Oil, Gas and Electricity Prices in US and in Europe

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RESEARCH CENTRE FOR ENERGY MANAGEMENT

Outline

- The energy markets
- Some literature
- The methodology
- The dataset
- Some results
- Conclusions

The energy markets

- During the last 10 years the energy sector has seen a broad transformation,which has led energy commodities to assume a strategic role in the global economy.
- Electricity and gas industries, moving from central owned systems to liberalized ones, had a deep impact on the financial choices. So, they required a stronger attention in order to develop new risk management strategies.
- The crude oil market has been also experiencing serious changes over the last decade caused by economic, thecnological and political issues.

The energy markets in EU

The factors determining future energy demand in the EU27 include:

- continued economic growth of more than 2% p.a.,
- hardly any rise in population;
- oil prices remaining at a high level;
- gas prices determined by market forces;
- increased environmental awareness in politics and among consumers;
- growing trend to save energy and to improve energy efficiency;
- thoughts at national level to use nuclear energy and expand the use of renewables.

The energy prices in EU

The price of energy in the EU depends on

- a range of different supply and demand conditions, including the geopolitical situation,
- import diversification,
- network costs,
- environmental protection costs,
- severe weather conditions,
- levels of excise and taxation

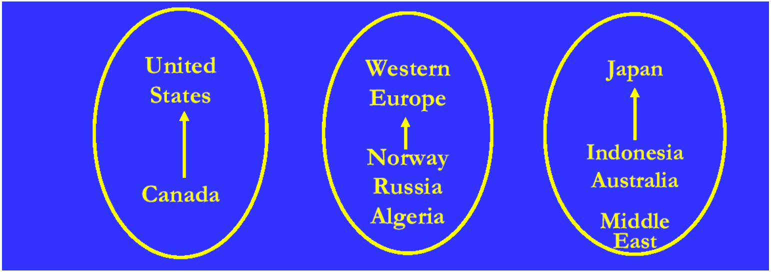
Relationships among prices?

The dynamics of natural gas, fuel oil, and power prices are expected to be related for several reasons.

- Fuel oil and natural gas, for example, are used as substitutes in industrial boiler, and oil and natural gas are used as peaking sources of supply for power generation for cooling loads in the summer and for heating loads in the winter.
- All these types of energy directly serve space heating demands during the winter.
- wholesale prices for these sources of energy are expected to respond similarly to different types of shocks.
- ....??

The gas markets

Until recently, three regional markets could be identified in the world, with limited trade between them because of the cost of transportation of gas over long distances



Increased LNG transport should help breaking down the barriers to current world segmentation

The major revolution; Shale gas

The gas markets volatility

Volatility in the markets for various forms of energy is nothing new.
Prices react to weather, political and economic developments, and speculation.
Short term prices of individual commodities can be influenced by any of these factors.
One measure is the relative price of natural gas compared to crude oil.
1 bbl crude oil has approximately 6 times the energy content of one thousand cubic feet (mcf) of natural gas.
The pricing relationship between oil and natural gas is almost never exactly 6:1.
Oil used to be a global commodity while natural gas is generally considered a commodity that is more influenced by local production and consumption trends.

The oil/gas ratio

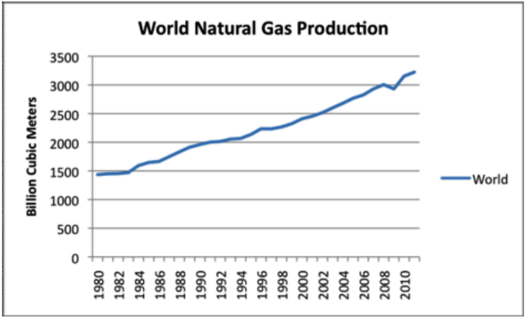
Ratio of one barrel of WTI crude oil to one mcf of natural gas since Jan'08

The oil/gas ratio

The current spike in the ratio has been caused by crude oil prices sustaining a move above the $80 per barrel level.
Natural gas prices have collapsed due to:

- the arrival of warmer weather,
- reports of plentiful inventories,
- continued high expectations for increased productions from unconventional domestic sources such as shale extraction.

The gas production



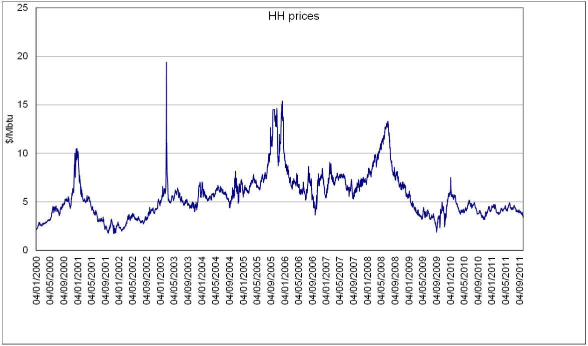
Gas price?

$6 Natural Gas to Earn a 5 to 10 Percent Return?
Investors also believe that the industry may be drilling its way to $2 to $4 gas.
Shale gas is far more expensive to extract compared to conventional sources.
In the short run, it appears that the increased production of natural gas is likely to continue depressing the price of the fuel relative to crude oil.
The ratio of a barrel of crude to one mcf of natural gas can remain at 20 or above.
In the past, prices of natural gas and oil have adjusted to result in a ratio that is more normally between 10 to 15.
This may present an interesting arbitrage opportunity for those inclined to pursue such strategies.

