Oil market uncertainty, Google searches and extreme stock market volatility

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Workshop in Econometrics

Nantes

September 24th 2021

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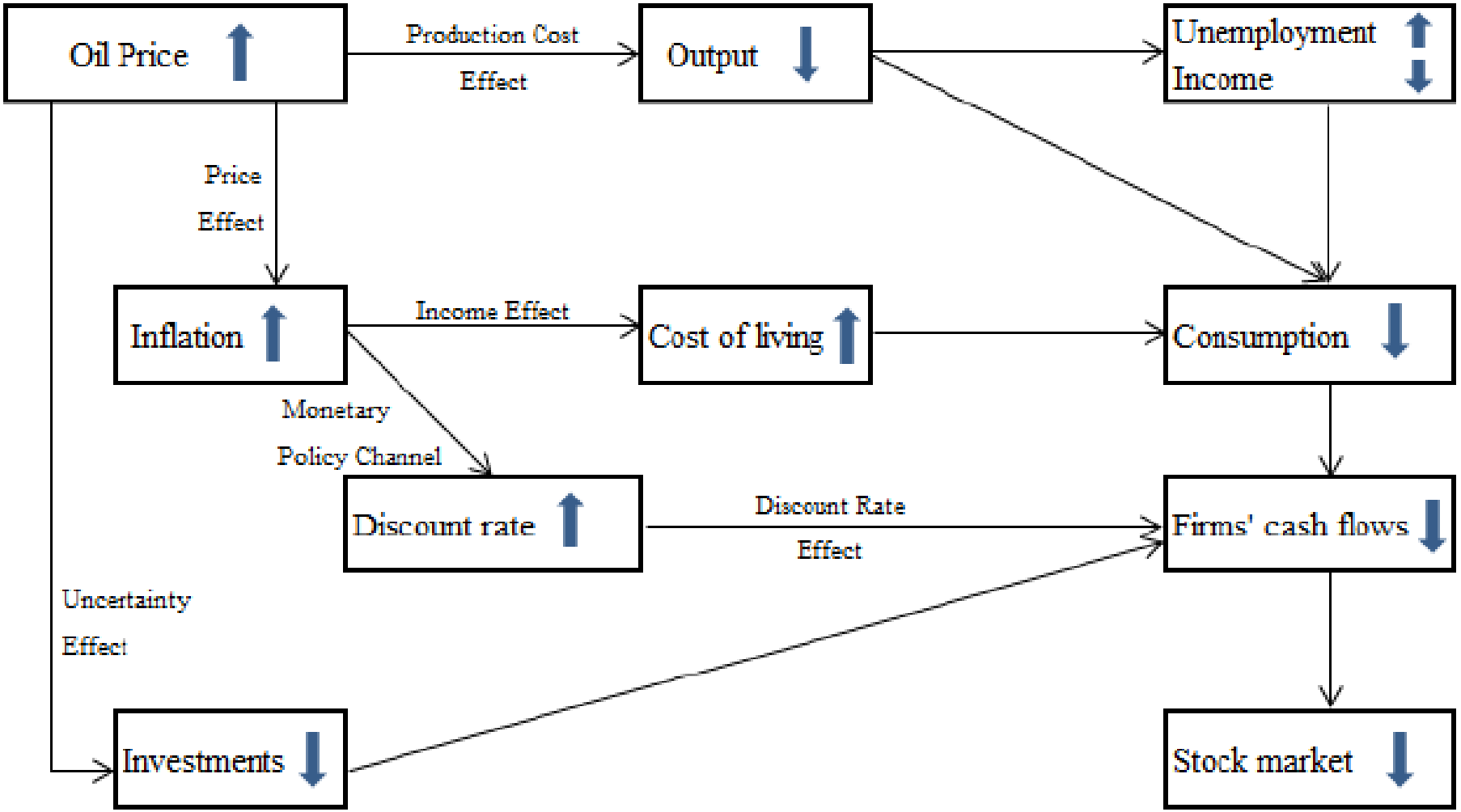
- Oil and oil products $\Rightarrow$ 41.6% (30.5%) of consumption (supply) in 2018
  - Hold a key role despite energy transition
  - Large literature on oil-macroeconomics links

- 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, ...]
  - $\Rightarrow$ the number of Google searches relative to the largest over the sample

