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Convenience yield, realised volatility and jumps: Evidence from non-ferrous metals

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ABSTRACT

Under the notion of convenience yield, a price of spot contract inherits relative implied value, against futures/forward contracts, for being readily available. This study examines the presence of a short-term lead-lag relationship between the volatility of futures price changes (including its decomposed components) and the convenience yield of major base metals, namely, aluminium, copper, nickel and zinc. Since an increase in the level of volatility may stimulate the demand for inventory, this study aims to provide alternative measures to understand the dynamic behaviour of convenience yield. Taken together, the results mostly support the presence of statistically significant relationships between the convenience yield and the realised volatility, which can be used for constructing effective inventory and investment strategies.

1. Introduction

A higher price variation of financial assets generally indicates a higher risk associated with investing funds into them, and thus investors require a higher return from making such an investment. A number of studies (e.g. Andersen et al., 2001; Koopman et al., 2005; Busch et al., 2011) disentangle the dynamic relationship between returns of a financial asset and its price volatility. In relation to this strand of academic studies, continuous effort has been made to develop techniques to measure volatility of returns. There are, however, a limited number of studies directly examining the relationship between the various components of the volatility and the perceived level of convenience yield of a commodity.

Convenience yield is a hidden relative value (against a long-distance futures/forward contract) of convenience awarded to a spot contract or a futures contract with a shorter maturity. In other words, benefits of readily available inventory or possessing physical assets are embedded in the price of those contracts. The notion is first introduced by Kaldor (1939) to explain a unique phenomenon observed in commodity markets where the price of a spot contract or futures contract with shorter maturity exceeds the price of distant futures contract. Since the introduction of convenience yield, a large number of scholars including Brennan (1958), Working (1948, 1949), Fama and French (1988), Hochradl and Rammerstorfer (2012), Narayan et al. (2013), Sévi (2015) and Fernandez (2016) use the notion to disentangle the dynamics of commodity markets.

Some scholars relate convenience yield with prices of commodities as many market participants use futures/forward markets to reduce exposure to unexpected changes in the price of industrial metals (i.e. for hedging purposes). Since the price of a commodity and its convenience yield are known to be positively correlated (see Stepanek et al., 2013), improving the predictability of convenience yield has the potential to facilitate trading decisions of speculators and hedgers. Furthermore, since intraday price information is more readily available, this study will provide an easily computable measure to predict convenience yield of durable commodities if statistically meaningful results can be obtained.

A recent study by Sévi (2015) investigates the lead-lag relationship between a discontinuous component of the realised volatility (*RV*) of futures price, known as the jump, and the convenience yield using the WTI crude oil market. As detection of a positive jump (an upward pressure to asset prices) suggests the presence of a positive shock, this may push the convenience yield upward. This is because, as conceptualised by Samuelson (1965), the price of a futures contract with

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shorter maturity is more sensitive to arrival of news than a futures contract with longer maturity. This relationship between the convenience yield and the jump should be clearer when the inventory level of the considered commodity is low as there would be a higher supply shortage risk.

In relation to the role of volatility in determining benefits of possessing a physical asset, Pindyck (2004) shows that incorporating changes in the price volatility can help explain spot-futures prices spreads; the simplest representation of convenience yield. To support this relationship, Knittel and Pindyck (2016) use a term "demand for storage": the total quantity of inventories held by producers, consumers or third parties. They argue that higher price volatility stimulates such demand because this indicates increases in the possible supply shortage risk, and causes convenience yields to react accordingly.

The relationship between the price variation and the convenience yield can be further clarified based on the idea of Gorton et al. (2013) and the theory of storage. In particular, Gorton et al. (2013) argue that the risk premium of an asset, represented by the expected excess return, and its volatility are positively correlated, while the risk premium is negatively related to its own inventory level. By combining these rationales and a fundamental notion of the theory of storage (convenience yield is a negative function of its own inventory level), convenience yield can be explained as a positive function of the volatility.

This rationalised relationship can be extended by isolating discontinuities from the volatility series. This strand of research may be of interest to various stakeholders; however, until Sévi (2015) there was no academic research directly examining this relationship. This study extends the work of Sévi (2015) by incorporating the realised volatility and its components and other control variables, including inventory level, to predict the convenience yield of four major base metals, namely, aluminium, copper, nickel and zinc.[1]

More specifically, this study focuses on examining the existence of the lead-lag relationship between the convenience yield, the *RV*, and the decomposed components of the *RV*. The base metals are some of the most suitable commodities to be studied due to the following reasons. First, while base metals are vital materials for our modern technologies, to the best of our knowledge, there is no academic research directly addressing the above-mentioned relationship between convenience yield and the *RV* and its continuous/discontinuous components.