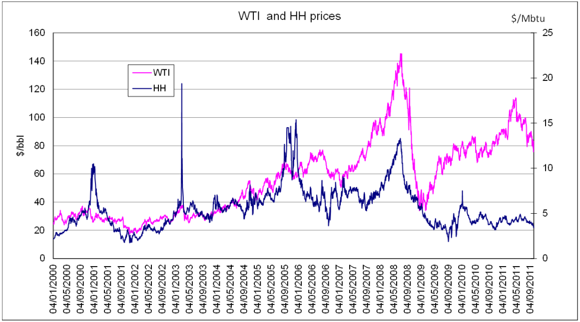
Some hypotesis

- Increased domestic supply by independents shifting from shale gas to shale oil is not likely to materially impact the price of crude oil but could potentially have a more significant impact on the supply of U.S. natural gas production.
- lower domestic supplies of natural gas could result in a greater impact to U.S. gas prices versus the impact of increased shale oil production on global oil prices.
- for investors interested in natural gas, owning shares of low cost producers able to make money even in the current low pricing environment could mitigate risk while providing benefits in the event of higher gas prices in the long run.

Price dynamics in US



Price dynamics in US



Gas and Power generation in EU

- The role of natural gas for power generation has increased significantly, ever since the 1990s.
- Gas-fired power stations produce 1/5 of the electricity in the EU27 (7.5% in 1990).
- The present situation for gas is heterogeneous between the individual member states.
- Developments depend on the energy policy (mainly nuclear) of the individual countries, the integration of renewables in electricity generation and the evolution of the European trading scheme.
- The price of gas will determine the load factor in which gas-fired power generation may/will be used.

LNG role

LNG will globalize the gas market and open further potential gas sources for Europe.

A number of new LNG terminals are under construction, while existing terminals are expanded.

The regasification capacity in Europe from 2005 to 2010 doubled.

In the long term LNG could represent 25% of the total EU supplies.

Whether or not it proves possible in the future to mobilise gas reserves and direct them towards European markets finally depends on the general framework for the energy industry on sales markets, on the availability of investments as well as on how the market value obtainable for gas develops in the course of time.

UK interconnector

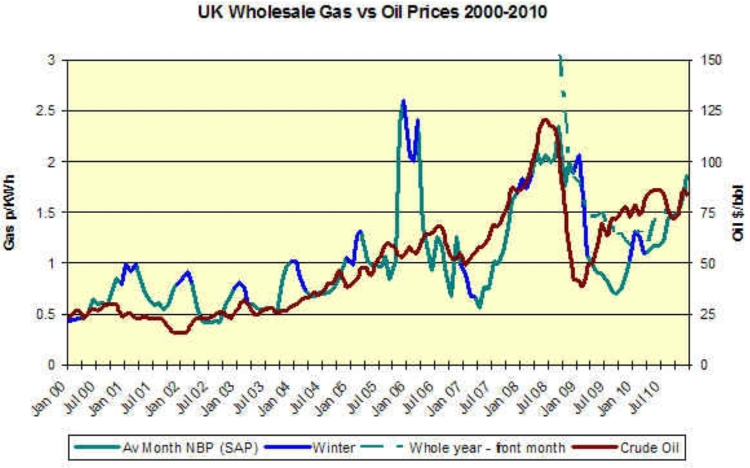
UK Wholesale Gas is traded at the National Balancing Point (NBP)
There are two liquid exchanges - APX (on-the-day trading) and ICE (futures contracts).
The NBP, is a virtual trading location for the sale and purchase and exchange of UK natural gas. It is the pricing and delivery point for the ICE natural gas futures contract
Gas at the NBP trades in pence per therm.
It is similar to the Henry Hub in the United States - but differs in that it is not an actual physical location.

UK prices

Over the last two years the oil price led the UK daily gas price upwards. The price seasonality (winter prices have been higher due to the use of expensive storage etc) seems to have largely disappeared, even with the cold weather in 2009.

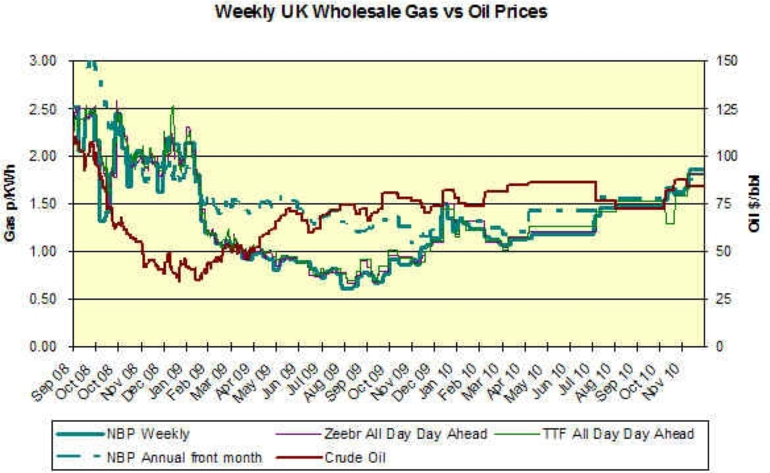
The price of wholesale gas is now one third of what it was in September 2008, tumbling after the oil price.

