The Lithium Industry and Analysis of the Beta Term Structure of Oil Companies

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In the case of the United States,

- Schurr and Netschert (1960) exposed the two energy transitions, were the use of coal was imposed on wood as a source of fuel in 1895, with 65% of coal versus 30%.
- The same occurred four and one-half decades later with oil and gas, where the coal represented 28% and oil and gas 65%.
- Cherif et al. (2017) conclude that, as in the previous cases, the same can happen to oil with renewable energies in relation to the transport sector in the next 10 to 25 years.

- BP (2017) argued that the most of the world's liquid fuel is in the transport sector.
- This transport produces 70% of total emissions of greenhouse gas (IPCC, 2007).
- To change this reality, in the Paris Agreement many countries including ten OPEC Member countries have focused the effort to deal with the impacts of climate change through appropriate financial flows, a new technology framework and an enhanced capacity building framework.
- Energy storage and electric mobility are having great relevance.

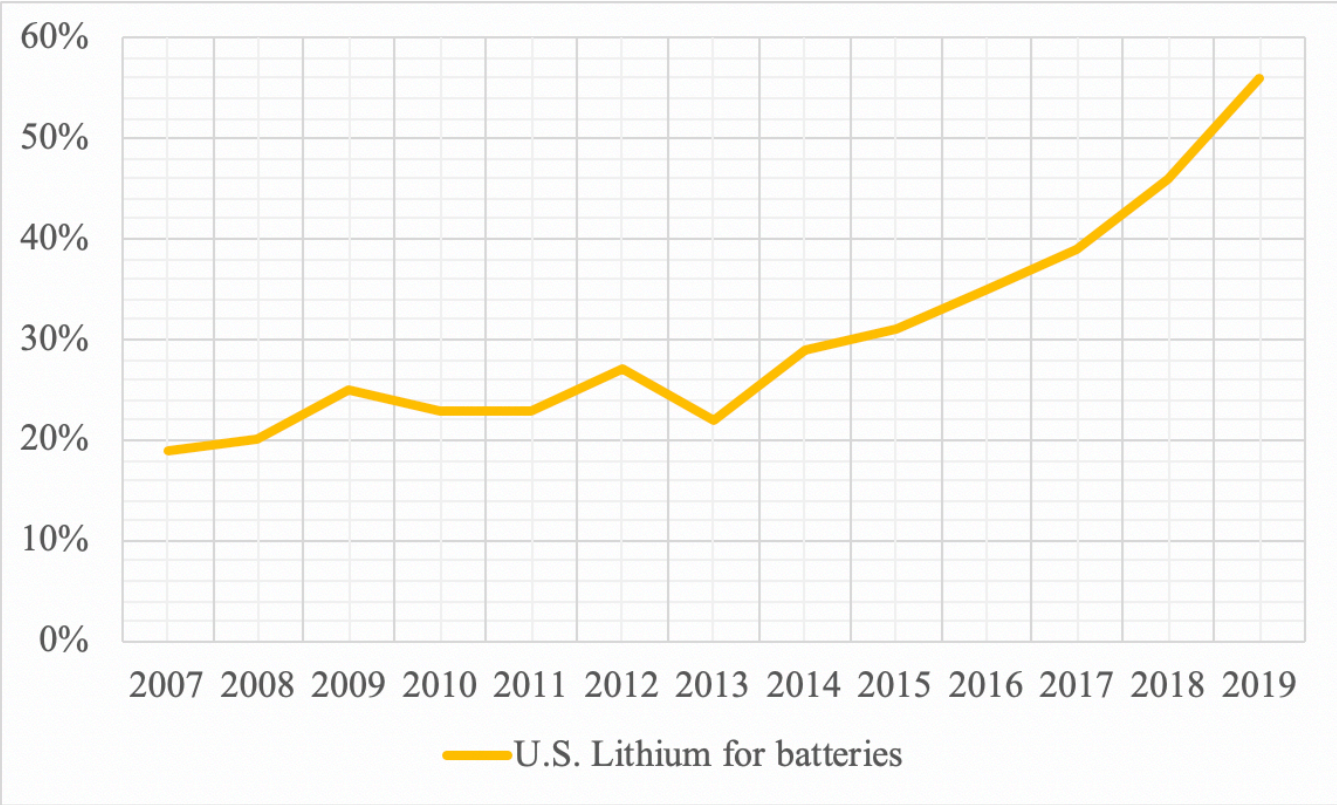

Figure: Percentage of the global lithium markets for batteries. Jaskula (2019)