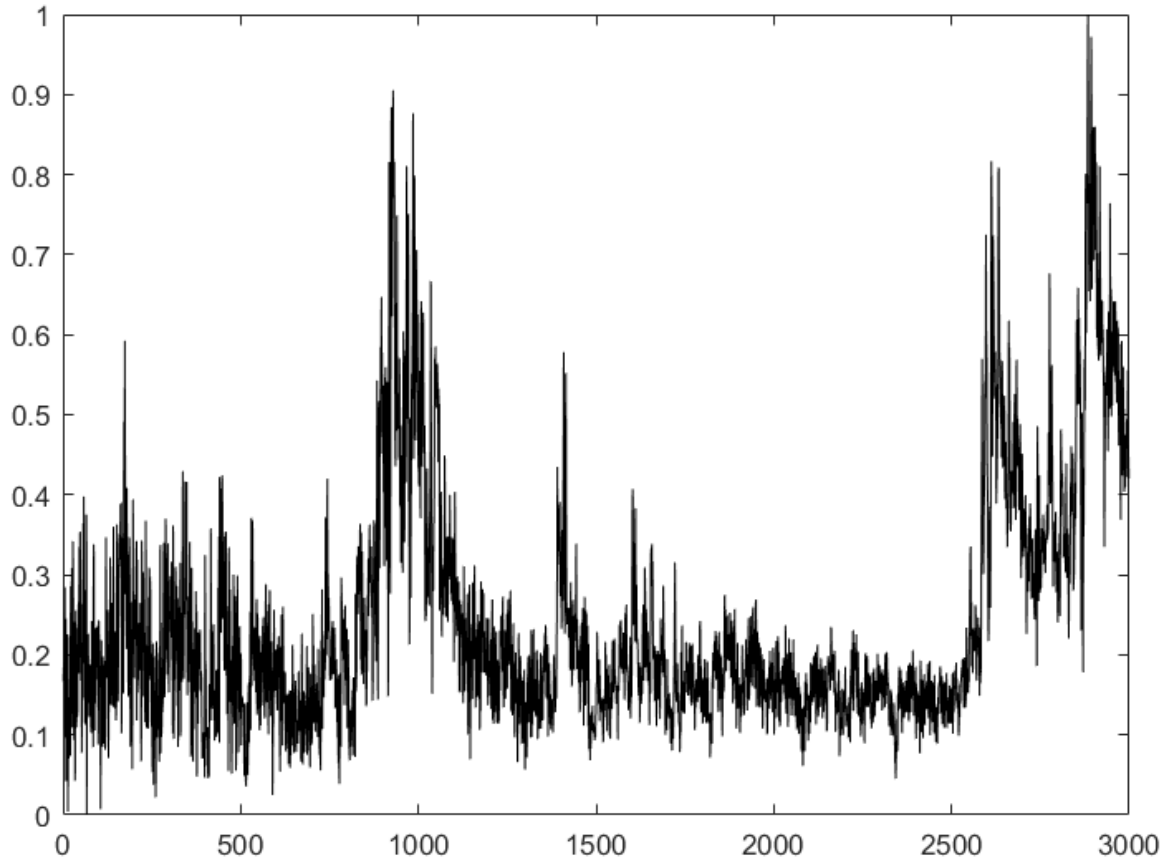


Figure 1: GSVI for "WTI"

- 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)