UK prices



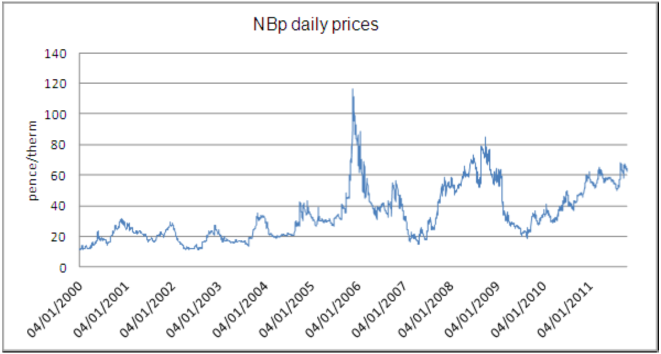
source http://sshassociates.co.uk/nbp.aspx

UK prices



source

UK prices



NBp daily prices
pence/therm
140
120
100
80
60
40
20
0
04/01/2000
04/01/2001
04/01/2002
04/01/2003
04/01/2004
04/01/2005
04/01/2006
04/01/2007
04/01/2008
04/01/2009
04/01/2010
04/01/2011

The oil markets

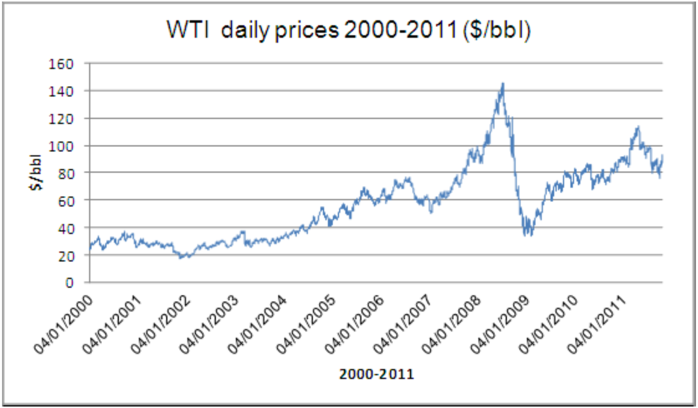
Do oil price increase for a speculative bubbles or simply reflects fundamental factors?

They do not passively reflect the fundamental conditions of demand and supply

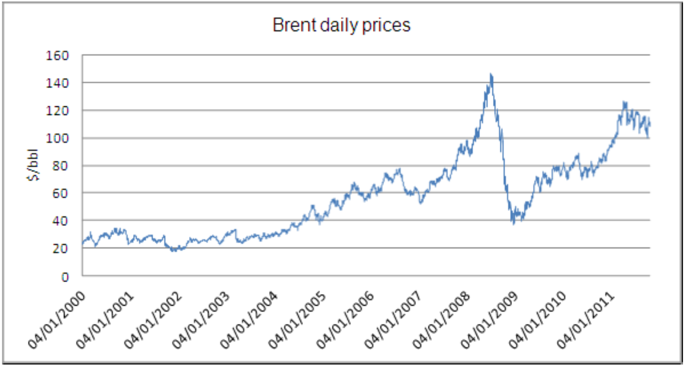
There is first some fundamental change, such as the increase in demand from emerging countries...

There is a misinterpretation of the new trend in prices that results from the change and this may cause speculative activity (bubble).

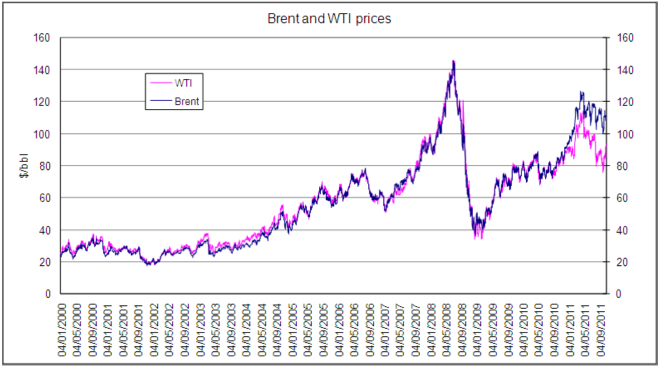
The oil markets US



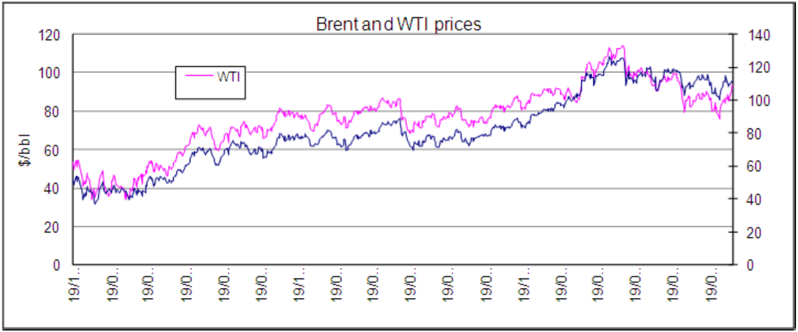
The oil markets EU



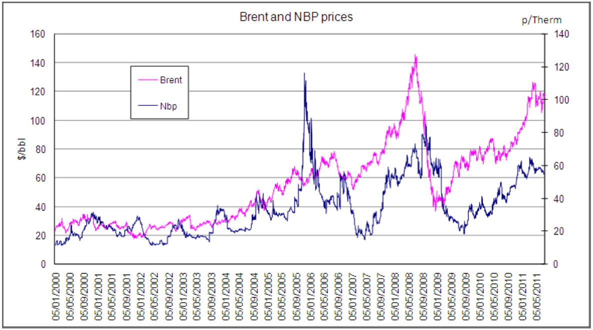
global oil market?



global oil market?



gas and oil market in Europe?



The Electricity Market

The introduction of competition in the electricity industry has been justified by the perceived benefits of introducing market forces in an industry previously viewed as monopoly.
Electricity a very special commodity:

1. Electrical energy cannot be stored (with the exception of hydroelectric power);
2. electricity must be generated at the instant it is consumed;
3. It has to be transported in a transmission network;no alternative;
4. the demand is highly inelastic very sensitive to weather conditions;
5. generation (supply) is characterized by generators with low marginal costs emergency units with high marginal costs

The Electricity Market

The price and reliability of energy supplies, electricity in particular, are key elements in a country's energy supply strategy.

