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Volatility forecasting of non-ferrous metal futures: Covariances, covariates or combinations? ☆

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This is the first comprehensive study on the forecasting of the realized volatility of non-ferrous metal futures. Based on 8.5 years of intraday data on copper, zinc, nickel, lead and aluminum, we explore a variety of extensions of the univariate heterogeneous autoregressive (HAR) model and seek to harness the economic linkages among these metals to improve forecasts. A simple approach that augments the models with shocks in other metals' series appears to outperform more sophisticated specifications, which explicitly model covariances. The results suggest that the information inherent in the volatility series of aluminum is most useful in enhancing the accuracy of forecasts for other metals. While consistently outperforming the original HAR model with an individual model is difficult, combination forecasts, especially with univariate specifications or Bayesian model averaging, are found to conclusively outperform the benchmark.

1. Introduction

The crucial importance of modeling and forecasting the volatility of financial markets is evidenced by the overwhelming volume of academic literature that has thrived on the availability of high-frequency data for various assets in recent years. This research domain is characterized by an ever-increasing number of estimators[2] and their adjustment to reflect the reality of markets, such as non-trading hours (e.g., Andersen et al., 2011; Hansen and Lunde, 2005), microstructure noise and outliers (e.g., Zhang et al., 2005; McAleer and Medeiros, 2008), and the introduction of sophisticated model specifications (e.g., Andersen et al., 2003; Engle and Gallo, 2006). While equity market volatility is at the heart of most empirical studies, commodity markets have become a burgeoning research interest.

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2 For example, Liu et al. (2015) compare the estimation performance of 400 different realized estimators.

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Due to the advance of financialization,[3] commodity market volatility, similar to equity market volatility, is of major practical importance for risk measurement, asset allocation and portfolio performance evaluation. Additionally, understanding and forecasting the volatility of commodities has significant implications for exporter and importer countries, hedging decisions of individual market participants and government regulation. This paper is the first to provide an extensive analysis of the out-of-sample performance of various volatility models in the London Metal Exchange (LME) market for five non-ferrous metals: aluminum, copper, nickel, lead and zinc. Non-ferrous metals are vital materials for most economies, and their prices are highly relevant for the extraction, processing and manufacturing sectors (Watkins and McAleer, 2004). Due to the wide range of their indispensable industrial applications, non-ferrous metals are also seen as indicators of the global economic state. Two major developments in industrial metal markets have been witnessed in recent years. On the one hand, a surge in demand for metals, mainly driven by emerging economies, was followed by a meltdown during the financial crisis period and a partial recovery. On the other hand, the increasing interest of institutional and private investors in these markets has resulted in the strong presence of market participants who do not have physical exposure to these assets. The LME is the world's largest venue for trading industrial metals, transacting 76% of the global non-ferrous futures business.[4] However, industrial metals, although also represented in broad commodity indices such as the Bloomberg Commodity Index and S&P GSCI, are still mainly known for their industrial applications, while the econometric modeling of their volatility has received comparatively less attention than other commodities with the notable exception of Todorova et al. (2014) and Watkins and McAleer (2004).[5] This study aims to combine two strands of the literature: volatility spillovers and volatility forecasting. While the first has been addressed in the literature on non-ferrous metals, surprisingly, a gaping void exists with regard to the latter, especially in terms of the performance of realized volatility measures, which are known to be superior volatility proxies than estimators based on data sampled daily or at lower frequencies.

Existing studies on volatility transmission focus on spillovers between primary and scrap metal markets (Xiarchos and Fletcher, 2009), commodity and other markets (Khalifa et al., 2012) or among international markets for the same metal (Lien and Yang, 2009). A limited number of further studies investigate spillovers among individual non-ferrous metals. Atenga (2014) utilizes GARCH class models for monthly metal prices of nickel, lead and copper and provides evidence of the existence of significant spillovers among these metals. Lucey (2014) shows results obtained with the Diebold and Yilmaz (2009) index for the daily spot prices of aluminum, copper, zinc, nickel, tin and lead and draws similar conclusions. Applying a multivariate extension of the heterogeneous autoregressive model (HAR) model to intraday LME futures data, Todorova et al. (2014) uncover significant short- and long-term spillover effects, which can be explained by the substitution and complementary effects on the metals' industrial uses.

Motivated by the documented econometric significance of the economic relations among industrial metals, the current study goes beyond an in-sample analysis and investigates the out-of-sample performance of competing volatility models. While volatility forecasting with realized measures for commodity markets mainly addresses energy assets (e.g., Haugom et al., 2014; Sévi, 2014) and precious metals (e.g., Khalifa et al., 2011; Lyócsa and Molnár, 2016) in the literature, to the best of our knowledge, very limited research addresses the realized volatility forecasting of LME non-ferrous metals. Using intraday COMEX data on copper, gold and silver, Khalifa et al. (2011) evaluate one-day-ahead GARCH-based forecasts, suggesting that with 5 and higher sampling frequency, realized volatility is the preferred choice of proxy for the integrated volatility. Focusing mostly on the metal market volatility in in-sample terms in a short forecasting exercise, Todorova (2015) establishes that the simple HAR model of Corsi (2009) cannot be conclusively outperformed by accounting for leverage effects or the volatility of realized volatility. To date, no research has examined the advantages of harnessing cross-metal relationships in an out-of-sample context.

The current study contributes to the literature by analyzing a variety of HAR models for five non-ferrous metals. The HAR model of Corsi (2009) is very popular in the volatility literature. The empirical applications of HAR-type models are often associated with technical extensions such as jumps (Andersen et al., 2007), leverage effects (Corsi and Reno, 2012), semivariance components (Patton and Sheppard, 2015), the combination of HAR with GARCH classes (Corsi et al., 2008), and generalized as well as intercept-free specifications (Bollerslev et al., 2017), among others. However, our analysis is not limited to running a horse race among a plethora of univariate HAR specifications, as the recent literature on energy markets has already shown that consistently beating the simple HAR model with a single specification is difficult (e.g., Sévi, 2014; Wen et al., 2016; Prokopczuk et al., 2016). Instead, we compare the performance of univariate model specifications, accounting for jumps, realized semivariances and real-world market idiosyncrasies, with multi-asset specifications based on the intuition that spillover effects that stem from the economic relations among the individual assets can be translated into improved forecasting accuracy. We first account for possible spillovers by including shocks in the realized volatilities of other assets as exogenous variables in the univariate HAR model. In addition to this relatively naïve approach (hereafter referred to as "HAR-X"), metal volatility is forecasted with a "true" multivariate model, namely, a model extension that specifically accounts for the covariances among individual assets. We not only study new data with an existing technique but also propose a new multivariate HAR model by estimating variance–covariance matrices using the approach of Fengler and Gisler

[3] See Adams and Glück (2015), Basak and Pavlova (2015), and Henderson et al. (2015), among others, for a detailed discussion of financialization.
[4] Source: www.lme.com.
[5] Recent studies on industrial metal market volatility without forecasting aspects include those of Behmiri and Manera (2015), Geman and Smith (2013) and Watkins and McAleer (2008).