- The figure is related to the statement made by Hao et al. (2016) where the increase in global demand for electric vehicles means an increase in lithium consumption.
- We see in the figure that 56% of global end-use lithium markets are used to get batteries (Jaskula, 2019).
- The previous arguments may have an impact in the crude oil prices due to technological transition process and climate policy implications and the resulting of these (see Nakicenovic et al. 1986; Sovacool, 2016; Fouquet, 2016; among others).

- The substitution for crude oil by renewable energy inputs in the transport sector is a major concern for oil producers.
- Among the different types of clean energies, lithium (Li) is currently assuming an increasingly strategic role.

Following the research line initiated by:

- Monge and Gil-Alana (2018)
- Gil-Alana and Monge (2019a)
- Monge and Gil-Alana (2019b)

we use Continuous Wavelet Transform (CWT) analysis to study the dynamics of the lithium industry and the beta risk behavior of the 10 largest oil companies in the world. Also, we study the dynamics of the beta series by using long-run dependence approaches.

Data

- The choice of oil companies for the dataset was based on the fact that they are among the world's largest oil firms according to revenue and are listed in the largest stock markets.
- This criteria ensures that the chosen firms are among the largest players in the market and their stocks are highly liquid.
- Additionally, we considered only these ten largest oil companies (and no more) because the markets for similar companies (in the case of petroleum) have similar risks.
- According to the classification done by Thomson Reuters in 2019, our final dataset is:

Name	Exchange	Revenue (in billion U.S. dollars)
China Petroleum & Chemical Corp (Sinopec)	Shanghai Stock Exchange	432.54
Royal Dutch Shell PLC	Euronext Amsterdam	382.97
Saudi Aramco	Saudi Arabian Stock Exchange	356.00
PetroChina Co Ltd	Shanghai Stock Exchange	347.76
BP PLC	London Stock Exchange	296.97
Exxon Mobil Corp	NYSE Consolidated	275.54
Total SA	Euronext Paris	185.98
Chevron Corp	NYSE Consolidated	157.21
NK Rosneft' PAO	Moscow Interbank Currency Exchange (MICEX)	132.73
Gazprom PAO	Moscow Interbank Currency Exchange (MICEX)	129.41

- We have used the exchange index to calculate the beta of each company.
- To represent the lithium industry, we have used **Solactive Global Lithium Index**

The daily data were obtained from Thomson Reuters Eikon database and cover the period 11th February 2009 to 10th January 2019 and they are expressed in U.S. dollars.

Continuous Wavelet Transform (CWT) analysis:

- See Aguiar-Conraria and Soares (2014).
- We use the Wavelet Coherency (WCO) for measuring the degree of local correlation between two-time series in the time-frequency domain to find evidence of interconnections, and the wavelet coherence phase differences (ϕ) tells us about the synchronism between those time series.

Fractional Integration

- Fractional integration is a time series technique that allows for a fractional degree of differentiation.
- Given a time series, $(x_t), t = 1, 2, \cdots$, we say that it is integrated of order d, and denoted by $I(d)$ if its d-differences are stationary $I(0)$.
- See Monge and Gil-Alana (2020); Monge and Gil-Alana (2021), among others.