Electricity prices are of particular importance for international competitiveness

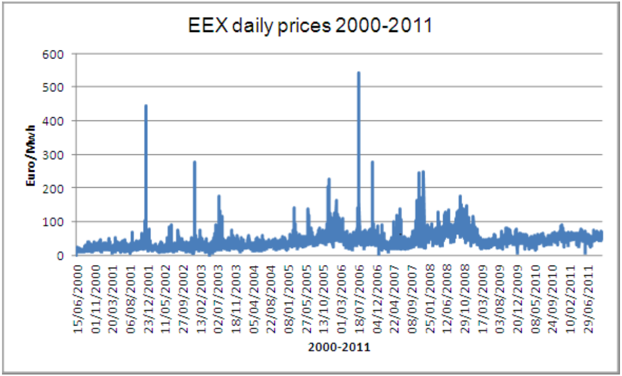
In contrast to the price of fossil fuels, which are usually traded on global markets with relatively uniform prices, there is a wider range of prices within the EU Member States for electricity or natural gas.

The price of electricity and natural gas is, to some degree, influenced by the price of primary fuels and, more recently, by the cost of carbon dioxide (CO2) emission certificates.

The Electricity Market

- It is a substitute for oil and gas.
- Can be produced using both commodities
- a competitive market for electricity implies that spot market prices may promptly respond to price changes in input fuel source markets. Oil and gas prices should be integrated with electricity prices.

The EEX prices



PJM Power market

PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia, an area that includes more than 51 million people. As of December 31, 2009, it had installed generating capacity of 167,326 megawatts (GW) and over 500 market buyers, sellers and traders of electricity. In 2009 demand peaked at 126.8 MW on August 10, the lowest annual peak since the last transmission integration.

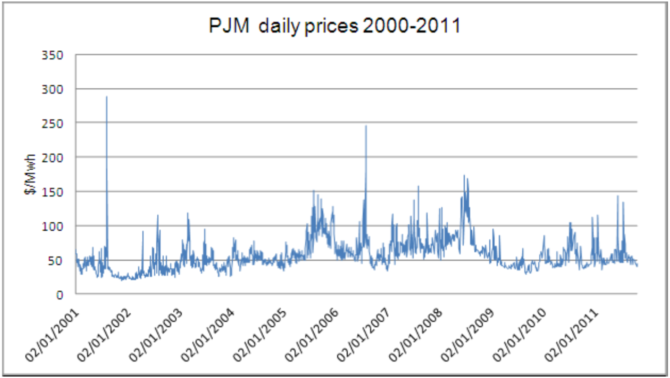
Marginal fuel type: *Coal (74%) and natural gas (22%)*

Generating capacity (summer 2009): 167,454 MW

Capacity reserve (summer 2009): 40,649 MW

Reserve margin (summer 2009): 32%

PJM Power prices



The relationship

- To investigate the short and long run relationship between energy commodity prices;
- A rolling correlation analysis is first performed among each pair of commodities.
- To estimate a possible integration of energy markets.
- To use a cointegration framework to investigate a possible meaningful relationship among energy commodities

Literature Review

Over the period 1996-2003 evidences of relationship among gas prices and oil prices

- **Gjølberg and Johnsen (1998)**: analyze co-movements between the prices of crude oil and major refined products during the period 1992-98. they study a long-run equilibrium price relationships, and whether deviations from the estimated equilibrium can be utilized for predictions of short-term price changes and for risk management.
- **Panagiotidis and Rutledge (2006)**: (1996-2003) investigate whether oil and gas decoupled. The existence of a cointegration relationship prior to the inauguration of the Interconnector indicates that despite the highly liberalized nature of UK gas market, gas prices and oil prices are moving together in the long-run

Literature Review

- **Bachemeir and Griffin (2006):** evaluate the degree of market integration both among and between crude oil, coal, and natural gas market. (ECM) framework to daily price data they find that crude oils from around the world trade in a highly integrated world market. Finally, they find that oil and natural gas are cointegrated in the long run and exhibit stronger evidence of market integration.

Literature Review

Based on US data

- **Hartley, Medlock and Rosthal (2007)**; evidence of cointegration relationship. find that seasonal fluctuations and other factors such as weather shocks and changes in storage have significant influence on the short run dynamic adjustment of prices. In addition they perform an ECM to include shocks as stationary exogenous variables and consider technology rather than a time trend as an explanatory factor in the evolving relationship.
- **Brown and Yucel (2007):** evidence of a cointegration relationship. They also find that short run deviations from the estimated long run relationship could be explained by influence of weather, seasonality, natural gas storage, and production in the Gulf of Mexico.A complete understanding of the long and short run

- **Villar and Joutz (2006)**: cointegration relationship between them despite periods where they may have appeared to decouple. A statistically significant trend term is found: natural gas prices grow at a slightly faster rate than crude oil prices. The prices exhibit a long run relationship that is slowly evolving rather than constant. While oil prices may influence the natural gas price, the impact of natural gas prices on the oil price is negligible.

