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Forecasting gold futures market volatility using macroeconomic variables in the United States

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ABSTRACT

The U.S. gold futures market has recently attracted significant attention and the gold volatility is closely linked to macroeconomics. As such, the question is how to analyze the impact of various macroeconomic variables on gold. We use the GARCH-MIDAS (mixed data sampling) model to investigate whether macroeconomic variables can improve the predictions on the volatility structure of U.S. gold futures. Our empirical results reveal that macroeconomic variables have a significant influence on gold volatility, especially during and after the global financial crisis, indicating macroeconomic variables are driving factors of the long-term volatility on the U.S. gold futures market. Additionally, we use principal component analysis to obtain key information on different macroeconomic variables and further investigate their joint effects on the volatility of gold futures, finding that the first and second principal components are good proxies of macroeconomic variables. Our results show that principal components improve forecast accuracy, as do macrovariables, which are robust to various forecast rolling window schemes.

1. Introduction

Gold, served as a multifaceted metal, has been a wealth preservation tool for centuries as it is an effective hedge against various risks. With the increasing role of the gold market, statistical modeling and forecasting of the gold market volatility has attracted broad attention (Batten et al., 2008; Elder et al., 2012; Mensi et al., 2013). In August 2015, global equity markets have taken a tumble, such as S&P500 is down 10%, but gold is up 5% in US dollars. Such phenomena were also found after the 2007 financial crisis and during Black Monday in 1987. World Gold Council's analysis demonstrates that gold can be used in portfolios to protect global purchasing power during periods of market shock. However, Barro and Misra (2016) pointed out that gold may not be a risk hedging tool. They found that the average annual gold return was 2.1% in a series of "macroeconomic disasters[1]", which was not much higher than that of 1.5% in the normal periods. Between 1836 and 2011, the standard deviation of annual returns in the gold market was 13.7%, which was only 3% lower than the U.S. stock volatility. Therefore, it is crucial to understand whether the gold market volatility is independent of the macroeconomic situation and how would the macroeconomic factors influence the U.S. gold market volatility.

Moreover, among all of the gold markets across the word, the U.S. gold markets aroused the most interest. The reasons are as follows. First, the gold futures in COMEX is one of the largest and most active gold futures product in all the exchanges worldwide. The earliest gold futures product is first launched in COMEX in 1975, and the volumes of gold futures in COMEX is also one of the largest in all exchanges worldwide. According to WGC (World Gold Council), the average daily notional gold volumes in 2016 in COMEX is 28.9 billion dollars.[2] These facts make transaction in COMEX attract much more attention than other exchanges in the world. Second, up to the second quarter in 2017, the Official gold reserves in US is 8133.5 tones, which occupies 74.5% of total reserves in US. Therefore, volatility of gold futures is much important to the government in US. In this paper, we focus on volatility predictability, and attempt to analyze whether including U.S. macroeconomic variables can improve the forecasting ability of volatility models in the gold market.

Recently, volatility component models have received considerable attention, not only because of their ability to capture complex dynamics through a parsimonious parameter structure, but it is also believed that they can endure structural breaks or non-stationarities in asset price

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[1] The " macroeconomic disaster" refers to a country's real per capita gross domestic product (GDP) dropped by at least 10% in the average period of three to four years. These "disasters" are considered to include the Great Depression, the economic performance of Germany and Japan during World War II.

[2] https://www.gold.org/what-we-do/gold-market-structure/global-gold-market.

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volatility. Because the analyses of time-varying volatility are primarily based on high-frequency data, previous studies are primarily limited to variables for which daily data are available. To investigate the effect of some low-frequency macroeconomic variables, some studies such as Batten et al. (2008) aggregate higher frequency data to a lower frequency by simply averaging assuming a representative high-frequency data point in time as a proxy for a low-frequency observation. This method generally impedes the extraction of information that is available in high-frequency data and discards a significant amount of potentially useful information (Ghysels et al., 2006).

We use GARCH-MIDAS approach by Engle et al. (2013) because it can better handle the problem of the data mismatching frequency of daily returns and monthly macroeconomic variables. The GARCH-MIDAS approach has the advantages that it separates short- and long-run components of volatility and uses a direct approach imputing macroeconomic time series to capture the economic sources of stock market volatility. More importantly, Engle et al. (2013) find that models with the long-term component driven by macroeconomic variables are on par in terms of out-of-sample prediction and outperform pure time series statistical models, in which the loss of efficiency due to multiple steps estimation is reduced. Furthermore, considering that the macroeconomy is slowly evolving, modelling the low-frequency component of volatility with GARCH-MIDAS model is more reasonable and it can be used for any series without requiring specification of the economic structure. A long-term component can describe the long memory features of the volatility process (Engle and Rangel, 2008). Therefore, we combine high-frequency gold return data with macroeconomic variables that are only observed at lower frequencies, and evaluate the relative performance when developing a forecast using the GARCH-MIDAS model by introducing the macroeconomic variables.

