Mergers and Acquisitions in the Lithium Industry. A Fractional Integration Analysis

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Abstract

Lithium has a strategic role as a natural resource as more and more clean technologies emerge. This paper aims to analyze the time-series properties of the mergers and acquisitions (M&A) activity in the behavior of the lithium sector, applying statistical methods based on long range dependence and fractional differentiation. Our results show that the series under investigation display long memory with a degree of integration strictly below 1, thus we can conclude that the impacts will be transient and are expected to disappear on their own in the long term.

Keywords: Lithium industry; mergers and acquisitions; fractional integration; long memory.

JEL Classification: C13, C14, E30, G30, Q42.

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Luis A. Gil-Alana gratefully acknowledges financial support from the "Ministerio de Ciencia, Innovación y Universidades" (ECO2017-85503-R). Both authors also acknowledged support from an internal UFV project.

1. Introduction

The concerns about the mineral resources industry has increased significantly during the last years. The interest of governments and industries in accessing new mineral sources has intensified the climate of geo-political tension between countries on a global scale. Lithium, in particular, has enforced its relevance in the energy industry fundamentally for the development of clean technologies as it is employed in the production of rechargeable lithium-ion batteries for electronic devices and especially the electric car industry.

Taking into account other energy transitions (see Schurr and Netschert, 1960), petroleum would seem to be losing importance as the most important energy source in the world in favor of new clean energies. This transition is especially remarkable in transportation, consuming most of the world's liquid fuel (BP Energy Outlook, 2017). Authors such as Cherif and Hasanov (2017) argue that the position of oil as the main energy source could change in the next 10–25 years in benefit of renewables for power generation. This is important, as the increase in electric vehicle industries may severely affect prices of important components in the production of these vehicles, as is the case with the lithium.

Moreover, the increase in climate and general environmental concerns during the last 20 years has accelerated the interest in the adoption of renewables energies, being especially relevant aspects such as energy storage, led by lithium. The Lithium Triangle of South America, an area rich in minerals where Bolivia, Chile and Argentina intersect, is home to more than half of the planet's lithium resources and is becoming a focus of investments and exploration in this sector.

Therefore, it is essential to have quantitative studies that attempt to explain the economic behavior of natural resources considered key for the future development of the economies, given the different stimuli of the traditional sectors such as the financial sector. At this point, it is fundamental to observe how financial market information can affect the behavior of the lithium industry and its dynamics. Particularly, this study focuses on the effect of mergers and acquisitions (M&A) on the behavior of the lithium price, given that the key players in the lithium market at various stages of the supply chain seek to consolidate lithium resources through strategic agreements. of acquisition, mergers, acquisitions and vertical associations. One of the countries most interested in consolidating the supply in the lithium industry is China, which is expected to demand 800,000 tons of this resource by 2025 in order to meet the rest of its electro-car industry. Based on Metal Bulletin analysts, we can expect to see more of this trend in M&A in the lithium industry. This leads to concern about the effects on the behavior of lithium prices being even more important for industry and for producing countries.

There is a shortage with respect to quantitative studies that analyze the effects of financial operations on the behavior of key mineral resource prices such as lithium. In this paper we analyze the influence of M&A in the behavior of the lithium sector by applying statistical methods based on long memory and fractional integration models.

2. Literature review

Gort (1969) and Coase (2009) argue that shocks in the economy and industry (including technological, regulatory and so on) produce a reallocation of assets through mergers and acquisitions. In line with previous appointments and the transition between crude oil to the renewable energies, various authors argue that oil companies in China and Saudi Arabia are investing in renewable energy sources through external M&A activity (Germeraad et al., 2017). This could be due to oil companies lacking sufficient core competence in the renewable technology areas. This is in line with the research conducted by authors such as Brealey and Richard (1995), Gregoriou and Renneboog (2007) and others about M&A activities, strategic purposes and efficiency gains. According to these authors, M&A carry valuable information regarding future expectations on energy prices that should be taken into account in predicting future values (Bos et al., 2018).