Literature Review

The relationship between electricity and fossil fuel prices (2000-on)
European DATA

- Gjolberg (2001): assumes the existence of a medium and long term correlation between electricity and fuel oil, since they are to some extent substitutes, but not perfectly substitutes given the considerable constraints related to technology, storage and transportation. This is technically equivalent to have cointegrated prices.
- Asche, Osmudsen and Sandsmark (2006): investigate the dynamic of gas, oil and electricity during an interim period 1995-1998 - after deregulation of the UK gas market (1995) and the opening up of the Interconnector (1998). Cointegration between natural gas, crude oil and electricity prices is found and a leading role of crude oil is also identified. Monthly price data for the period 1995-1998 indicates a highly energy integrated market where wholesale demand refers to energy commodities more than a specific source.

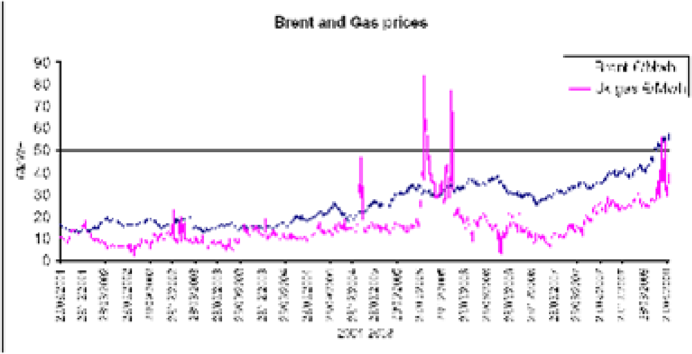
Literature Review

- Bosco et al. (2006): examine electricity price interdependencies at European level analyzing the main electricity exchanges for the period 2004-2006. They find the presence of strong integration among various European exchanges (APX, EEX, EXAA and Powernext) and the presence of a common trend among electricity prices which is in turn cointegrated

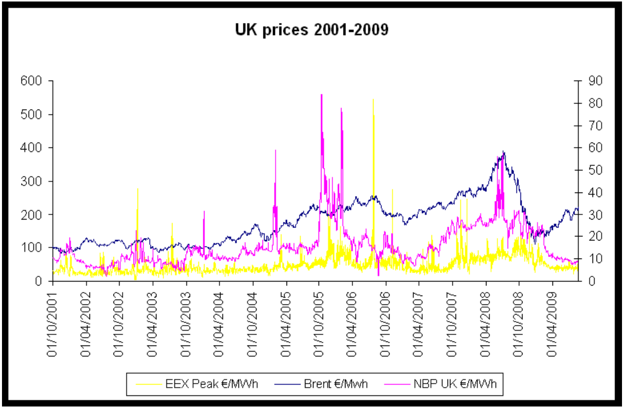
US DATA

- Serletis et al.(1999), use North America natural gas, oil and power prices from 1996 to 1997 to find a cointegrating relationship between them.
- Mjelde and Bessler (2009);using a multivariate time series framework and prices from two diverse markets: PJM and Mid-Columbia (Mid-C), and four major fuel sources: natural gas, crude oil, coal, and uranium find that the eight price series are cointegrated. However, they are not able to detect one single source of randomness (one common trend) but find that fuel source prices move electricity prices.
- Mohammadi (2009): They find that the three fossil fuels (coal, natural gas and crude oil) do not affect electricity prices significantly. Significant long-run relationships are found only between electricity and coal prices.

Price Dynamics



Price Dynamics



The methodology

- Analysis of the stationarity of the data.
- Analysis of correlation: Rolling correlation, $\rho_s(x, y)$, over a window of 100 days or 250 days (Eydeland (2003) for the period 2001-11 is estimated for each pair of commodities (Elect;gas)(Elect;oil), (gas;oil):
- The long run relationship is analyzed using:
  - a VECM framework (Johansen)
  - an ECM approach (Granger and Engle).

The stationarity analysis

We test the order of integration using the Augmented Dickey-Fuller (ADF) type regression:

$$\Delta y_t = \alpha_0 + \alpha_1 t + \gamma y_{t-1} + \sum_{j=1}^{k} \beta_j \Delta y_{t-j} + \epsilon_t \quad (1)$$

where $\Delta y_t = y_t - y_{t\text{-}1}$ and the lag length k is automatic based on Scharwz information criterion (SIC).

We run the test without any exogenous variable, with a constant and a constant plus a linear time trend as exogenous variables

The rolling correlation approach

Rolling correlation over $\tau_j = 100$ and $\tau_j = 250$ days is estimated to measure the short term relationships according to:

$$\rho_s[x, y] = \frac{\frac{1}{\tau_j - 1}\sum_{i=s}^{s+\tau_j}(x_i - \widehat{x})(y_i - \widehat{y})}{\widehat{\sigma}_x\widehat{\sigma}_y} \qquad s = 1, ..., T - \tau_j$$

where the entire period 2001-2011 is made by T observations, $\widehat{\sigma}_x$ $\widehat{\sigma}_y$ are the standard deviation of x and y, estimated on the corresponding time window.

Cointegration framework (long run)

- If two or more series are non-stationary, a linear combination of them may be stationary. In this case the series are said cointegrated.
- Several tests may be used to test the presence of cointegration amon various time series:
  - The Johansen and Stock and Watson , based on VAR, to find all possible cointegrating relationships.
  - The Engle-Granger method, to assess whether single equation estimates of the equilibrium errors are stationary, tests the cointegration among two variables and allows to understand the relationship between each pair of commodities.

Johansen Method (long run)

To examine the number of cointegrating vectors we estimate a vector error correction model (VECM) based on the so called reduced rank regression method .

Assume that the n-vector of non-stationary $I(1)$ variables Y_t follows a vector autoregressive (VAR) process of order p

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + \epsilon_t \quad (2)$$

with ϵ_t as the correponding n-dimensional white noise, and nxn A_i matrices of coefficients.

