on the first trading day of the month closing prices between 5 January 2004 through 2 June 2008.

Day-Ahead

We assume that day-ahead prices are the spot prices.

BELBEX, EEX, Endex, NordPool

Table 4: **Realized risk premiums.**

Market	**Maturity**	**Mean**	**t value**
APX	M1	4.31	4.44
APX	M2	5.58	4.57
APX	M3	5.55	4.11
APX	M4	4.19	2.78
APX	M5	3.63	2.30
APX	M6	3.38	1.97
BELPEX	M1	2.36	2.00
BELPEX	M2	2.55	1.81
BELPEX	M3	6.83	3.47
EEX	M1	1.96	2.00
EEX	M2	2.25	2.52
EEX	M3	1.65	1.74
EEX	M4	0.79	0.81
EEX	M5	0.34	0.33
EEX	M6	0.23	0.22
NPX	M1	2.61	4.30
NPX	M2	3.84	3.92
NPX	M3	4.29	3.40
NPX	M4	4.74	3.33
NPX	M5	4.99	3.32
NPX	M6	4.91	3.19

Table 3: **Regressions of the spot price change 5 and the risk premium 6 on the basis.**

M1	**Max.**	**Obs.**	β_1	β_2	**t**(β_1)	**t**(β_2)	R_1^2	R_2^2
APX	54	54	0.72	0.28	5.50***	2.12**	0.43	0.10
BELPEX	45	45	0.69	0.31	5.78***	2.55**	0.42	0.12
EEX	65	65	0.70	0.30	6.12***	2.62**	0.43	0.12
NPX	39	39	0.96	0.04	4.04***	0.14	0.30	0.00
M2	**Max.**	**Obs.**	β_1	β_2	**t**(β_1)	**t**(β_2)	R_1^2	R_2^2
APX	54	54	0.76	0.23	5.22***	1.60	0.41	0.06
BELPEX	45	45	0.77	0.23	5.07***	1.53	0.41	0.06
EEX	65	65	0.73	0.27	4.74***	1.72*	0.41	0.09
NPX	39	39	1.04	-0.04	3.64***	-0.16	0.32	0.00
M3	**Max.**	**Obs.**	β_1	β_2	**t**(β_1)	**t**(β_2)	R_1^2	R_2^2
APX	54	54	0.70	0.30	5.33***	2.22**	0.39	0.10
BELPEX	45	30	0.82	0.18	4.63***	1.00	0.46	0.04
EEX	65	65	0.65	0.35	3.61***	1.95*	0.36	0.14
NPX	39	39	0.94	0.06	4.05***	0.27	0.29	0.00
M4	**Max.**	**Obs.**	β_1	β_2	**t**(β_1)	**t**(β_2)	R_1^2	R_2^2
APX	54	48	0.74	0.26	6.42***	2.29**	0.44	0.09
BELPEX	45	–	–	–	–	–	–	–
EEX	65	65	0.67	0.33	3.96***	1.99*	0.37	0.13
NPX	39	39	1.04	-0.04	5.67***	-0.24	0.35	0.00
M5	**Max.**	**Obs.**	β_1	β_2	**t**(β_1)	**t**(β_2)	R_1^2	R_2^2
APX	54	48	0.82	0.18	8.45***	1.83*	0.50	0.04
BELPEX	45	–	–	–	–	–	–	–
EEX	65	65	0.70	0.30	4.61***	1.99*	0.40	0.11
NPX	39	39	1.08	-0.08	5.20***	-0.37	0.37	0.00
M6	**Max.**	**Obs.**	β_1	β_2	**t**(β_1)	**t**(β_2)	R_1^2	R_2^2
APX	54	48	0.83	0.17	7.61***	1.53	0.45	0.03
BELPEX	45	–	–	–	–	–	–	–
EEX	65	65	0.77	0.23	6.12***	1.88*	0.42	0.06
NPX	39	39	1.07	-0.07	4.16***	-0.25	0.37	0.00

The t-statistics $t(\beta_1)$ and $t(\beta_2)$ are based on robust Newey-West Heteroskedasticity

Do Heterogeneous Expectations Explain Power Forward Price Dynamics?

R. Huisman, R.A.F. Maliepaard, and R.C.J. Zwinkels

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Heterogeneous Expectations

The electricity forward price reflects expected future spot prices and a time-varying risk premiums depending on the fuel mix in the market.

$F(T,t) = E_t\{s(T)\} + p(T,t)$

$\Delta F(T,t+1) = F(T,t+1) - F(T,t) = E_{t+1}\{s(T)\} - E_t\{s(t)\} + p(T,t+1) - p(T,t)$

Changes in forward prices are due to changes in expectations about the spot price in de delivery period and changes in the risk premium.

Huisman, Maliepaard, and Zwinkels examine whether electricity future price changes are driven by heterogenous agents.

Relation between price and demand

Assume that the change in the forward price from t to t+1, dP(t), depends on the demand at time t and an error term.

$dP(t) = \theta\, D(t) + \varepsilon(t)$

The demand comes from two types of traders fundamentalists and chartists:

$D(t) = w(t)\, D(c,t) + (1-w(t))\, D(f,t)$

where w(t) is the fraction of fundamental agents at time t.

