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Realized volatility spillovers in the non-ferrous metal futures market

Neda Todorova [a,*], Andrew Worthington [a], Michael Souček [b]

[a] Griffith Business School, Griffith University, 170 Kessels Road, Nathan, Queensland 4111, Australia
[b] Department of Business Administration, European University Viadrina, Große Scharrnstraße 59, 15230 Frankfurt (Oder), Germany

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ABSTRACT

In contrast to energy and precious metals commodities, relatively little is known about the volatility dynamics of base (or industrial) metals commodities. To address this deficiency, this paper employs a multivariate heterogeneous autoregressive (HAR) model to consider the volatility spillovers between the five of the most liquid and important non-ferrous metals contracts (aluminium, copper, lead, nickel, and zinc) traded on the London Metal Exchange using intraday data over the period June 2006–December 2012. This period encompasses both the surge in commodities prices associated with the burgeoning industrial demand of many emerging economies, especially China, resulting in market peaks in May 2007 and April 2008 and the subsequent negative reaction of base metals markets to the collapse of stock markets during the recent global financial crisis. The results show that the volatility series of other industrial metals appear to contain useful incremental information for future price volatility. However, the own dynamics are often sufficient for describing most future daily and weekly volatility, with the most pronounced volatility spillovers identified in the longer term. Combined together, the results in this study provide useful findings for exporter and importer countries dealing with the continuing volatility in these industrially important commodity markets.

Introduction

Base or industrial (nonprecious) metals (including aluminium, lead, zinc, copper, and nickel) continue to play a critically important role in industrial manufacturing and economic activity worldwide, a feature particularly pronounced given the burgeoning demand for base metals by the rapidly growing Chinese economy and the commodities boom of the 2000s. In turn, this naturally focuses attention on the enhancement of our knowledge of price discovery and other behavior in physical and derivatives markets for base metals for, among other things, hedging by producers and manufacturers and portfolio allocation decisions by investors seeking asset exposure to commodities, especially in light of continuing global economic uncertainty and volatile equity and bond markets.

However, in stark contrast to the significant volume of work on energy commodities (oil, natural gas, and electricity) and precious metals (gold, silver and platinum), computationally advanced studies using high-frequency data from base metals markets remain limited. For example, Watkins and McAleer (2004) identified just 45 articles in refereed journals over the period 1980–2002 focusing on the prices for industrial metals, none of which utilize intraday data. This is certainly not for a lack of important and practical topics of interest in base metals, with work recently addressing price behavior (Watkins and McAleer, 2006, 2008; Hammoudeh and Yuan, 2008), inventory linkages between physical spot and derivatives markets (Geman and Smith, 2013), asset price linkages and information spillovers (Wang et al., 2007; Hammoudeh et al., 2009) and the links between spot and futures markets (Liu et al., 2008; Aruga and Managi, 2011). In the area of volatility transmission, spillover patterns have also been examined across international markets in the same metal (Lien and Yang, 2009), primary and scrap metal markets (Xiarchos and Fletcher, 2009) and between currency, commodity and equity markets (Khalifa et al., 2012).

The purpose of the study is to contribute to this important but small literature by identifying volatility spillover effects between the futures of five of the most actively traded base (non-ferrous) metals contracts on the London Metal Exchange (LME), the world's largest center for trading in industrial metals accounting for more than 80% of global non-ferrous business. The contracts selected are for aluminium, copper, lead, nickel, and zinc.

Of course, base metal price volatility has profound impacts as far as resource policy is concerned. To start with, the collective expectation is that high price volatility will remain a feature of

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[*] Corresponding author. Tel.: +61 7 3735 7219; fax: +61 7 3735 3719.
E-mail addresses: n.todorova@griffith.edu.au (N. Todorova), a.worthington@griffith.edu.au (A. Worthington), soucek@europa-uni.de (M. Souček).

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most of these markets in the future. This has significant implications for both exporter and importer countries, their businesses, and their governments. Exporting countries are potentially subject to rapid changes in tax revenues, investment, and economic confidence. Importing countries may suffer the negative inflationary and growth effects of excessive volatility and high prices. In response, several monetary and fiscal policies may assist governments dealing with base metal price volatility. These include the hedging of base metals revenues, inflation targeting, diversification into non-commodity markets, countercyclical fiscal policies and the establishment of stabilization funds. These all require a complete understanding of the underlying volatility dynamics, for which this analysis is invaluable.

Our study contributes to the existing literature of commodity markets and volatility transmission in four different ways. First, to our best knowledge, volatility transmission between futures contracts for non-ferrous metals have not been previously examined. Industrial metal prices are subject to both short-term price movements and longer-term price trends. In turn, short-term price movements relate to influences on demand and supply in the market, like supply disruptions (e.g. natural disasters and industrial accidents), and risk premiums arising from geopolitical tensions, economic shocks or speculative activity. In the longer term, major influential factors of commodities prices are the supply side marginal costs of production and demand-side efficiency improvements, as well as the investment strategies of agents with a long-term perspective. Taken together, these effects along with the complementary and substitute relationships between various metals may explain why the volatility series sometimes share periods of similar behavior, while at other times each market exhibits volatility unable to be simultaneously observed in the remaining series. Against this backdrop, it is important for market participants to identify spillover patterns among the individual metals.