Second, recent ups and downs in the prices of base metals help market participants realise that understanding the characteristics of these markets is becoming important. However, most studies mainly focus on other major commodities such as precious metals and energy commodities.

Third, the inventories of base metals held for trading are recorded by exchanges and available to the public. Hence, the impact of changes in the current inventory level can be accurately controlled for and a more clear picture about the role of the realised volatility and its components can be obtained.

Fourth, non-ferrous metal markets may inherit market characteristics substantially different from those of crude oil in various regards.[2] For this reason, it would be of great interest to both academic researchers and practitioners to understand whether the association between volatility measures and the value of physical assets also holds in the industrial metal market.

Fifth, as reported by Metal Bulletin (2013), it can be estimated that major copper smelters receive less than 10 per cent of the metal's value from the mining company as a processing fee [observed for copper prices between 5000 and 10,000 USD per metric tonne (MT) over 2008–2016]. It is a pressing issue for metal producers to enforce a quality inventory strategy. Thus, our study contributes to facilitating this strand of needs.

This study employs multiple approaches including the vector autoregressive (VAR) analysis and associated Granger-causality tests to examine the existence of the hypothesised relationship described below. Furthermore, in relation to detecting jumps, this study mainly uses the median realised volatility (*MedRV*).[3] This method is selected because it (1) successfully detects jumps even when there are a considerable number of zero-returns (Andersen et al., 2012; Sévi, 2015), and (2) avoids contamination from large jumps and microstructure noise through using the median operator (Chevallier and Sévi, 2010; Nolte and Xu, 2015). The detailed estimation model is presented in the Data and Methodology section below.

In summary, while the lead-lag relationship between the convenience yield and the *RV* variable is generally supported, the results rarely support the existence of a statistically significant relationship when the realised jump is used to explain the convenience yield. The difference between the results at hand and those of Sévi (2015) on the crude oil market can be due to various reasons including difference in (1) the liquidity level of the markets, (2) the characteristics of the market participants, (3) that detected jumps may be less related to the supply/demand environment of these metals, and (4) the sample period of the study. Furthermore, since this study incorporates various control variables, partitioning the influence of the factors may directly influence the significance of the realised volatility measures.

2. Research question

Conceptually, the convenience yield represents the benefit of possessing physical assets and the value of this convenience is determined by how much supply shortage risk is anticipated in the near future. For this reason, the *RV* and the components of the *RV* (e.g. the discontinuities) may be used to predict the convenience yield of a commodity. However, there is no extensive study directly examining whether or not this relationship holds for major non-ferrous metals. To fill this gap, the study at hand poses a research question: "Do realised volatility and its decomposed components help predict the convenience yield of base metals?" To answer this question, we propose the following hypotheses:

H_1. The convenience yield of a non-ferrous metal is a positive function of its realised volatility.

H_2. The convenience yield of a non-ferrous metal is a positive function of the positive discontinuous component of its realised volatility.

H_1 follows the idea of Knittel and Pindyck (2016) who argue that increases in the variability of market prices of the relevant financial asset would stimulate the demand for storage, and thereby cause increases in its convenience yield. H_2 follows Sévi (2015) who provides evidence of the positive relationship between the convenience yield and the discontinuous component of the *RV*. The idea of Sevi's study is consistent with Samuelson (1965); the price of a futures contract with a shorter maturity date is more sensitive to arrival of news. If positive news pushes up the price of a shorter contract more than a contract with a longer maturity, this would then cause the convenience yield to increase.

[1] These metals are selected based on the market size and the frequency of successful execution observed during five-minute intraday trading intervals. According to researchers including Andersen et al. (2012), a large number of zero-returns during a day may also put a downward bias on computed measures used to detect jumps.

[2] Non-ferrous metal markets are relatively less developed compared to the crude oil market, and metals are considered as durable commodities which can be recycled through re-refining process.

[3] As a robustness check, we employ another detection method, a bi-power variation method to estimate the discontinuous component of the *RV*. This method is a branch of power variation methods introduced, developed and used by a number of researchers including Barndorff-Nielsen and Shephard (2004a, 2004b), Tauchen and Huang (2005), Barndorff-Nielsen et al. (2006), Hansen and Lunde (2006), Corsi et al. (2010), Busch et al. (2011), Andersen et al. (2012) and Sévi (2015).