Our results show that the macroeconomic variables have a significant impact on gold market volatility during and after the economic turmoil, and including the low-frequency macroeconomic variables in the GARCH-MIDAS model improves its prediction ability. Moreover, we use different rolling windows to forecast volatility for out-of-sample volatility to confirm the robustness of this result, which indicates that macroeconomic variables are additional driving factors of long-term volatility in the U.S. gold futures market. In addition, Principal component analysis (PCA) is used to gather key information on different macroeconomic variables, and the first and second principal components are good proxies of the macroeconomic variables.

This article contributes to the literature in several ways. First, the impact of various U.S. macroeconomic variables on the volatility of gold returns in the United States is examined more comprehensively. We incorporate 10 macroeconomic variables, such as EPU, employment growth, inflation rate, capacity utilization, and consumer confidence. Furthermore, using PCA, we obtain key information on these variables, which helps to analyze the overall influence of U.S. macroeconomic variables. Second, we incorporate data which are observed at different frequencies into the same model. In this way, information loss is avoided and the impact of the macroeconomic variables on the long-term volatility of gold returns is better identified. Third, unlike prior studies on the effect of macroeconomic variables that scarcely conducted out-of-sample predictions, our results confirm macroeconomic variables could improve the out-of-sample predictive power of gold volatility. Accurate forecasting could thus offer information advantages to the various market participants in discerning investment and managing risk.

The remainder of this paper is organized as follows. Section 2 discusses the related literature. Section 3 focuses on the data and the main methodology. Section 4 discusses the empirical results and conducts further analysis. Section 5 presents the study's conclusions.

2. Literature review

The literature documents the relationship between different macroeconomic variables and the volatility of the gold market. David et al. (2000) examine the effects of monthly macroeconomic news releases on gold and find that gold responds strongly to a CPI news announcement, in addition to the unemployment rate, GDP, and PPI. Using a high frequency dataset, Cai et al. (2001) find that interest rates, oil prices, and inflation rates have a relatively stronger impact on the gold market. Tully and Lucey (2007) confirm that gold and the dollar are negatively related by using the asymmetric power GARCH model (APARCH). Batten et al. (2008) use a VAR framework to investigate the macroeconomic variables (business cycle, financial market sentiment and monetary environment) of gold volatility, showing that gold volatility can be explained by monetary determinants. Aye et al. (2015) develop several models to examine macroeconomic predictors of gold returns and conclude that the forecasting ability of the exchange rate is supreme. Dyhrberg (2016) indicates the hedging capabilities and advantages of gold as a medium of exchange. Furthermore, a study that predicts gold volatility with macroeconomic determinants is of interest to both investors and policymakers opting to purchase gold (David et al., 2000; Capie et al., 2005; Cai et al., 2017). However, on examination of these literature, it is surprising to find out that these models are based mostly on data of the same frequency, inevitably ignoring the information of either the gold or the macroeconomic variables. The GARCH-MIDAS model proposed by Engle et al. (2013) separates the short-term volatility component from the long-term component and the former is captured by a GARCH process while the latter is in the spirit of MIDAS regression. Thus the model has an outstanding advantage that it permits us to better handle the relationship between the volatility observed on daily frequency and the macro-finance variables sampled monthly or even lower frequency.

Due to these advantages, the GARCH-MIDAS model has been widely applied on the researches of various markets. With respect to the stock markets, Asgharian et al. (2013) and Conrad and Loch (2015) examine the relationship between macroeconomic variables and US stock market volatility. They note that term spread, housing starts, corporate profit and the unemployment rate are more informative among variables. In addition, Girardin and Joyeux (2013) account for the influence of economic fundamentals augmented with the speculative factors that are proxied by volume. Pan and Liu (2018) extend the GARCH-MIDAS model to account for the leverage effect in short-term and long-term volatility components. For bond markets, Nieto et al. (2015) confirm that contrary to the typical GARCH model, GARCH-MIDAS plays a better role in predicting the corporate bond volatility. Asgharian et al. (2015) investigate the impacts of macroeconomic uncertainty (MUI), showing that MUI has a significant influence on the long-run stock volatility while the long-run bond market is unaffected. There is other literature that documents specific to commodity markets using the GARCH-MIDAS model. Donmez and Magrini (2013) investigate the main driver of agricultural commodity price volatility by using this model to combine daily crop prices with other monthly market-specific and macroeconomic drivers. Omitting agriculture, Mo et al. (2017) also examine the macroeconomic determinants of the volatility of metal futures and oil futures in the Chinese and Indian markets. From researches above can be seen, GARCH-MIDAS model has an extensive application. However, to our knowledge, few similar work has been done in gold markets.

The spillover effects (see, Diebold and Yilmaz, 2009; Al Rahahleh and Bhatti, 2017) and information flow (Al Rahahleh et al., 2017) have been observed among various coupled international stock markets, nevertheless gold could act as a safe haven during stock market crashes in most countries (Nguyen et al., 2016). Given the increasing role that gold plays in modern finance, the investigation of gold futures market volatility appears more essential and significant. Therefore, we apply GARCH-MIDAS model, which has the advantage of allowing the inclusion of data from different frequencies in the same model, to predict gold futures market volatility using macroeconomic variables.