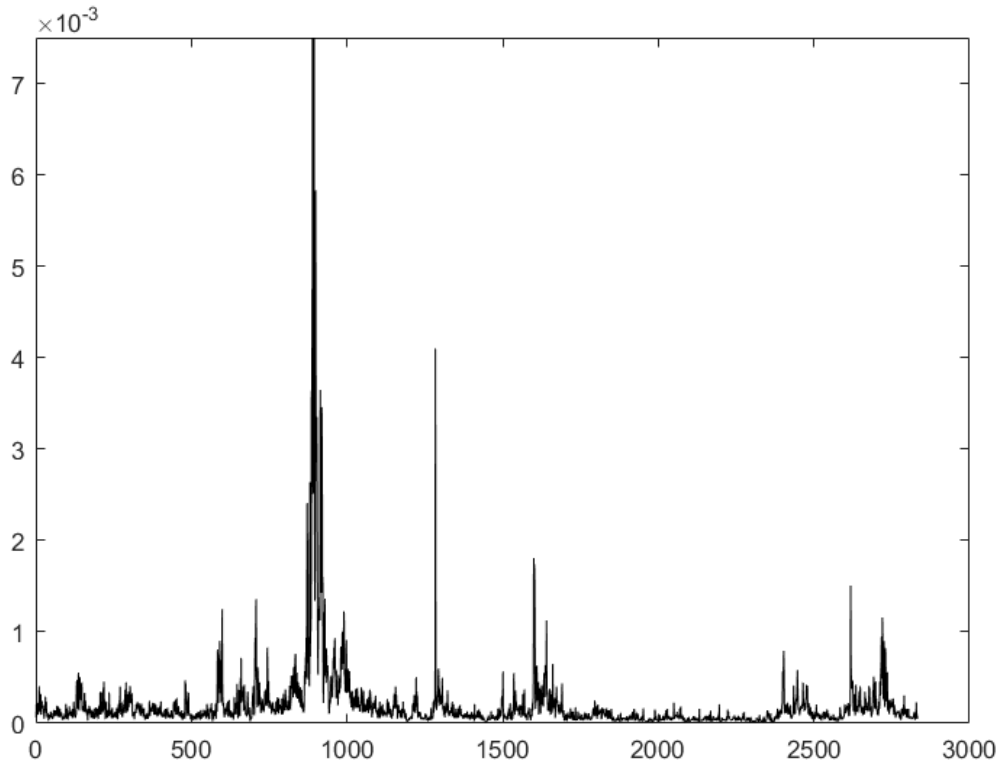


Figure 2: Realized volatility for energy portfolio

- 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

	$\alpha = 10\%$				$\alpha = 5\%$			
	rv	bv	medv	rsv	rv	bv	medv	rsv
$H = 5$								
Energy	**0.0425**	**0.0273**	**0.0219**	0.1739	**0.0281**	**0.0628**	**0.0115**	0.5233
Finance	**0.0017**	**0.0027**	0.1578	**0.0468**	**0.0002**	**0.0166**	**0.0304**	**0.0513**
$H = 10$								
Energy	**0.0786**	0.1439	0.1110	0.2212	0.1123	0.3086	**0.0991**	0.4951
Finance	**0.0018**	**0.0240**	0.1294	**0.0441**	**0.0002**	**0.0349**	**0.0388**	0.2937

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...

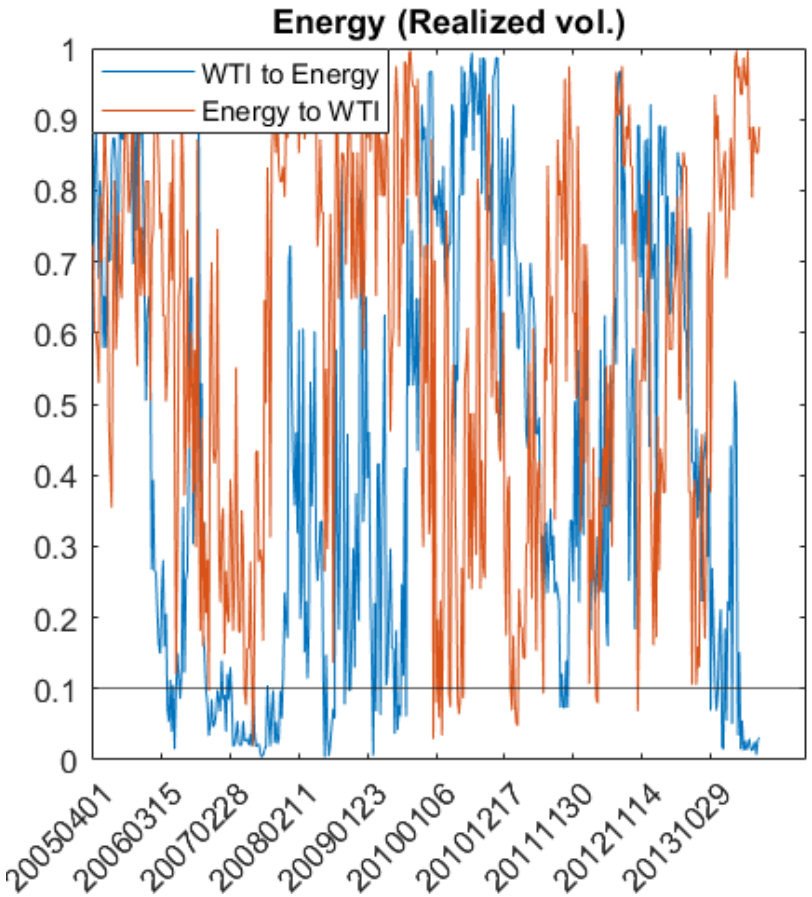
Table 2: Test results for causality from portfolios extreme risk to "WTI"

