Volatility and Risk Management in European Electricity Futures Markets

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This Paper

- …the efficacy of futures traded on a number of European electricity exchanges in terms of their ability to manage risk through reductions in Variance (Volatility) and a financial risk measure called Value at Risk (VaR)

- Mechanism is hedging

What is Hedging?

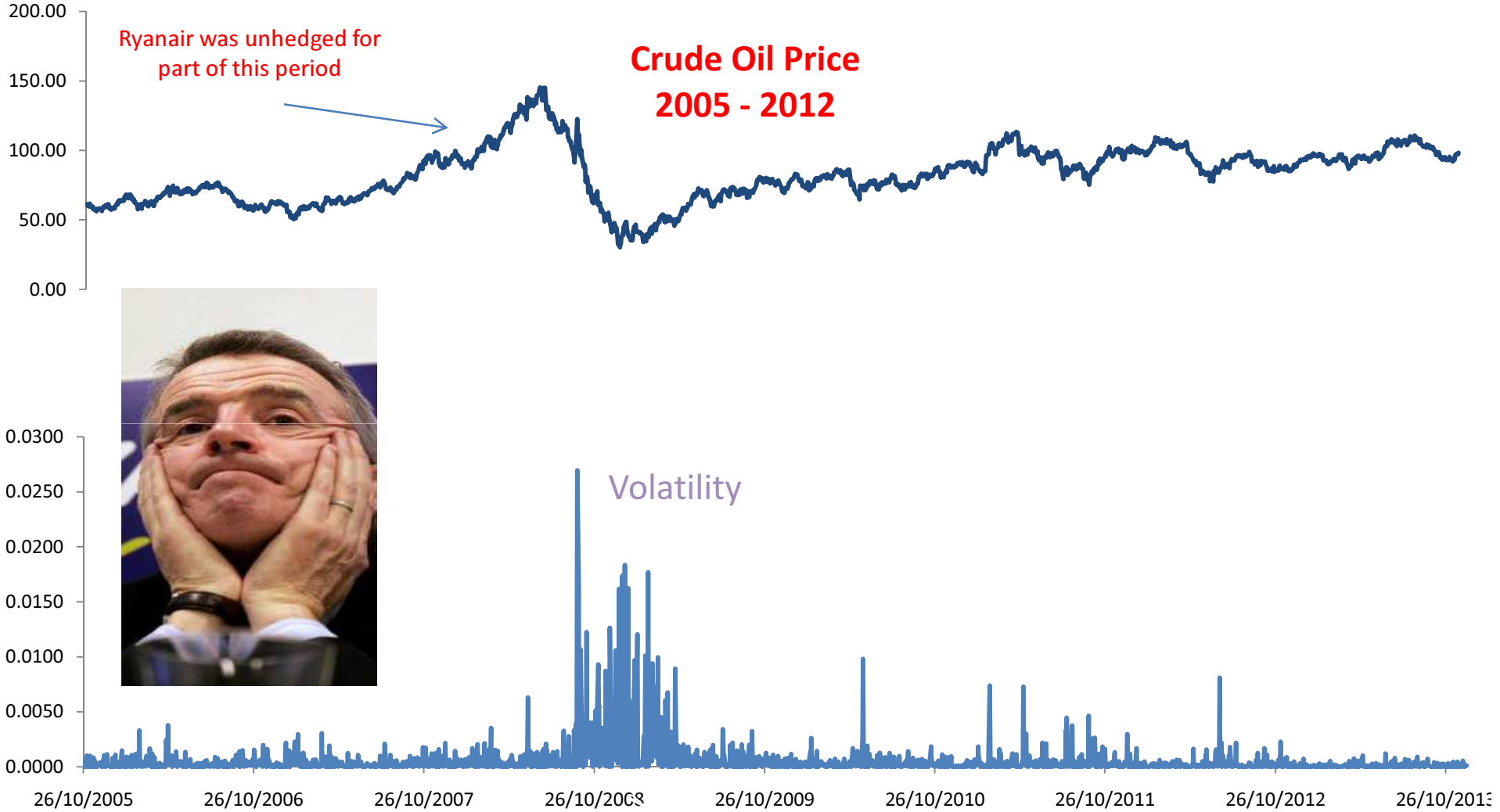
- Hedging is a form of Insurance
- Its purpose is to offset risk
- By risk we could use a variety of measures but in essence it means volatility
- Basic idea is that you find an asset that is highly correlated with the asset you hold and then take an opposite position in that asset

What is Hedging?