The relevant and global interest to develop new projects that increase the lithium supply, feeds the interest to know how mergers and acquisitions in this industry can lead to changes in price dynamics in the market. Following the research done by Harford (2005), economic, technological and regulatory shocks provide the main reasons for M&A occurring in waves. Thus, there are several papers dealing with merger waves including, among others, Golbe and White (1988, 1993), Ravenscraft (1987), Shleifer and Vishny (1990), Nelson (1995), Holmstrom and Kaplan (2001), Mitchel and Mulherin (1996), Andrade et al. (2001), Harford (2005) In addition, there are also papers dealing with the modelling the merger wave. Town (1992) and Resende (1999) used switching models to model the merger series. In a more recent context, Monge et al. (2017) use wavelets to look at changes in pattern of M&A in the petroleum industry and crude oil prices. Monge and Gil-Alana (2018) use methods which employ Continuous Wavelet Transform (CWT) and Vector AutoRegressive Models (VAR) to study the dynamics of the lithium industry and mergers and acquisitions in the U.S. oil and gas industry, finding evidence of correlation in the long term between the variables of interest. Bos et al. (2018) propose a novel approach in the oil-stock market, investigating the predictive ability of M&A over West Texas Intermediate (WTI) oil returns and volatility using a non-parametric approach based on quantile methods. Their findings suggest that M&A activity plays a significant role in predicting oil returns and volatility dynamics.

As far as we are concerned there are no previous econometric works relating to the M&A in lithium industry using long range dependence and fractional differentiation. For this reason, following the research done by Monge and Gil-Alana (2016), we also investigate the behavior of waves in the lithium industry.

The remaining paper contains the following sections. Section 3 describes the dataset and presents the techniques employed in the paper. Section 4 contains the empirical results, while Section 5 concludes the manuscript.

3. Data and Methodology

3a. Data

The data used in this research paper correspond to the mergers and acquisitions in lithium industry all over the world from May 1985 to January 2019, obtained from the Thomson Reuters Eikon database. The research uses daily number of M&A in the lithium industry to form the aggregate monthly series.

