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Energy Price Transmissions during Extreme Movements

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Energy market volatility

- Energy price dynamics are frequently volatile (real and financial factors: Hamilton (2009), Kilian (2009), Mjelde & Bessler (2009), Cifarelli & Paladino (2010), ...)

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⇒ energy price fluctuations → extreme market risks, affect the whole economy (Hamilton (2003), Killian (2008), ...)
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- Energy market behaviors → interrelated in the long-run: production/substitution/competition (Bachmeier & Griffin (2006), Ma & Oxley (2010), Joëts & Mignon (2011), ...)

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**Globalization process**

- Energy market behaviors → interrelated in the long-run: production/substitution/competition (Bachmeier & Griffin (2006), Ma & Oxley (2010), Joëts & Mignon (2011),...)

⇒ Long-run relation during "normal" times and not short-run causality between prices during extreme fluctuations
Introduction & Motivations

Motivations: the financial properties of energy markets

- Financial literature:
  - Comovements between financial assets ↑ in bear markets (Hong et al. (2009), Amira et al. (2009), Ding et al. (2011), ...)

- High volatility coupled with highly interrelated markets (fads/herd behaviors: Black (1986), Delong et al. (1990); belief dispersion: Shalen (1993), Lin et al. (1994)) diversification almost impossible under uncertain movements
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$\Rightarrow$ can we extend the analysis to energy market dynamics?
Restrictive energy risk measurement papers

- Giot & Laurent (2003), Feng et al. (2004), Sadeghi & Shavvalpour (2006), Aloui & Mabrouk (2006), and Fan et al. (2008) → oil markets and restrictive approaches for extreme movements (i.e. normality, positivity,...)
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Scarce energy risk transmission studies

- Volatility spillover effects: Lin & Tamvakis (2001) NYMEX/IPE crude oil contracts relationship → volatility is not a satisfactory measure of risk
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Scarce energy risk transmission studies

- Volatility spillover effects : Lin & Tamvakis (2001) NYMEX/IPE crude oil contracts relationship → volatility is not a satisfactory measure of risk

- Extreme risk spillover effects : Fan et al. (2008) WTI/Brent with Hong et al. (2009)’s causality test → quantile at specific levels rather than tails behavior
Our contributions are threefold:

1. We investigate causality between oil, gas, coal and electricity forward markets (at distinct maturities) during "normal" times and extreme periods (upward/downward).
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2. We model extreme movements by robust CAViaR approach (Engle and Manganelli (2004)).
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1. We investigate causality between oil, gas, coal and electricity forward markets (at distinct maturities) during "normal" times and extreme periods (upward/downward).

2. We model extreme movements by robust CAViaR approach (Engle and Manganelli (2004)).

3. We investigate causality during extreme movements by multivariate tail causality test (Candelon, Joëts, & Tokpavi (2012)) : CJT test.
European energy daily forward prices at distinct maturities (1, 10, 20, 30 months) of oil/gas/coal/electricity from Jan. 3, 2005 to Dec. 31, 2010 (Platt’s IEA)

**Fig.:** One month forward energy returns (prices in first log difference)
Methodological aspects
Risk measurement: CAViaR approach

- Asymmetric CAViaR specification (Engle & Manganelli (2004)):
  - autocorrelation (Boudoukh et al. (1994), Eom et al. (2004))
  - asymmetric response of volatility to news (Black (1976), Christie (1982))

\[
f_t (\beta) = \beta_1 + \beta_2 f_{t-1} (\beta) + \beta_3 (y_{t-1})^+ + \beta_4 (y_{t-1})^-
\]
CJT risk causality test: an extension of Hong et al. (2009)'s test in multivariate framework allowing tails behavior:
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Fig.: CJT causality test in tails distribution — graphical illustration
Results

Risk measurement

- Fossil energy prices:
  - asymmetric behavior between bullish/bearish markets and left/right tails: predominence of downside movements (negative returns)

- Electricity prices:
  - Regime switching causes CAViaR model misspecification
Energy price transmissions
Normal times (causality in mean)