Second, in contrast to the multivariate generalized autoregressive conditional heteroscedasticity (MGARCH) methodology, which provides the standard econometric tool in the study of volatility transmission, we utilize a multivariate heterogeneous autoregressive model (HAR) which is able to reveal the role of volatility components established over different time periods. Extending the HAR model to a multivariate context allows for a better understanding of the spillover effects as they can be assigned to short-, mid- or long-term volatility. Importantly, the disentangling of spillover effects into daily, weekly and monthly horizons cannot be done by means of the more widely established multivariate GARCH framework. Commonly encountered in equity markets research, the application of the HAR model to commodity markets research has been rather more limited. As exceptions, Chevallier and Sévi (2011) employ the model to study the volatility of CO_2 emissions, Liu and Wan (2012) apply it to oil futures and Wu (2011) focuses on grain markets. Nonetheless, to our best knowledge, no multivariate extension has been utilized for studying volatility transmission in commodity markets. An additional methodological contribution of this paper is the introduction of an orthogonalized version of a multi-asset HAR model. This helps avoid any ambiguous findings arising from potential multicollinearity emerging from a model setting within which we simultaneously consider the realized volatilities of multiple assets. The chosen approach is easy to use and considers the fact that base metals, as pointed out by Geman and Smith (2013), which exhibit marginal seasonal variation in supply and demand, do not require the imposition of any additional requirements in considering seasonal effects.

Third, by adjusting realized volatility according to the approach in Hansen and Lunde (2006), we are the first to utilize an advanced intraday data based volatility proxy that accounts for the distorting effect of microstructure noise for studying base metal market volatility. The utilization of high-frequency data is known to allow for more precise inference for univariate volatility estimation and forecasting and is thus considerably more promising for gaining insights into volatility transmission patterns than data sampled at lower frequency which provides noisy volatility estimates. Of the aforementioned studies, only Lien and Yang (2009) utilize intraday data in an application of GARCH to 5-min futures returns in three copper markets during 2005.

Finally, our sample covers the period from June 2006 to December 2012 and hence considers volatility transmission in the light of most recent market history. This period encompasses both the surge in commodities prices associated with the burgeoning industrial demand of many emerging economies, especially China, resulting in market peaks in May 2007 and April 2008 and the subsequent negative reaction of metals markets to the collapse of stock markets during the recent global financial crisis.[1]

The remainder of the paper is structured as follows. Section 2 discusses the methodology. Section 3 presents the data. Section 4 reports the empirical results. Section 5 provides some concluding remarks.

Methodology

To measure the daily quadratic variation using intraday data we employ a realized variance measure. Realized volatility in its original form, as proposed by Andersen and Bollerslev (1998), is based on the intraday futures' prices $P_{t,i}$ observed at time intervals of fixed length. The resultant continuous intraday returns are

$$r_{t,i} = \ln\left(\frac{P_{t,i}}{P_{t,i-1}}\right) \quad \text{for } i > 0, \tag{1}$$

with the first index t denoting the day of observation $t = 1, 2, \ldots, T$. The index i denotes the time of observation on a particular day $i = 0, 1, 2, \ldots, I$. The realized variance on a trading day t is estimated by finding the total of the squared intraday returns, $\sum_{i=1}^{I} r_{t,i}^2$.

To account for the fact that the price process may be contaminated by market microstructure noise, which in turn may cause the realized variance to be a biased and inconsistent estimator of the nonobservable volatility, we follow the kernel-based approach in Hansen and Lunde (2006) and make following adjustment:

$$RV_t = \sum_{i=1}^{I} r_{t,i}^2 + 2\sum_{j=1}^{q}\left(1 - \frac{j}{q+1}\right)\sum_{i=1}^{I-j} r_{t,i} r_{t,i+j}. \tag{2}$$

This estimator exhibits the comforting feature of providing always positive values for realized variance. After analyzing the autocorrelation functions of the employed intraday returns, we set $q = 1$ for our study. Barndorff-Nielsen et al. (2008) discuss the asymptotic properties of the kernel-based estimator in Hansen and Lunde (2006).[2]

To reveal interrelationships between the second moments of our chosen financial assets, we use a multivariate version of the HAR model of Corsi (2009). Motivated by the heterogeneous market hypothesis of Müller et al. (1997) and Dacorogna et al. (1998), Corsi (2009) proposes a simple autoregressive-type model for realized volatility involving volatilities realized over different periods, based upon the premise that traders with different time horizons have a different impact on volatility. This notion is

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[1] See Humphreys (2010) for a retrospective on the boom and subsequent crash in global metals markets in the 2000s.

[2] For alternative adjustment approaches for microstructure noise, see, for example, Bandi and Russell (2006), Oomen (2005), Zhang et al. (2005) and Zhou (1996).