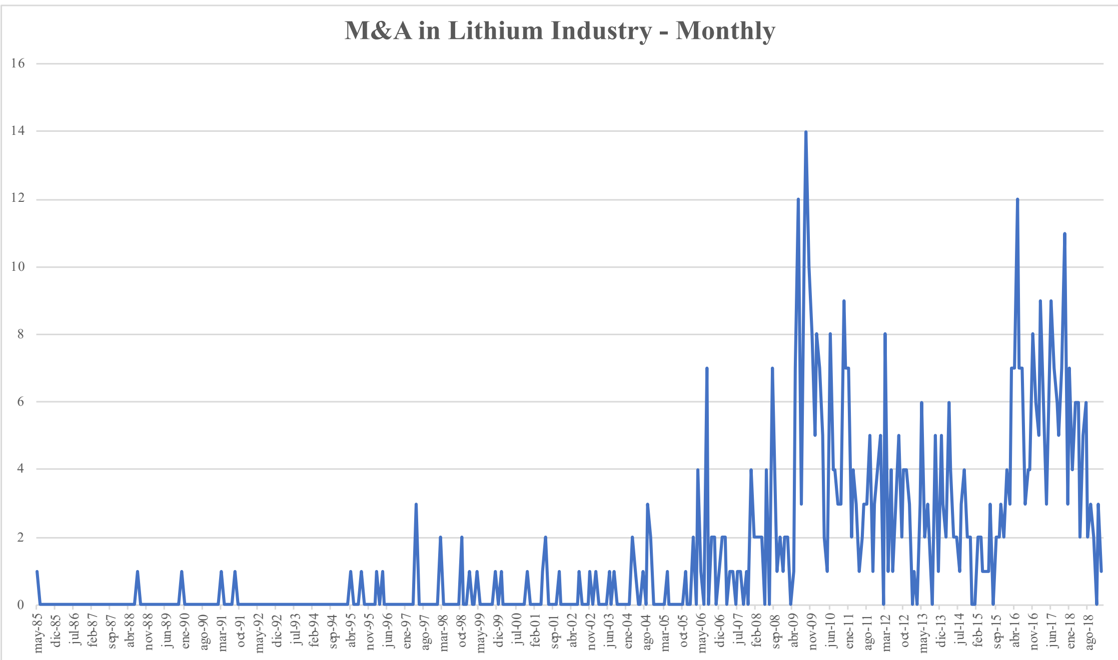

Figure 1. Mergers and Acquisitions (M&A) in Lithium Industry.

We notice in Figure 1 that in line with the United States Geological Survey (2011) and Maxwell (2014), we observe that the mergers and acquisitions in the lithium industry substantially increased after the Global Financial Crisis in 2008.

3b. Methodology

The methodology used is based on long range dependence or long memory, and in particular, we use fractional differentiation. The starting point is the definition of integration of order 0 or I(0). We say that a process is I(0) if it is a second order stationary process with the infinite sum of its autocovariances assumed to be finite. The frequency domain counterpart definition says that a process is I(0) if its spectral density function is positive and finite at the zero frequency. These two are both broad definitions that include many models of interest, including the stationary and invertible Auto Regressive Moving Average (ARMA). Based on its degree of persistence, on the other extreme, we have nonstationary processes, defined as having unit roots and also denoted as integrated of order 1, i.e., I(1) processes. Among them, the simplest one is the random walk:

$$(1 - B) x_t = u_t, \qquad t = 1, 2, \ldots, \qquad (1)$$

where B is the backshift operator ($Bx_t = x_{t-1}$) and with I(0) u_t. In this context, if u_t is ARMA(p, q), x_t in (1) is then ARIMA(p, 1, q). However, both I(0) and I(1) cases are very specialized models within the fractionally integrated or I(d) case, where d can be a fractional value. Thus, we consider a model of the following form:

$$(1 - B)^d x_t = u_t, \qquad t = 1, 2, \ldots, \qquad (2)$$

where d can be 0, a value between 0 and 1, 1, or even above 1.[1]

[1] Gil-Alana and Hualde (2009) provides a review of the applications involving fractional differentiation.

Processes of form as in (2) with positive d belong to the long memory category, given that the infinite sum of its autocorrelation is infinite, or, using the frequency domain approach, because the spectral density function goes to infinite as the frequency approaches to zero. Originally proposed by Granger (1980, 1981), Granger and Joyeux (1980) and Hosking (1981), they noticed that many economic aggregates presented an extremely large value in the estimated spectral density at frequency zero, which was consistent with first differentiation; however, once first differences were adopted, the estimated spectral density was close to zero at frequency zero, a clear indication that the series was overdifferenced. These models became popular in the 90s through the works of Sowell (1992), Baillie (1996), Gil-Alana and Robinson (1997), Baum et al. (1999), Silverberg and Verspagen (1999) and others, and they have also been used very recently in the analysis of various metals and products by authors such as Panas (2001), Arouri et al. (2012), Gil-Alana and Tripathy (2014) and Gil-Alana et al. (2015) among others.

The estimation of the degree of integration, i.e., d, is conducted by using both parametric and semiparametric approaches. In the parametric case, we employ the frequency domain version of the Whittle function (see, Dahlhaus, 1989) and we implement it through a simple version of the tests of Robinson (1994). Semiparametric local Whittle approaches (Robinson, 1995, Shimotsu and Phillips, 2006) will also be employed in the paper.

There are several values which are crucial when estimating d. Thus, from a statistical perspective, a relevant value is 0.5, noting that x_t will be second order stationary as long as $d < 0.5$, while it is nonstationary if $d \geq 0.5$. Another relevant value is 1. If $d < 1$, shocks will be transitory, disappearing in the long run, while if $d \geq 1$ shocks will not be mean reverting and their effects will persist forever. Thus, d is an indicator of the degree of persistence of the data.