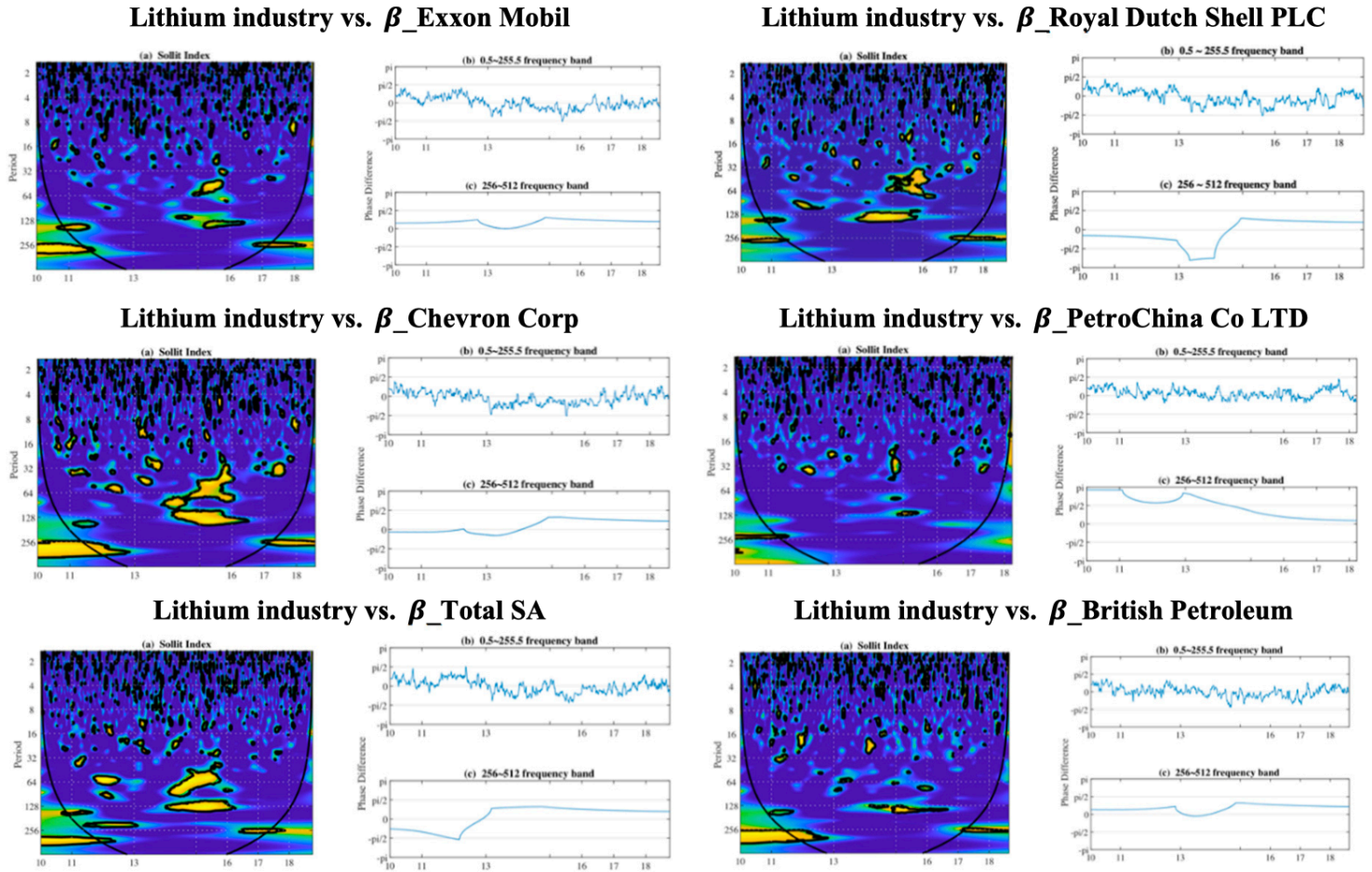

Figure: Wavelet coherency and phase difference

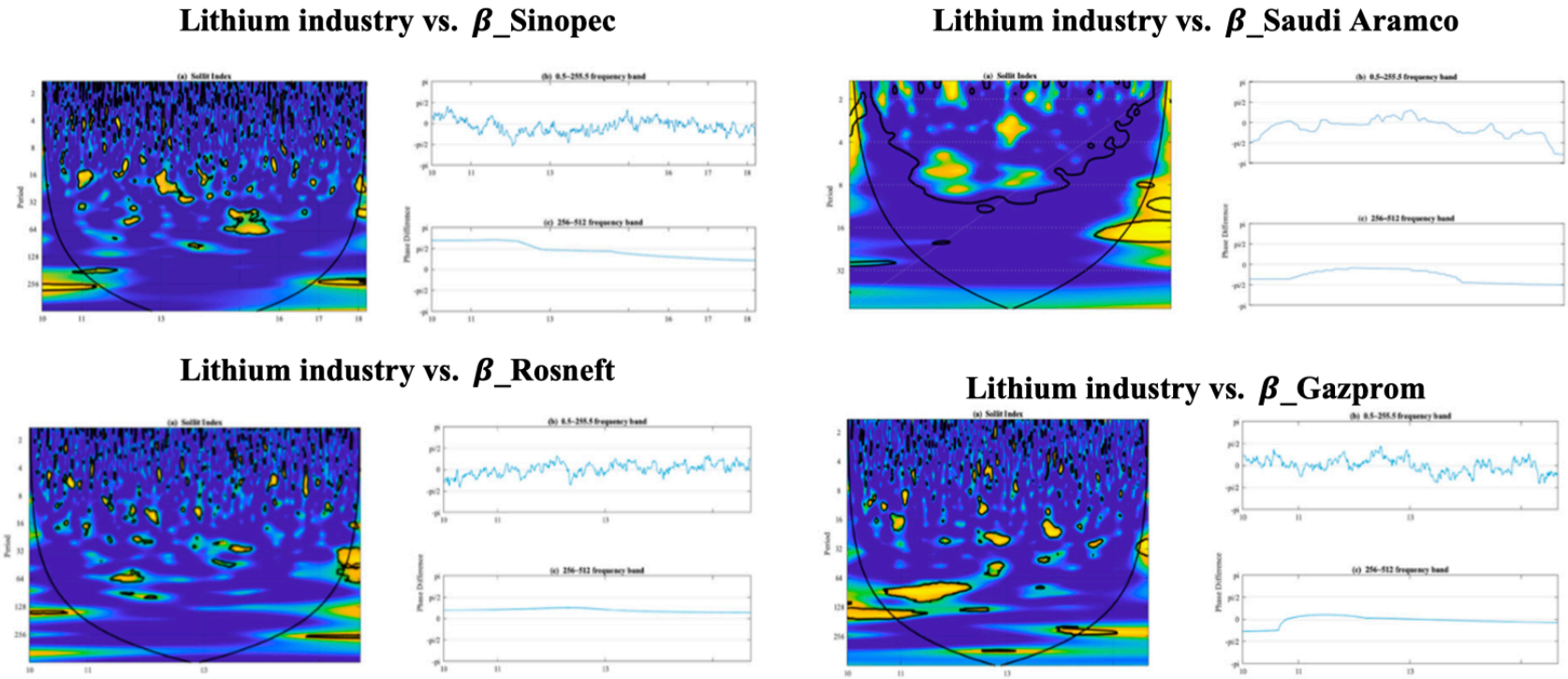

Figure: Wavelet coherency and phase difference results.

Table 2. Estimates of d for the betas with white noise.

	No Regressors	An Intercept	A Linear Time Trend
Exxon	1.00 (0.97, 1.03)	1.11 (1.08, 1.14)	**1.11** **(1.08, 1.14)**
Royal Dutch Shell	1.00 (0.97, 1.03)	1.12 (1.10, 1.15)	**1.12** **(1.09, 1.15)**
Chevron	1.00 (0.97, 1.03)	1.09 (1.07, 1.12)	**1.09** **(1.07, 1.12)**
PetroChina	0.98 (0.95, 1.00)	1.09 (1.06, 1.13)	**1.09** **(1.06, 1.13)**
Total SA	1.00 (0.97, 1.03)	**1.10** **(1.08, 1.13)**	1.10 (1.08, 1.13)
British Petroleum	1.00 (0.96, 1.03)	1.15 (1.11, 1.18)	**1.15** **(1.11, 1.18)**
Sinopec	1.04 (0.99, 1.08)	**1.05** **(0.99, 1.10)**	1.06 (1.00, 1.10)
Saudi Aramco	0.94 (0.85, 1.04)	**1.08** **(0.92, 1.24)**	1.08 (0.91, 1.24)
Rosneft	0.93 (0.85, 1.01)	0.83 (0.77, 0.99)	**0.87** **(0.76, 1.00)**
Gazprom	0.96 (0.93, 1.03)	0.92 (0.86, 1.01)	**0.92** **(0.86, 1.01)**

Note: The values in parentheses indicate the 95% confidence band for the values of d; those in bold indicate the selected model for each series.