The VECM framework (long run)

(2) is equivalently written in a VECM framework,

$$\Delta Y_t = D_1 \Delta Y_{t-1} + D_2 \Delta Y_{t-2} + ... + D_p \Delta Y_{t-p} + \epsilon_t \tag{3}$$

with $D_1 = -(A_{i+1} + ... + A_p)$ $i = 1, 2, ...p - 1$. and
$D = (A_1 + .. + A_p - I_n)$
The Granger's representation theorem asserts that if D has reduced rank $r \in (0, n)$, then $n \times r$ matrices Γ and B exist, each with rank r, such that $D = -\Gamma B'$ and $B' Y_t$ is $I(0)$. r is the number of cointegrating relations and the coefficients of the cointegrating vectors are reported in the columns of B.

The ECM framework (long run)

To better analyze the dynamics of the markets we use the Engle-Granger two-step methodology.
This method follows two steps:

- estimating the parameters of the cointegrating vector,
- using the parameters in the Error Correction form:

$$y_{1,t} = \alpha + \beta y_{2,t} + z_t \tag{4}$$

is estimated only to fit the long run or equilibrium relationship. The coefficients β's in Eq.4, which represent the factors of proportionality for the common trend, are estimated by ordinary least squares (OLS), getting the linear combination with the smallest variance. OLS estimates provide consistent coefficients of long run model but standard errors are unreliable.

The ECM framework (long run)

The OLS residuals z_t estimates of the equilibrium errors.
In step 2, the OLS residuals are tested for stationarity using the ADF test with critical values compared with MacKinnon tables.
The basic ECM (Engle and Granger) is commonly used to investigate the degree of integration among different markets.
The basic ECM, focusing on the pairwise series analysis, has the merit to be more transparent and elegant than its generalization, VECM (Bachmeier and Griffin): if two markets are integrated, prices tend to be affected by common factors, therefore price changes in one market tend to be linked with price changes in the second market.

The ECM framework (long run)

The advantage of the ECM is that it tests not only for the existence of a long run equilibrium relationship between two variables, like the standard tests for cointegration, but it also provides summary statistics on the degree of the market integration.

$$\Delta y_{1,t} = \phi \Delta y_{2,t} + \theta \left(y_{1,t-1} - \alpha - \beta y_{2,t-1} \right) + \epsilon_t \tag{5}$$

where $\left(y_{1,t-1} - \alpha - \beta y_{2,t-1} \right)$ represents the error correction term $z_{t,1}$, ϕ measures the contemporaneous price response, θ represents the speed of the adjustment towards the long term cointegrating relationship, and ϵ_t is $i.i.dN(0, \Sigma)$.

The US and European daily prices for natural gas, crude oil and electricity are used.
Period October 2001-December 2011 for both markets.

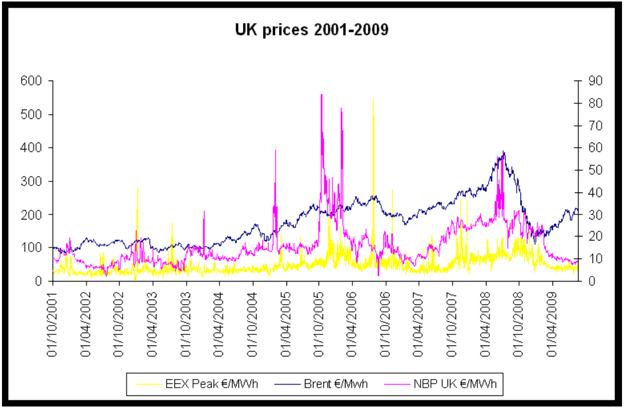
- The European dataset is made by daily prices for ICE Brent crude oil, for natural gas at the National Balancing Point (NBP), and for European Energy Exchange (EEX) electricity.
- The US dataset is made by daily prices data for natural gas at the Henry Hub (HH, West Texas Internediate (WTI) for crude oil and Pennsylvania, New Jersey, Maryland (PJM) electricity.

Conversion factors

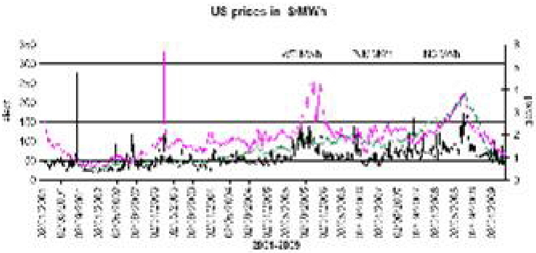
All prices are converted in €/MWh using the conversion factors for energy content provided by the EIA:

- 1 barrel of crude oil is equal to 0.136 tons of oil equivalent (toe),
- 1 toe=39.68 MBtu and
- 1MBtu=293.1 kilowatt hour (KWh)
- the daily series of US$/€ exchange rates.

Price Dynamic EU



Price Dynamic US



The statistical features EU

Table 1. Descriptive Statistics for crude oil, natural gas and electricity time series (1749 observations in all). Data expressed in €/MWh.

Series	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis
Oil	22.40978	19.55279	38.61227	12.59362	6.964128	0.594954	1.981763
Gas	17.08501	17.06196	43.92360	6.763734	6.063457	1.529624	6.254072
Elect.	45.76490	38.48000	543.7200	0.800000	30.71776	6.300120	74.90917

The results of stationarity

Table 1
Unit root test results for the logged EU price series.