- In general a long spot position in an asset where you hold the asset is hedging by taking a short position in the futures contract that best matches the spot asset you wish to hedge

Why Hedge?

WHY HEDGE?



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Motivation for this Paper…

- …large changes in prices and volatility are of particular interest given the challenge they represent for electricity market participants and the need for efficient hedging strategies to deal with them.
- …the persistence of shocks over relatively long periods (monthly)
- …papers in the more general hedging literature have looked at hedging performance but electricity hedging has been neglected in this regard – only a few papers
- …risk metrics have moved on from the more traditional variance based frameworks to include one sided risk measures such as Value at Risk but their use has also been limited in terms of electricity hedging

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The Model

The Optimal Hedge Ratio (OHR) is the ratio that minimises the risk of the payoff of the hedged portfolio which is given by:

$$+ r_{st} - \beta_t \; r_{ft}$$

Where r_{st} and r_{ft}

are the returns on the cash and futures respectively

β_t is the OHR

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OHR Estimation

$$\beta(OHR) = \frac{\sigma_{sft}}{\sigma^2_{ft}}$$

σ_{sft} is the covariance between spot and futures returns

σ^2_{ft} is the variance of futures return

3 Hedging Models

Naïve HR (1:1)

Constant HR
- OLS

Time Varying OHR's
- Dynamic Conditional Correlation GARCH (DCCGARCH)

OHR Estimation

Dynamic Conditional Correlation Model or DCCGARCH model of Engle (2002).

$$y_t = E(y_t|F_{t-1}) + \varepsilon_t, \varepsilon_t = D_t \eta_t$$

$$\text{var}(\varepsilon_t|F_{t-1}) = D_t R D_t$$

$$h_{it} = \omega_i + \sum_{j=1}^{r} \alpha_{ij} \varepsilon_i^2, _{t-j} + \sum_{j=1}^{s} \beta_{ij} h_{i,t-j}$$

$$y_t|F_{t-1} \sim N(0, Qt), t = 1,2,...,n$$

$$Q_t = D_t R D_t$$

OLS model for Constant HR

$$r_{st} = \alpha + \beta r_{ft} + \varepsilon_t$$

Hedging Effectiveness

Hedging effectiveness is measured using four methods

- (HE1) Variance
- (HE2) Value at Risk (99% confidence level)
- We measure the % reduction for each of the above as compared with an unhedged portfolio
- We do this for each of the model based hedges

$$HE = 1 - \left[\frac{RiskMeasure_{HedgedPortfolio}}{RiskMeasure_{UnhedgedPortfolio}} \right]$$

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Data and Estimation

- Three Electricity Contracts
  - NORDPOOL
  - APXUK
  - EEX (PHELIX)
- Two Holding Periods
  - Weekly
  - Monthly

Full Sample

October 15th 2004 to October 1st 2014

In Sample 2005 to 2012

- 365 hedges weekly
- 92 hedges monthly

Out-of Sample 2012 – 2014

- 1-step ahead forecasts
- Random Walk assumed for OLS
- Rolling window for time varying GARCH