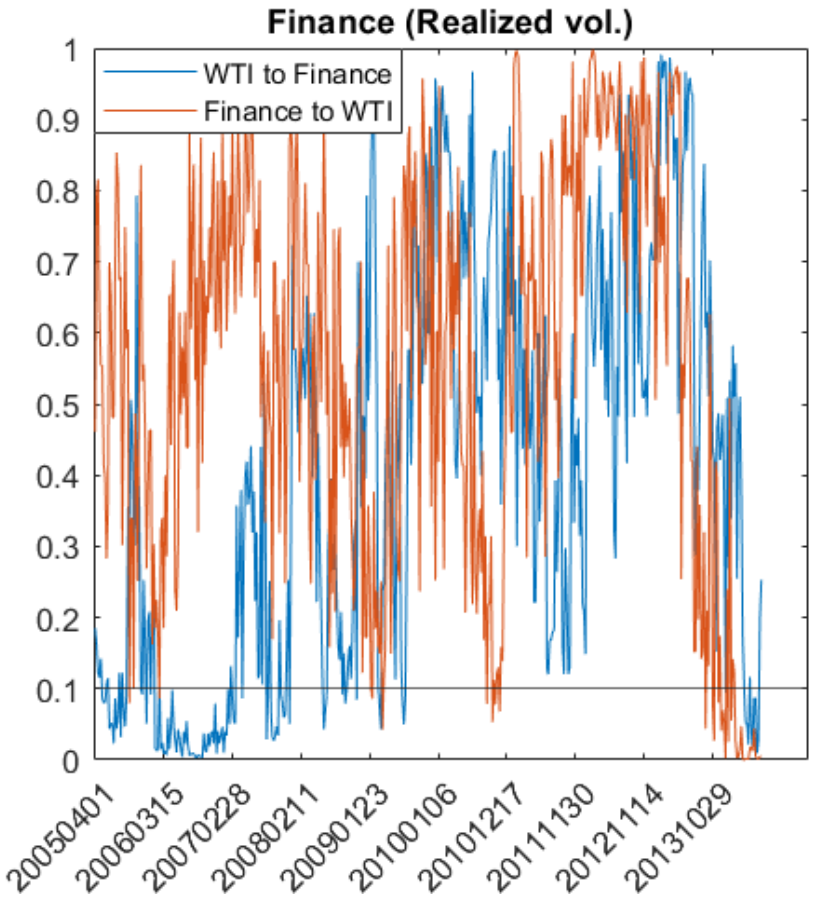
	$\alpha = 10\%$				$\alpha = 5\%$			
	rv	bv	medv	rsv	rv	bv	medv	rsv
$H = 5$								
Energy	**0.0219**	**0.0926**	0.1726	0.3050	0.1636	**0.0911**	0.2403	**0.0272**
Finance	**0.0122**	**0.0001**	**0.0009**	**0.0230**	0.4134	0.7427	0.3422	**0.0179**
$H = 10$								
Energy	**0.0045**	0.1502	0.1380	0.3000	0.1931	**0.0189**	**0.0572**	**0.0375**
Finance	**0.0592**	**0.0001**	**0.0062**	**0.0927**	0.2334	0.9600	0.7315	**0.0151**

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

	$\alpha = 10\%$				$\alpha = 5\%$			
	rv	bv	medv	rsv	rv	bv	medv	rsv
$H = 5$								
Energy	0.3863	0.5028	0.6522	0.8178	0.1825	0.4240	0.5448	0.4197
Finance	**0.0072**	**0.0067**	**0.0494**	**0.0935**	0.0053	**0.0135**	**0.0100**	0.5174
$H = 10$								
Energy	**0.0560**	0.4418	0.3871	0.4098	0.1958	0.3003	0.3044	0.3008
Finance	**0.0072**	**0.0067**	**0.0494**	**0.0935**	**0.0053**	**0.0135**	**0.0100**	0.5174

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

	$\alpha = 10\%$				$\alpha = 5\%$			
	rv	bv	medv	rsv	rv	bv	medv	rsv
$H = 5$								
Energy	**0.0696**	0.1795	**0.0322**	**0.0025**	0.3110	0.5424	0.1261	**0.0878**
Finance	0.4997	0.4904	0.6423	0.4479	0.6512	0.5428	0.8302	0.6512
$H = 10$								
Energy	0.2601	0.4526	0.1298	**0.0337**	0.2413	0.6611	0.2706	0.2970
Finance	0.5471	0.5737	0.5799	0.1331	0.2681	**0.0678**	0.1768	0.5907

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

	$\alpha = 10\%$				$\alpha = 5\%$			
	rv	bv	medv	rsv	rv	bv	medv	rsv
$H = 5$								
"WTI" to Energy	0.1546	**0.0053**	**0.0904**	0.4877	0.1100	**0.0224**	**0.0378**	0.5942
"WTI" to Finance	**0.0218**	**0.0373**	**0.0350**	**0.005**	**0.0363**	**0.0125**	**0.0363**	0.4158
Finance to "WTI"	**0.0376**	**0.0118**	**0.0572**	**0.000**	0.4141	0.2754	0.2848	**0.0213**
$H = 10$								
"WTI" to Energy	0.1244	**0.0042**	0.1312	0.5607	**0.0817**	**0.0523**	**0.0333**	0.8160
"WTI" to Finance	**0.0961**	**0.0759**	**0.0134**	**0.0004**	0.1109	**0.0523**	**0.0755**	**0.0466**
Finance to "WTI"	0.1322	**0.0614**	**0.0981**	**0.0004**	0.2334	**0.0494**	0.1711	**0.0756**

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

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