Oil market uncertainty, Google searches and extreme stock market volatility

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Workshop in Econometrics
Nantes
September 24th 2021
• Oil and oil products ⇒ 41.6% (30.5%) of consumption (supply) in 2018
  - Hold a key role despite energy transition
  - Large literature on oil-macroeconomics links

• Financialization of oil market since 2000’s (Chari and Christiano, 2017)
  - Growing interest in the oil-stock markets relationship
  - Especially since the Global Financial Crisis (Degiannakis et al., 2018)
• Negative impact of oil price changes on the returns of aggregate indices
  - Time varying link
  - Heterogeneous across sectors
  - Depends on type of oil shocks and volatility states of oil price

• But conflicting results on volatility spillovers
  - Depend on sectors
    - Oil volatility seems to lead energy and automotive sectors
    - But not financial, telecommunication or building sectors
  - Depend on time horizon
    - Oil volatility seems to lead SP500 volatility at 8 to 16 days
    - No spillovers at 2 to 4 days
Source: Degiannakis et al. (2018)
• Volatility spillovers are likely to be different in the tails than in the center of the distribution
  • Only Xiao et al. (2019) analyze volatility spillovers in their complete distribution (in China)
  • Highlight stronger spillovers in the upper tails
• We thus focus on these extreme events using US data

• Oil volatility usually interpreted as uncertainty
  • While volatility $\Rightarrow$ risk
• We thus use oil-related Google search volume index (GSVI)
  • Useful way to measure unsophisticated investor attention (Da et al., 2011)
  • Oil prices predictor (Li et al., 2015)
  • OVX predictor (Campos et al., 2017)
  • Volatility predictor for oil, gasoline and natural gas (Afkhami et al., 2017)
• Daily GSVI [WTI, Crude oil, Brent, Oil news, Nymex, …]
  ⇒ the number of Google searches relative to the largest over the sample

![Figure 1: GSVI for “WTI”](image)
- Daily realized volatility measures for S&P500 companies
  - Realized volatility, Bipower variation, Median realized volatility, Realized semi-variance
  - For energy and financial (Bank, Finance and Insurance) portfolios (market cap weighted)

Figure 2: Realized volatility for energy portfolio
Data and Methodology

- **Granger causality test in extreme variance**
  - With \( IV_{1,t} \) and \( IV_{2,t} \) the integrated variance for 2 financial assets:
    \[
    \mathcal{H}_0 : \mathbb{E}\left( z_{1,t}(\alpha) | \mathcal{F}_{t-1}^{(1)} \right) = \mathbb{E}\left( z_{1,t}(\alpha) | \mathcal{F}_{t-1}^{(1)}, \mathcal{F}_{t-1}^{(2)} \right)
    \]
  - Where \( \mathcal{F}_{t-1}^{(i)} = (z_{i,t-H}, \ldots, z_{i,t-1}) \) is the information set at time \( t - 1 \)
  - And \( z_{i,t} \) an exceedance (extreme variance) indicator:
    \[
    z_{i,t} = \begin{cases} 
    1 & \text{if } IV_{1,t} \geq q_{i,t}(\alpha) \\
    0 & \text{otherwise}
    \end{cases}
    \]
  - \( q_{i,t} \) estimated with a quantile heterogeneous autoregressive (HARQ) model
  - Using a Portmanteau-type statistic:
    \[
    Q(H) = T(T+2) \sum_{h=1}^{H} \frac{\hat{\rho}^2(h)}{T-h} \sim \chi^2(H), \text{ if } T \to \infty
    \]
  - Where \( \hat{\rho} \) is the sample cross-lagged correlation function associated with the estimated exceedance indicators
### Table 1: Test results for causality from “WTI” to portfolios extreme risk

<table>
<thead>
<tr>
<th></th>
<th>rv</th>
<th>bv</th>
<th>medv</th>
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<tr>
<td>Energy</td>
<td>0.0425</td>
<td>0.0273</td>
<td>0.0219</td>
<td>0.1739</td>
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<td>0.0281</td>
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<td>0.0441</td>
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<td>0.0002</td>
<td>0.0349</td>
<td>0.0388</td>
<td>0.2937</td>
</tr>
</tbody>
</table>

P-value in bold means the rejection of the null hypothesis of no causality from the keyword “WTI” to portfolios extreme risk.