Fundamentalist expectations

The demand depends on what the fundamentalists expect how the forward prices will change.

$$D(f,t) = a(f)\,[E\{P(t+1),f\} - P(t)]$$

The price expectation of fundamentalists depends on whether the current price of the forward contract differs from the fundamental value (mean-reversion).

$$E\{P(t+1),f\} = P(t) + b(f)\,[P(t) - F(t)]$$

After substitution we have that

$$D(f,t) = a(f)\,b(f)\,[P(t) - F(t)]$$

Chartist expectations

The demand depends on what the chartists expect how the forward prices will change.

$$D(c,t) = a(c)\,[E\{P(t+1),c\} - P(t)]$$

The price expectation of chartists depends on whether the current n period trend in the price will prevail.

$$E\{P(t+1),c\} = P(t) + b(c)\,[P(t) - P(t-n)]$$

After substitution we have that

$$D(c,t) = a(c)\,b(c)\,[P(t) - P(t-n)]$$

Switching strategies

We assume that the number of agents that adopt a chartist strategy changes over time; they adopt that strategy that works best.

Performance of the fundamentalists strategy:

$\pi(f,t) = \Sigma_k \left(E\{P(t-k-1),f\} - P(t-k) \right)^2$

Performance of the chartist strategy:

$\pi(c,t) = \Sigma_k \left(E\{P(t-k-1),c\} - P(t-k) \right)^2$

The weight then depends on the relative performance of the fundamental strategy.

$w(t) = 1 / [1 + \exp\{ \gamma (\pi(c,t) - \pi(f,t)) / (\pi(c,t) + \pi(f,t)) \}]$

The heterogenous agents model

$$\Delta P_t = c + w_t \alpha^{f*}(P_t - F_t) + (1 - w_t)\alpha^{c*} \sum_{i=1}^{I} (P_{t-i+1} - P_{t-i}) + \epsilon_t \qquad (12)$$

$$w_t = \left[1 + \exp\left(\gamma \left(\frac{\pi_t^c - \pi_t^f}{\pi_t^c + \pi_t^f}\right)\right)\right]^{-1}$$

$$\pi_t^c = \sum_{k=1}^{K} (E_{t-k-1}^c(P_{t-k}) - P_{t-k})^2$$

$$\pi_t^f = \sum_{k=1}^{K} (E_{t-k-1}^f(P_{t-k}) - P_{t-k})^2$$

We set I equal to 1 (AR(1) type of expectation by the chartists).

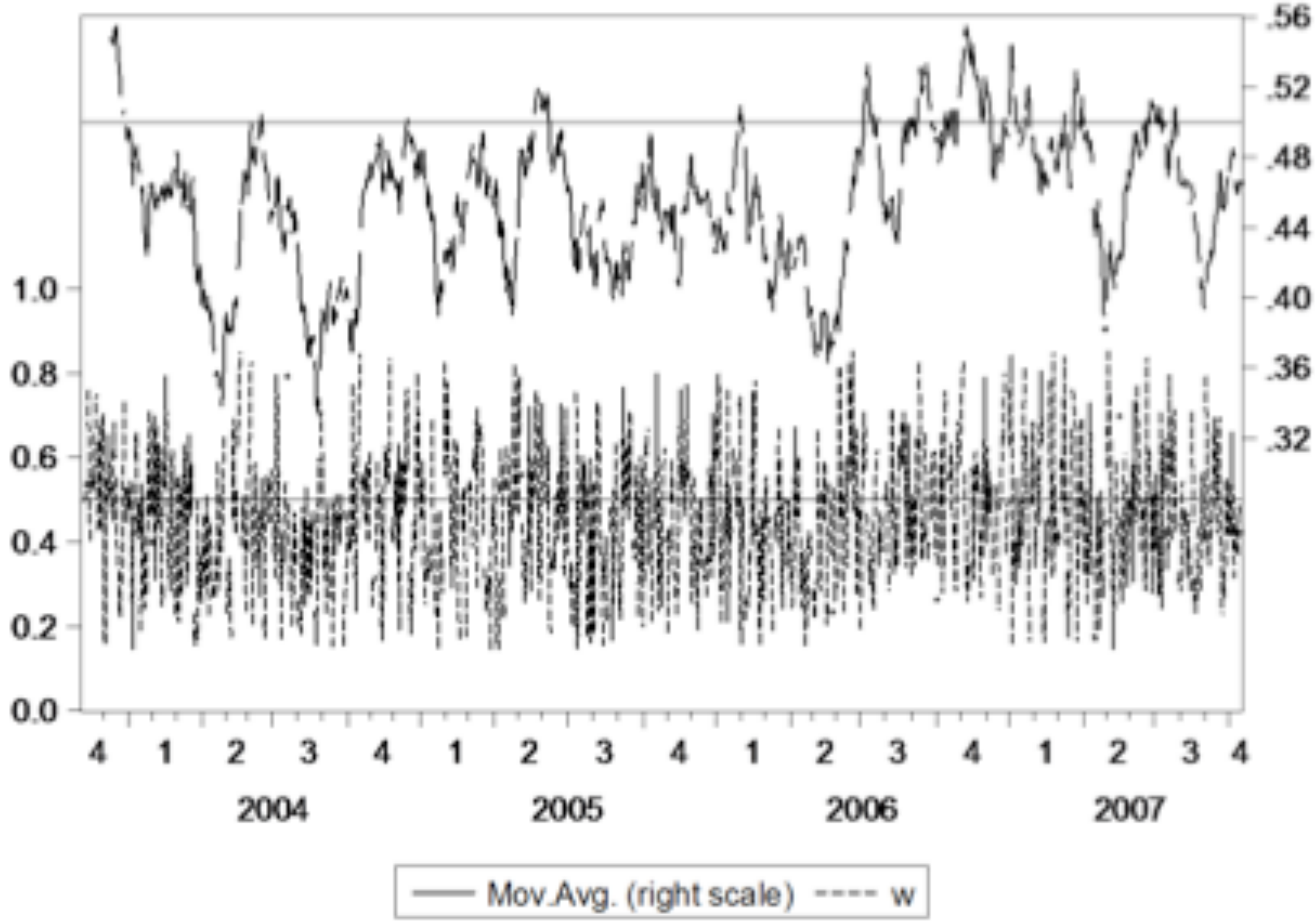
K is set at 2.