Nordpool

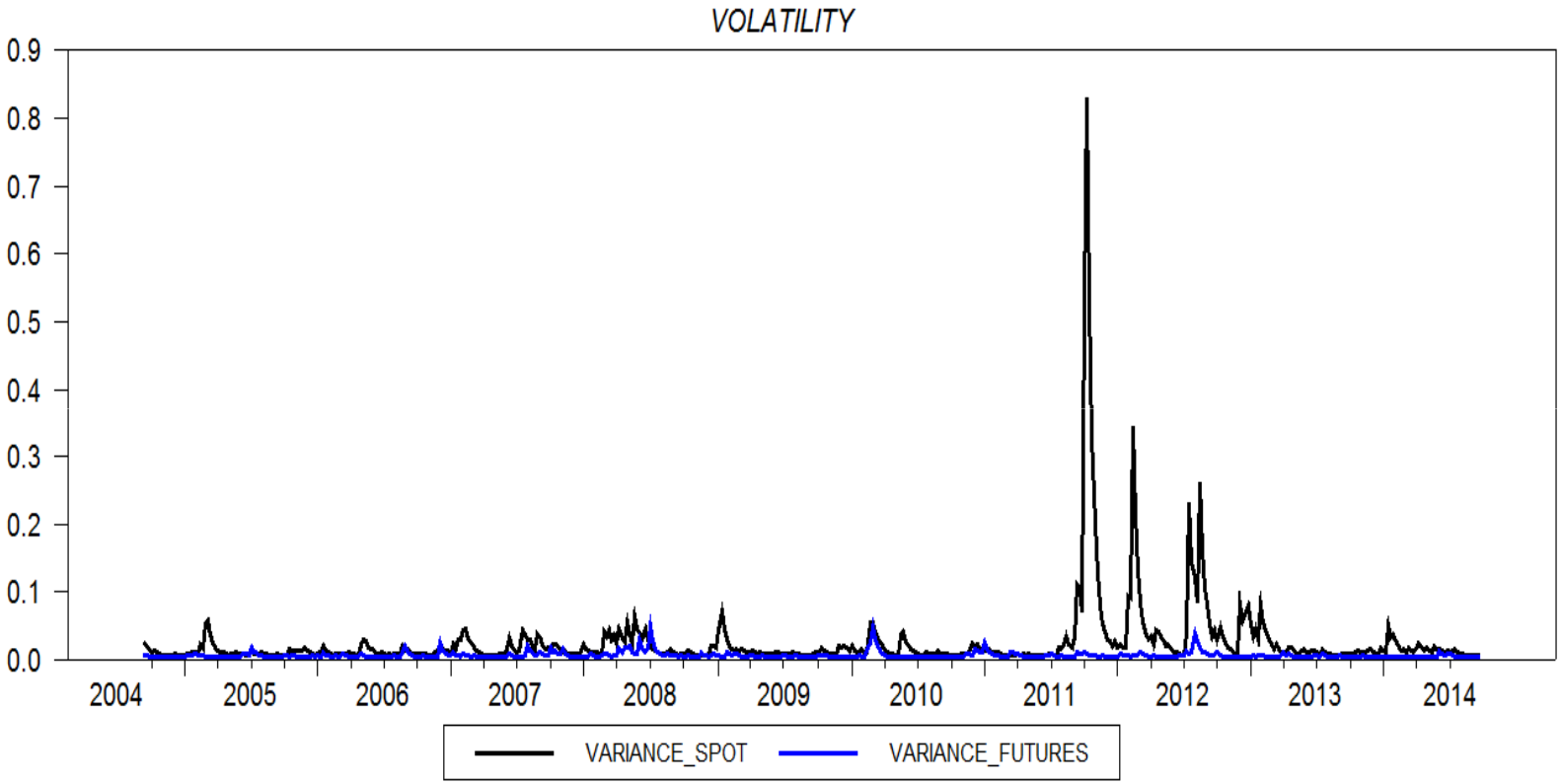
VOLATILITY
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
VARIANCE_SPOT
VARIANCE_FUTURES