- Uncertainty in the oil market leads to risk in stock markets
- The effect disappears after 1 week for energy sector
- Similar results with “Crude oil” for $\alpha = 10\%$ but no causality for $\alpha = 5\%$
- No causality found with other keywords
- However...
### Table 2: Test results for causality from portfolios extreme risk to “WTI”

<table>
<thead>
<tr>
<th></th>
<th>$\alpha = 10%$</th>
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<tr>
<td>Energy</td>
<td>0.0219</td>
<td>0.0926</td>
<td>0.1726</td>
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<tr>
<td>Finance</td>
<td>0.0122</td>
<td>0.0001</td>
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<td>Energy</td>
<td><strong>0.0045</strong></td>
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<td>Finance</td>
<td><strong>0.0592</strong></td>
<td><strong>0.0001</strong></td>
<td><strong>0.0062</strong></td>
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P-value in bold means the rejection of the null hypothesis of no causality from portfolios extreme risk to the keyword “WTI”

- Risk in stock markets also leads uncertainty in the oil market
- Similar results with “Crude oil” for $\alpha = 10\%$ and $\alpha = 5\%$
- Close results with “Brent”
- No causality found with other keywords
• But time varying behavior of this relationship

• 2 main periods with causality from “WTI”: 2006-2009 and 2014-2016
• 1 main period with causality from the energy sector: 2010-2012
• 1 main period with causality from the financial sector: 2014-2016
Table 3: Test results for causality from “WTI” to portfolios extreme risk 2006-2009

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<td>Finance</td>
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</tr>
</tbody>
</table>

P-value in bold means the rejection of the null hypothesis of no causality from the keyword “WTI” to portfolios extreme risk.

- Causality from “WTI” to financial sector
  - During boom period in oil market 2006-2008 and fall end of 2008
  - $\approx 60$ in January 2006, $\approx 140$ in July 2008 and $\approx 35$ in January 2009
- No causality to the energy sector
- No causality from stocks to “WTI”
### Table 4: Test results for causality from portfolios extreme risk to “WTI” 2010-2012

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P-value in bold means the rejection of the null hypothesis of no causality from the keyword “WTI” to portfolios extreme risk.

- **Causality from the energy sector to “WTI” mainly at short term and 10%**
  - Due to shale oil development
  - Or volatility in oil price moving between 80$ and 110$
- **No causality from the financial sector**
- **No causality from “WTI”**
Table 5: Test results for causality 2014-2016

<table>
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<tr>
<td>“WTI” to Energy</td>
<td>0.1546</td>
<td>0.0053</td>
<td>0.0904</td>
<td>0.4877</td>
<td>0.1100</td>
<td>0.0224</td>
<td>0.0378</td>
<td>0.5942</td>
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<tr>
<td>“WTI” to Finance</td>
<td>0.0218</td>
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<td>0.0125</td>
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<tr>
<td>“WTI” to Energy</td>
<td>0.1244</td>
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<td>0.1312</td>
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<tr>
<td>“WTI” to Finance</td>
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</table>

P-value in bold means the rejection of the null hypothesis of no causality.

- Period with the highest causality relationship
  - Two-way causality between “WTI” and the financial sector
  - Except from the energy sector to “WTI”
    - during fall in oil price
    - $\approx 100\$ before September 2014 and $\approx 50\$ in 2015
• Analyze causality relationships between oil uncertainty and extreme risks in energy and financial stocks

• Highlighting 3 main periods:
  - 2006-2009 when oil uncertainty leads extreme risks in the financial sector
  - 2010-2012 when extreme risks in the energy sector leads oil uncertainty
  - 2014-2016 when extreme events in oil uncertainty and stocks risks are interrelated

• Could be due to:
  - Shale oil development in 2010-2012
  - High rise and drop in oil prices

• Work still in progress in order to:
  - Analyze causality between oil uncertainty and oil volatility index (OVX)
  - ...
Thank you for your attention