Series	t_γ	τ_0	τ_1	τ_d	Decision
Brent	0.36 (1)	−1.56 (1)	−1.46 (1)	−48.4 (0)	I(1)
NBP	−0.54 (6)	−3.44** (6)	−5.82** (2)	−22.7 (5)	I(1)
EEX	−0.19 (14)	−3.40* (15)	−4.75** (15)	−20.4 (13)	I(1)

Table 2
Unit root test results for the logged US price series.

Series	t_γ	τ_0	τ_1	τ_d	Decision
WTI	0.57 (1)	−1.64 (1)	−1.48 (1)	−46.7 (0)	I(1)
HH	−0.46 (2)	−3.02* (2)	−2.71 (2)	−37.7 (1)	I(1)
PJM	−0.28 (6)	−4.45** (6)	−5.76** (6)	−26.5 (5)	I(1)

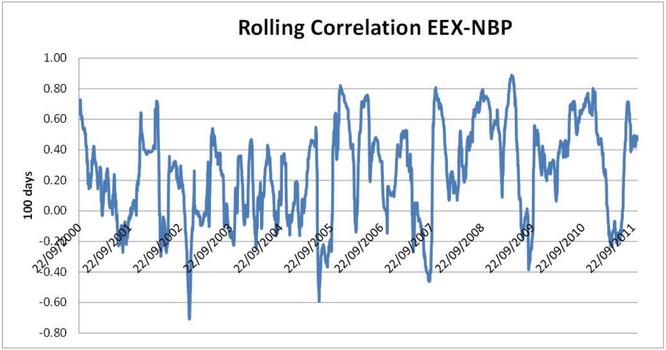
The short run relationship

Rolling Correlation in Europe T=1897

Elec Oil	Elec Gas	Oil Gas
Mean over the period		
-0.0226	0.6039	-0.1279
DevSt		
0.462	0.103	0.360
Max		
0.304	0.676	0.126
Min		
-0.349	0.531	-0.382
Unconditional Correlation		
0.6131	**0.3270**	**0.6777**

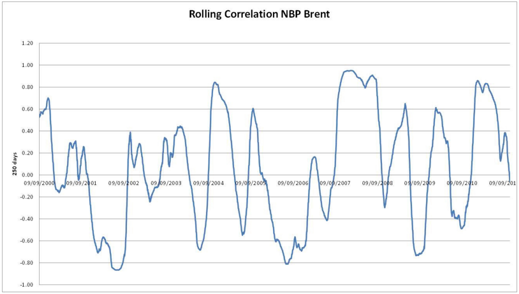
The short run relationship

Rolling Correlation in Europe: Elect vs Gas

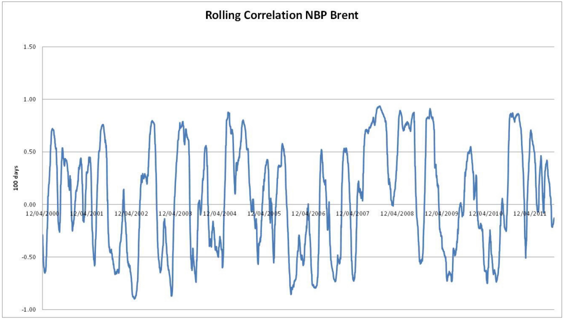


The short run relationship

Rolling Correlation in Europe: Oil vs Gas 250 days



Rolling Correlation in Europe: Oil vs Gas 100 days



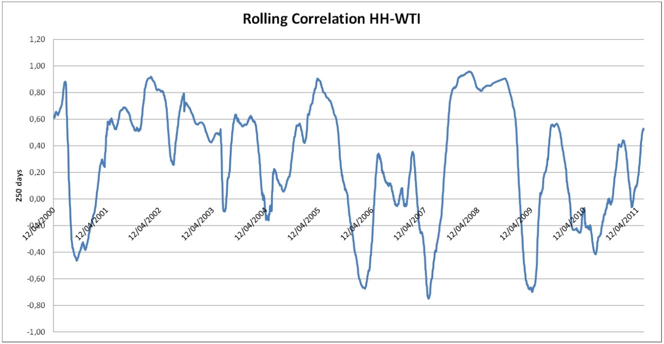
The short run relationship

Rolling Correlation in US T=1856

Elec Oil	Elec Gas	Oil Gas
	Mean	
-0.125	0.400	0.394
	DevSt	
0.275	0.090	0.220
	Max	
0.069	0.464	0.549
	Min	
-0.320	0.336	0.238
	Unconditional Correlation	
0.7499	**0.8137**	**0.8004**