Table 3. Estimated coefficients for the selected models in Table 2 with white noise.

	No Regressors	An Intercept	A Linear Time Trend
Exxon	1.11 (1.08, 1.14)	0.98911 (10,829.35)	0.000007 (1.74)
Royal D.	1.12 (1.09, 1.15)	0.94053 (5586.11)	0.000028 (3.21)
Chevron	1.09 (1.07, 1.12)	1.007611 (10,981.33)	−0.000006 (−1.72)
PetroChina	1.09 (1.06, 1.13)	0.989113 (10,829.33)	0.000007 (1.64)
Total SA	1.10 (1.08, 1.13)	1.00405 (9699.80)	—
BP PLC	1.15 (1.11, 1.18)	0.75244 (1370.34)	0.000111 (3.08)
Sinopec	1.05 (0.99, 1.10)	0.9863 (226.50)	—
Saudi Aramco	1.08 (0.92, 1.24)	1.1847 (12.47)	—
NK Rosneft PAO	0.87 (0.76, 1.00)	0.5582 (74.55)	−0.00023 (−2.30)
Gazprom PAO	0.92 (0.86, 1.01)	0.5289 (49.03)	−0.00034 (−4.50)

Table 4. Estimates of d for the betas with autocorrelateion.

	No Regressors	An Intercept	A Linear Time Trend
Exxon	0.99 (0.95, 1.05)	1.17 (1.13, 1.21)	**1.17** **(1.13, 1.21)**
Royal D.	0.99 (0.95, 1.05)	1.17 (1.14, 1.21)	**1.17** **(1.14, 1.21)**
Chevron	0.99 (0.95, 1.05)	1.12 (1.09, 1.16)	**1.12** **(1.09, 1.16)**
PetroChina	0.99 (0.95, 1.05)	**1.07** **(1.03, 1.11)**	1.07 (1.03, 1.11)
Total SA	0.99 (0.94, 1.05)	**1.22** **(1.18, 1.27)**	1.22 (1.18, 1.27)
BP PLC	0.99 (0.95, 1.05)	1.07 (1.03, 1.12)	**1.07** **(1.03, 1.12)**
Sinopec	0.89 (0.79, 1.01)	**0.92** **(0.87, 1.03)**	0.91 (0.87, 1.03)
Saudi Aramco	0.89 (0.80, 1.02)	**1.04** **(0.93, 1.12)**	1.05 (0.93, 1.13)
NK Rosneft PAO	0.87 (0.94, 1.02)	0.98 (0.91, 1.09)	**0.97** **(0.91, 1.07)**
Gazprom PAO	0.93 (0.88, 1.02)	0.93 (0.88, 1.01)	**0.92** **(0.88, 1.02)**

Note: The values in parentheses indicate the 95% confidence band for the values of d; those in bold indicate the selected model for each series.

Concluding comments

The results using CWT techniques shows that:

- There is a period that start around 2013 telling us how important and strong the relation is between the time series (high levels of dependence) and continues until 2016.
- This occurs in the long run frequencies (between 32 and 198 days).
- About the results obtained by the phase difference which give us information about the magnitude of the impact that a shock in one variable has on the other, and providing an economic explanation, we can conclude that the beta term reflects and advances the responsiveness of the oil companies to movements in the lithium market.

The fractional integration approach shows

- The homogeneous results across firms with values of d slightly above 1, nevertheless, statistically significantly above 1, thus rejecting the hypothesis of a random walk in the data and showing a lack of mean reversion.

It will be a pleasure to answer your questions.

THANK YOU