Table 1 Descriptive Statistics

	Index	Mean	Std Dev	Skewness	Kurtosis	JB	LM	STATIONARITY				Correlation	
		%	%					ADF	PP	KPSS		Price	Return
NORDPOOL										CONSTANT	TREND		
DAILY	Spot	0.0063	7.87	0.30	11.20	13730.8	212.8	-24.17	-53.72	0.010	0.008	0.900	0.09
	Futures	0.0052	3.51	1.27	17.08	32541.9	5.0	-23.61	-48.16	0.032	0.022		
WEEKLY	Spot	0.0314	15.53	-0.28	19.11	7976.5	84.2	-9.20	-26.03	0.016	0.012	0.894	0.28
	Futures	0.0262	8.19	0.34	3.52	280.0	32.3	-26.03	-24.14	0.039	0.026		
MONTHLY	Spot	0.5776	29.34	0.38	11.22	638.1	33.9	-5.87	-16.66	0.057	0.028	0.8957	0.49
	Futures	0.0702	15.83	-0.38	2.12	25.5	7.2	-5.84	-10.93	0.033	0.030		
APXUK													
DAILY	Spot	0.0268	15.47	0.32	6.39	4496.8	149.2	-31.77	-78.65	0.009	0.005	0.8020	0.16
	Futures	0.0201	2.75	2.17	24.76	68997.8	47.3	-23.84	-48.16	0.051	0.043		
WEEKLY	Spot	0.1339	20.99	-0.31	5.38	640.5	45.8	-14.56	-36.60	0.029	0.015	0.8010	0.28
	Futures	0.1003	6.09	0.26	4.93	536.7	54.3	-7.58	-22.89	0.043	0.036		
MONTHLY	Spot	1.8892	25.72	0.54	6.42	213.6	14.0	-4.39	-16.73	0.263	0.055	0.8250	0.38
	Futures	0.4499	13.18	-0.66	3.88	84.5	33.7	-4.95	-8.19	0.047	0.033		
EEX PHELIX													
DAILY	Spot	0.0151	23.33	-0.05	13.97	21312.5	575.3	-31.86	-84.06	0.004	0.003	0.7110	0.07
	Futures	0.0029	3.32	2.07	38.43	163061.6	9.2	-22.82	-49.69	0.042	0.019		
WEEKLY	Spot	0.0756	29.34	-1.17	11.93	3227.3	59.7	-14.47	-40.60	0.015	0.011	0.7431	0.29
	Futures	0.0146	7.56	0.49	5.21	613.2	28.0	-11.12	-23.43	0.044	0.020		
MONTHLY	Spot	1.6047	36.73	0.27	4.31	95.0	31.5	-6.39	-19.46	0.341	0.054	0.7568	0.41
	Futures	0.1281	15.41	-0.12	0.24	0.6	12.7	-4.99	-12.00	0.058	0.030		
	1% C.V					9.21	13.23	-3.43	-3.43	0.74	0.22		

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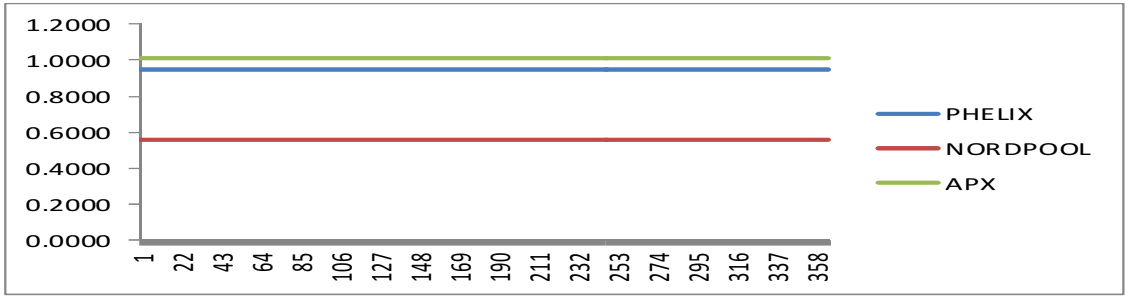
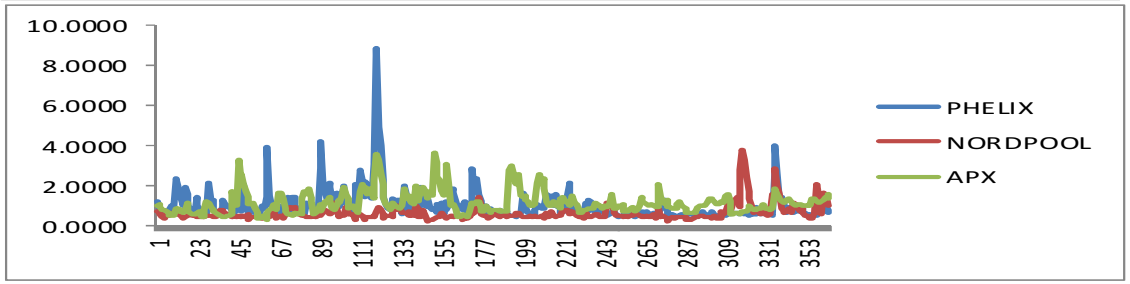
OPTIMAL HEDGES - WEEKLY