**Tab.:** Results of Granger causality test in mean at 1 month ("normal" times)

<table>
<thead>
<tr>
<th>$X \Rightarrow Y$</th>
<th>Oil</th>
<th>Gas</th>
<th>Coal</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>$X$</td>
<td>1.10</td>
<td>4.05</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.00***</td>
<td>(0.80)</td>
</tr>
<tr>
<td>Gas</td>
<td>1.32</td>
<td>$X$</td>
<td>0.67</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td></td>
<td>(0.90)</td>
<td>(0.35)</td>
</tr>
<tr>
<td>Coal</td>
<td>1.07</td>
<td>1.29</td>
<td>$X$</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>(0.35)</td>
<td>(0.12)</td>
<td></td>
<td>(0.98)</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.79</td>
<td>1.22</td>
<td>0.87</td>
<td>$X$</td>
</tr>
<tr>
<td></td>
<td>(0.77)</td>
<td>(0.19)</td>
<td>(0.66)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: () p-values. *** denotes rejection of the null hypothesis at 1% significance level. Granger causality tests are computed using $p=30$ lags. Causality run from the left series to the top series.
### Normal times

- No short-run causalities across energy markets (except for oil and coal prices) (the same results hold for longer maturities)
  - → **diversification between energies can be possible**
**Energy prices transmission**

**Extreme periods (CJT tails causality)**

**FIG.**: Results of Granger causality test in distribution tails at 1 month (extreme movements)

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>Gas</th>
<th>Coal</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>X ⇒ Y</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>X</td>
<td>301.6</td>
<td>347.6</td>
<td>325.7</td>
</tr>
<tr>
<td>Gas</td>
<td>360.49</td>
<td>X</td>
<td>372.5</td>
<td>340.02</td>
</tr>
<tr>
<td>Coal</td>
<td>2.03</td>
<td>6.05</td>
<td>X</td>
<td>328.27</td>
</tr>
<tr>
<td>Electricity</td>
<td>11.10</td>
<td>4.29</td>
<td>9.08</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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</tr>
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<tbody>
<tr>
<td><strong>DR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>X</td>
<td>7.83</td>
<td>4.25</td>
<td>4.85</td>
</tr>
<tr>
<td>Gas</td>
<td>4.28</td>
<td>X</td>
<td>6.83</td>
<td>15.25</td>
</tr>
<tr>
<td>Coal</td>
<td>4.26</td>
<td>4.96</td>
<td>X</td>
<td>2.44</td>
</tr>
<tr>
<td>Electricity</td>
<td>3.92</td>
<td>12.92</td>
<td>13.67</td>
<td>X</td>
</tr>
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Notes: Between parentheses p-values. *** (resp. **, *) denotes rejection of the null hypothesis at 1% significance level (resp. 5%, 10%). Granger causality tests are computed using p=30 lags. DR and UR denote Downside and Upside Risks respectively. Causality run from the left series to the top series.
Extreme periods

- Asymmetric causalities between downturn and upturn situations: comovements are higher (resp. no significant) between fossil markets during periods of price decrease (resp. price increase)
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- Behavior of forward energy prices (1 month) $\sim$ behavior of stock returns $\rightarrow$ **diversification between energy markets almost impossible during extreme volatility periods**
2 potential reasons

- Fundamental/speculative:
  - During market downturn (negative shock), volatility of fundamental variables is usually higher and accompanied by higher market risk (Kim et al. 2008, Campbell and Diebold 2009, Campbell and Hentschel 1992, ...).

- Behavioral:
  - Investors react more sensitively to bad news than good news (Barberis et al. 1998).

- Prospect Theory: Investors react differently to market circumstances due to loss aversion (Kahneman & Tversky 1979).

- Affect Infusion Theory: Investors are more influenced by their emotions when extreme bearish market movements occur (Joints 2012).
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From maturity effect to Samuelson Causality Effect (SCE)

- CJT causality tests for forward energy prices at 10, 20 and 30 months → asymmetric downturn causality between markets remains significant at 10 months, but fades strongly at 20 and 30 months revealing an SCE phenomenon
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⇒ diversification more profitable at longer maturity
Conclusion

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**Extensions**
- Explore more precisely the relevance of the Samuelson Causality Effect to improve energy portfolio allocation/ diversification
- Extend the analysis to other commodities markets (i.e. precious metals, agricultural, ...)

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Thank you!