4. Empirical Results

Table 1 and Table 2 display the estimated values of the differencing parameter for the database of M&A in lithium industry. We see that the values are very similar for the three models considered for the deterministic components (i.e., with no terms, with a constant, and with a constant and a linear trend) and also across the different modeling assumptions for the disturbances (white noise or weakly autocorrelation). If u_t is uncorrelated, the time trend coefficient is significantly positive, and the estimated value of the differencing parameter d is lower than 0.5 meaning that the time series is covariance stationary. If we impose autocorrelation by means of using Bloomfield's (1973)[2] model, the time trend is now insignificant, and the estimated value of d is slightly higher (0.59), though the null hypothesis of a unit root (i.e. d = 1) is again rejected in favor of reversion to the mean (d < 1), implying transitory shocks though with long lasting effects.

Table 1: Estimates of d under three different specifications

Disturbances	-----	An intercept	A linear time trend
White noise	0.39 (0.35, 0.45)	0.41 (0.37, 0.46)	**0.36** **(0.31, 0.42)**
Autocorrelation	0.57 (0.47, 0.69)	**0.59** **(0.49, 0.72)**	0.55 (0.42, 0.71)

Table 2: Estimated coefficients in the selected specification

Disturbances	-----	An intercept	A linear time trend
White noise	**0.36** **(0.31, 0.42)**	-0.5106 (-1.93)	0.0109 (3.64)
Autocorrelation	**0.59** **(0.49, 0.72)**	0.2473 (1.98)	---

[2] This is an approach where no functional form is adopted, simply using a spectral density function that approximates the one produced in ARMA models.

Nevertheless, the results based on this parametric approach produce some confronting results. Thus, under no autocorrelation on the error term, the estimated degree of differentiation is 0.36 and the confidence interval fully ranges in the stationary area ($d < 0.5$). However, under autocorrelation, which apparently might be a more realistic approach, the value of the differencing parameter is much larger and above 0.5 implying a nonstationary pattern. Because of this, we also implement an approach that is semiparametric in the sense that no functional form is imposed on the error term. For this purpose we use Robinson (1995) mainly because of its simplicity and that it relies simply on a single bandwidth parameter unlike other methods which might be very sensitive to their user-chosen parameters. The results using this approach, and using a bandwidth number m from 10 to 30 ($20 = T^{0.5}$) are displayed across Table 3. We observe that all them are once more in the range (0, 1) supporting fractional differentiation and also above 0.5 implying nonstationarity though displaying reversion to the mean.[3]

Table 3: Estimates of d based on a local "Whittle" approch

Bandwidth	Estimate of d	Bandwidth	Estimate of d
11	0.666	21	0.727
12	0.721	22	0.722
13	0.767	23	0.736
14	0.816	24	0.719
15	0.829	25	0.685
16	0.801	26	0.669
17	0.787	27	0.664
18	0.812	28	0.674
19	0.838	29	0.669

[3] Very similar results were obtained using Shimotsu and Phillip's (2006) approach.

20	0.768	30	0.641

5. Concluding comments

This article examines the influence of the mergers and acquisitions (M&A) in the behavior of lithium sector applying statistical methods based on long memory and fractional differentiation. As far as we are concerned there are no previous econometric works relating to the M&A in the lithium industry using these methodologies. Our results suggest that the time series is fractionally integrated and mean reverting, as the estimated value of d is lower than 1 both for the white noise and imposing autocorrelation. Nevertheless, it seems to be stationary under the white noise specification for the error term while nonstationary under autocorrelated disturbances. Performing a semiparametric approach the latter specifications seems to be preferred since the value of d is in the range (0.5, 1). Therefore, we observe mean reversion ($d < 1$), implying transitory shocks albeit with long lasting effects. Hence, we can conclude that the impacts for the lithium industry due to M&A will be transient and are expected to disappear on their own in the long term.

Compliance with Ethical Standards

- All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.

- This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

- The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

- This article does not contain any studies with human participants performed by any of the authors.

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