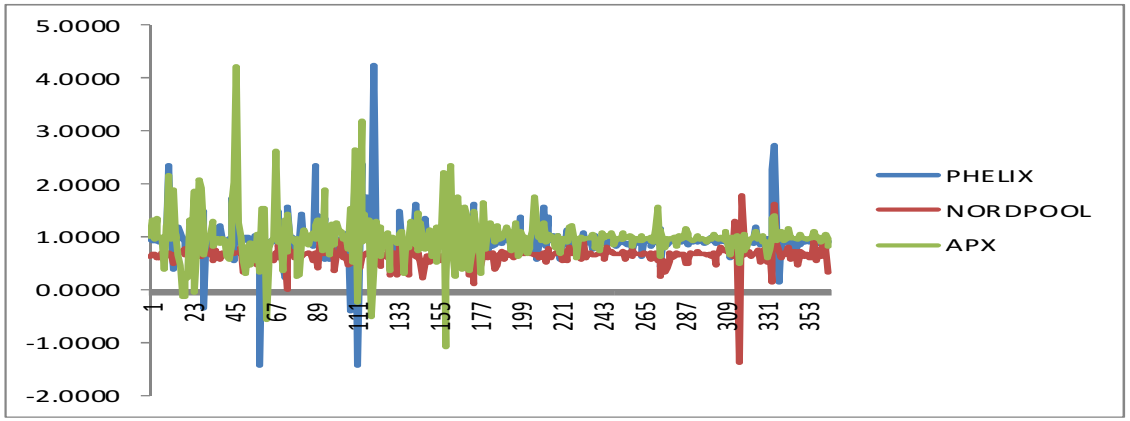
OLS



CCGARCH



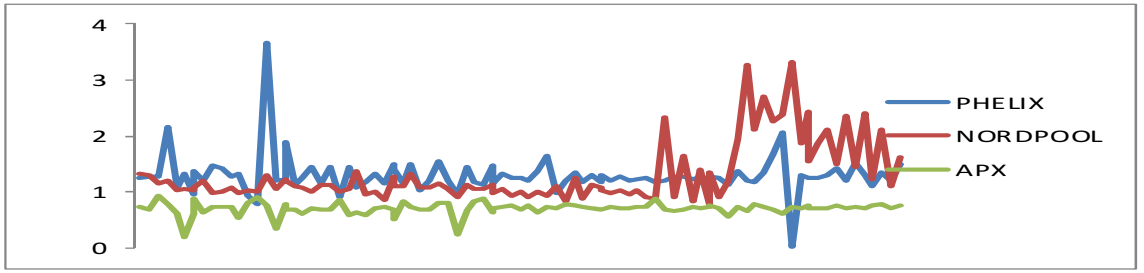
DCCGARCH



OPTIMAL HEDGES - MONTHLY

OLS

CCGARCH



DCCGARCH

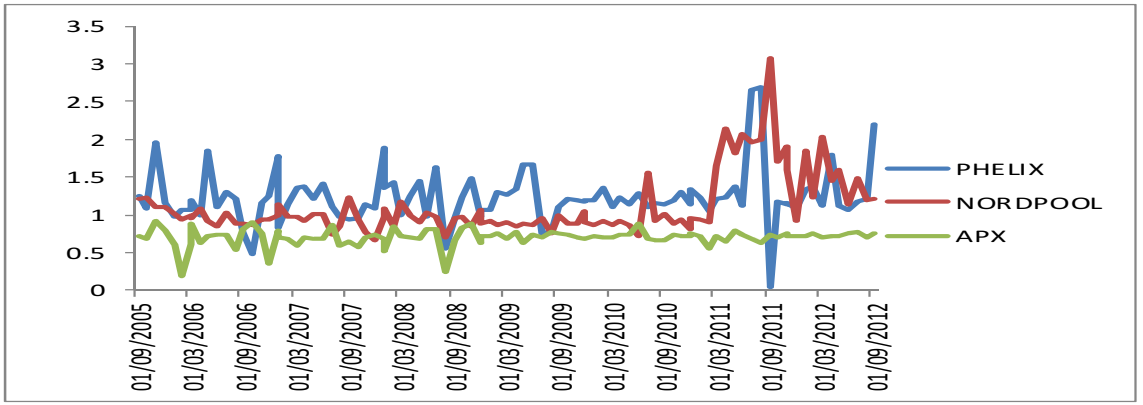


TABLE 2

RISK MEASURES

	WEEKLY				
	NO HEDGE	NAÏVE	OLS	CCGARCH	DCCGARCH
NORDPOOL					
MEAN	-0.0004	-0.0001	-0.0002	0.0000	0.0010
VARIANCE	0.0288	0.0278	0.0263	0.0262	0.0276
VaR	-€ 395,288	-€ 388,305	-€ 377,439	-€ 376,656	-€ 385,805
APKUK					
MEAN	0.0004	0.0002	0.0002	-0.0025	0.0040
VARIANCE	0.0536	0.0492	0.0492	0.0505	0.0486
VaR	-€ 538,258	-€ 515,982	-€ 515,979	-€ 525,066	-€ 509,018
PHELIX					
MEAN	0.0001	0.0002	0.0002	-0.0013	-0.0008
VARIANCE	0.0777	0.0715	0.0715	0.0779	0.0752
VaR	-€ 648,492	-€ 621,914	-€ 621,841	-€ 650,505	-€ 638,869
	MONTHLY				
	NO HEDGE	NAÏVE	OLS	CCGARCH	DCCGARCH
NORDPOOL					
MEAN	0.0000	-0.0022	-0.0019	-0.0010	0.0046
VARIANCE	0.1020	0.0771	0.0769	0.0790	0.0741
VaR	-€ 742,901	-€ 648,254	-€ 646,834	-€ 654,864	-€ 628,562
APKUK					
MEAN	0.0013	-0.0002	0.0003	-0.0050	0.0013
VARIANCE	0.0676	0.0574	0.0558	0.0578	0.0544
VaR	-€ 603,683	-€ 557,538	-€ 549,238	-€ 564,390	-€ 541,296
PHELIX					
MEAN	-0.0074	-0.0066	-0.0067	0.0084	-0.0014
VARIANCE	0.0979	0.0745	0.0744	0.0981	0.0811
VaR	-€ 735,341	-€ 641,801	-€ 641,252	-€ 720,118	-€ 663,897

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TABLE 3 – HEDGING PERFORMANCE

	IN-SAMPLE								
	WEEKLY					MONTHLY			
	NAÏVE	OLS	CCGARCH	DCCGARCH		NAÏVE	OLS	CCGARCH	DCCGARCH