The fundamental value is a 3-days moving average.

Table 2: **Parameter estimates**

	APX/Endex		EEX		Nordpool	
	Static	Switching	Static	Switching	Static	Switching
c	0.0005*	0.0005	0.0006*	0.0006*	0.0007	0.0007
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0005)	(0.0005)
α^{f*}	0.0199	-0.5813***	-0.5304***	-0.7139***	0.0492	0.0406
	(0.1660)	(0.1872)	(0.1039)	(0.1204)	(0.2156)	(0.1599)
α^{c*}	0.4563***	0.8032***	0.0716	0.1619**	0.1645	0.1642*
	(0.1281)	(0.1272)	(0.0699)	(0.0781)	(0.1695)	(0.0986)
γ	—	-1.0640***	—	-1.7706**	—	-15.871
		(0.3338)		(0.7528)		(47.627)
$LogL$	2556.86	2562.13	3175.64	3177.57	2098.24	2098.59
$2\Delta LL$	—	10.548***	—	3.850**	—	0.708
AIC	-6.7805	-6.7919	-6.4203	-6.4222	-6.0353	-6.0334
AC	-0.001	-0.012	0.004	0.005	0.000	0.001
AC^2	0.219	0.195	0.368	0.360	0.275	0.270

Figure 5: **Fundamentalists weights EEX**



Microstructure Effects on the Risk Premium

R. Huisman and Y.T.A. ter Huurne

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A Natural Experiment

The Dutch day-ahead market is organized as a call market.

The TSO runs an imbalance market for up to 15 minutes delivery (spot).

A new Intraday/Strips market was introduced on September 14th, 2006. It was designed for parties to fine tune their demand for electricity, and it gives them the opportunity to trade up to two hours before delivery.

On the Intraday market, members can trade products of 15 minutes (a PTU), one hour or two hour blocks, starting the day ahead. The Strips market opens two days before delivery, and is used to trade standardized blocks of hours.

We compare the prices and volumes of hour 1 and 24 delivery on the day-ahead and imbalance markets in the first three quarters of 2006 with those in the first three quarters of 2007.

Day-ahead forward premium

Table 6.5 Forward premia (€/MWh)	2006		2007	
	Forward premium h1	Forward premium h24	Forward premium h1	Forward premium h24
Mean	3.35	-1.92	2.67	7.69
T-statistic within year		1.0025		-3.1698
Probability		0.3166		0.0016
T-statistic between years			0.2349	-2.0585
Probability			0.8144	0.0400
Median	10.41	13.96	4.12	10.04
T-statistic within year		1.1137		3.0034
Probability		0.2654		0.0027
T-statistic between years			2.0706	1.7651
Probability			0.0384	0.0775
Minimum	-192.55	-265.21	-57.23	-44.06
Maximum	102.98	154.71	41.86	40.20
Standard deviation	43.08	75.16	20.14	16.62
F-statistic between years			4.5744	20.4462
Probability			0.0000	0.0000
Skewness	-1.22	-1.22	-0.49	-0.77
Sum	911	-522	726	2092
Observations	272	272	272	272

Imbalance prices

Difference in uncertainty of imbalance prices between 2006 and 2007 disappeared, but 2007 prices were more positively skewed.

Bessembinder and Lemmon (JF, 2002):

$F(t) = E_{t-1}(P(t)) + b\ Var(t) + c\ Skew(t) + e(t)$

where b is negative and c is positive

Table 6.6 Changes in statistics	2006	2007	% change
Stdev WAP hour 1	43.54	19.58	-55.0%
Stdev WAP hour 24	76.96	16.65	-78.4%
Skewness WAP hour 1	1.38	0.44	-68.5%
Skewness WAP hour 24	1.30	0.92	-29.0%