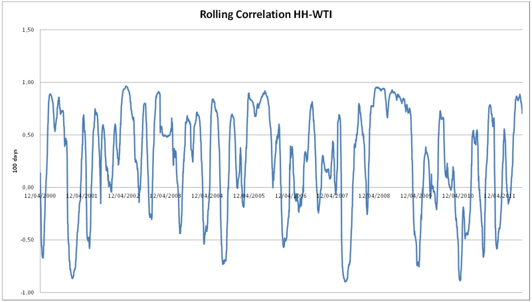
The short run relationship

Rolling Correlation in US oil vs Gas 250 days



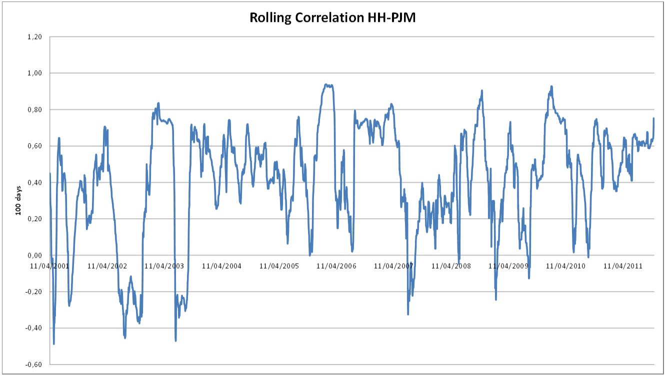
The short run relationship

Rolling Correlation in US: oil vs Gas 100 days



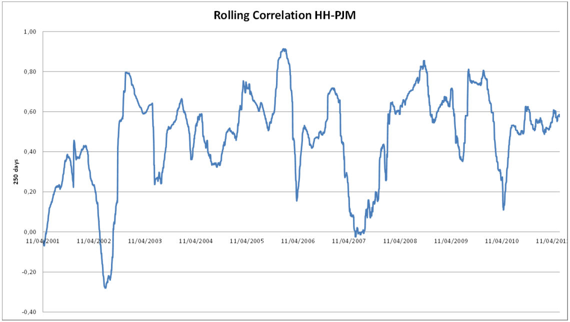
The short run relationship

Rolling Correlation in US: electricity vs Gas, 100 days



The short run relationship

Rolling Correlation in US: electricity vs Gas



Short run relationship

- The price volatility is strongly time dependent for these energy commodities
- The covariance and the unconditional correlation are time dependent as well.
- The high volatile correlation measure does not allow to capture the real nature of the relationship between the main characters of the energy market.

Cointegration results: Europe

$$\Delta Y_t = D_1 \Delta Y_{t-1} + D_2 \Delta Y_{t-2} + \ldots + D_p \Delta Y_{t-p} + \epsilon_t \tag{6}$$

Two cointegrating vectors are found : r = 2

$n - r = 3 - 2 = 1$ common trend

Cointegration results: Europe

Table 5
Cointegration rank test for the EU log prices.

Nr. of coint. vec.	Eigenvalue	λ_{trace}	$\lambda^{0.05}_{\text{trace}}$	$\lambda_{\max}$	$\lambda^{0.05}_{\max}$
$r = 0$	0.044	116.6	29.79	86.92	21.13
$r \leq 1$	0.014	29.74	15.49	27.03	14.26
$r \leq 2$	0.001	2.708	3.841	2.708	3.841

Cointegration results: US

Table 6
Cointegration rank test for the US log prices.

Nr. of coint. vec.	Eigenvalue	λ_{trace}	$\lambda_{\text{trace}}^{0.05}$	$\lambda_{\max}$	$\lambda_{\max}^{0.05}$
$r = 0$	0.063	139.0	29.79	120.6	21.13
$r \leq 1$	0.008	18.45	15.49	15.45	14.26
$r \leq 2$	0.001	2.995	3.841	2.995	3.841

ECM results: EU

$$\Delta y_{1,t} = \phi \Delta y_{2,t} + \theta \left(y_{1,t-1} - \alpha - \beta y_{2,t-1} \right) + \epsilon_t \qquad (7)$$

Table 9
ECM parameters for the EU log prices.

Dep. variable	Indep. variable	ϕ	t_ϕ	P-value	θ	t_θ	P-value
Δ NBP	Δ Brent	-0.020	-0.175	0.860	-0.053	-7.224	0.000
Δ EEX	Δ Brent	-0.291	-0.954	0.339	-0.425	-22.70	0.000
Δ EEX	Δ NBP	0.094	1.558	0.119	-0.437	-23.19	0.000

ECM results: EU with lag

Table 10
ECM parameters with lags for the EU log prices.

Dep. variable	Indep. variable	ϕ	t_ϕ	P-value	θ	t_θ	P-value
Δ NBP	Δ Brent (-7)	-0.223	-1.944	0.051	−0.053	−7.258	0.000
Δ EEX	Δ Brent (-1)	0.752	2.455	0.014	0.422	22.50	0.000
Δ EEX	Δ NBP (-2)	-0.260	-4.318	0.000	−0.443	−23.54	0.000

ECM results: US

$$\Delta y_{1,t} = \phi \Delta y_{2,t} + \theta \left(y_{1,t-1} - \alpha - \beta y_{2,t-1} \right) + \epsilon_t \tag{8}$$

Each couple of commodities result to be integrated.

Table 11: ECM parameters for the US log prices.

Dep. variable	Indep. variable	ϕ	t_ϕ	P-value	θ	t_θ	P-value
Δ HH	Δ WTI	0.224	5.243	0.000	−0.023	−4.852	0.000
Δ PJM	Δ WTI	0.251	1.984	0.047	−0.158	−12.58	0.000
Δ PJM	Δ HH	0.711	10.88	0.000	−0.194	−14.15	0.000

Conclusions

- The price volatility is strongly time dependent and, as consequence, the covariance and the unconditional correlation are time dependent as well.
- The simple correlation analysis among the various time series results non effective and it does not allow to capture the real nature of the relationship between the main characters of the energy markets, even if the rolling correlation records more positive values for the US market.
- The existence of two cointegrating relationships, hence one common (stochastic) trend, among the three commodity price series in both markets is provided using the Johansen method. The common trend may be interpreted as a source of randomness (the oil market) which affects the the dynamics of the two other commodities (electricity and gas) within each market.

Conclusions

- The Engle-Granger approach witnesses a long run equilibrium between electricity and oil prices as well as between electricity and gas prices or gas and oil prices both for the European and the American markets
- The integration of energy markets in Europe is less strong than in the US:
  - the gas and the oil markets.
  - electricity/oil or electricity/gas for the European dataset the integration seems to be stronger, the contemporaneous price adjustment in the short run may be identified with a lag of some day (less than one week).

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