HE1 - Variance									
NORDPOOL	3.38	8.77	9.01	4.08		24.37	24.65	22.54	27.37
APXUK	8.18	8.19	5.88	9.30		15.13	17.51	14.53	19.56
PHELIX	8.01	8.03	-0.19	3.23		23.87	24.02	-0.15	17.17
HE2 - VaR									
NORDPOOL	1.77	4.52	4.71	2.40		12.74	12.93	11.85	15.39
APXUK	4.14	4.14	2.45	5.43		7.64	9.02	6.51	10.33
PHELIX	4.10	4.11	-0.31	1.48		12.72	12.80	2.07	9.72

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TABLE 4 – HEDGING PERFORMANCE OF MAINSTREAM ENERGY COMMODITIES

	IN-SAMPLE								
	WEEKLY					MONTHLY			
	NAÏVE	OLS	CCGARCH	DCCGARCH		NAÏVE	OLS	CCGARCH	DCCGARCH
HE1 - Variance									
WTI	96.44	96.47	96.60	96.77		99.57	99.58	99.59	99.60
HEATINGOIL	93.62	93.63	93.28	93.11		97.50	97.50	97.51	97.52
NATURAL GAS	33.55	42.59	41.70	42.23		87.23	87.23	87.70	87.78
HE2 - VaR									
WTI	80.90	80.96	81.10	81.64		87.76	87.61	87.54	87.57
HEATINGOIL	74.44	74.48	73.98	73.73		76.59	76.53	76.57	76.59
NATURAL GAS	20.74	25.44	25.37	25.65		45.67	45.79	44.85	46.78

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CONCLUSIONS

Large differences in optimal hedges and hedging performance between the different electricity markets

Poor hedging performance across models and markets at the weekly frequency with risk reduction of the order of 8 % - 9 % as measured by the variance and even lower for VaR

Better performance at monthly frequency but still far short of conventional energy commodities

Futures are of limited use for risk management of electricity price risk