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Long memory volatility of gold price returns: How strong is the evidence from distinct economic cycles?

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HIGHLIGHTS

- This paper examines the long memory behavior of gold returns volatility.
- We perform a sub-sample analysis using the FIGARCH(1,*d*,1) model.
- We use daily data from 1985–2009.
- We found mixed evidence of long memory over the eight sub-samples considered.
- When we consider the full sample, evidence shows long memory in the volatility.

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ABSTRACT

This paper examines the long memory behavior in the volatility of gold returns using daily data for the period 1985–2009. We divided the whole sample into eight sub-samples in order to analyze the robustness and consistency of our results during different crisis periods. This constitutes our main contribution. We cover four major world crises, namely, (i) the US stock market crash of 1987; (ii) the Asian financial crisis of 1997; (iii) the World Trade Center terrorist attack of 2001 and finally, (iv) the sub-prime crisis of 2007, in order to investigate how the fractional integrated parameter of the FIGARCH(1,*d*,1) model evolves over time. Our findings are twofold: (i) there is evidence of long memory in the conditional variance over the whole sample period; (ii) when we consider the sub-sample analysis, the results show mixed evidence. Thus, for the 1985–2003 period the long memory parameter is positive and statistically significant in the pre-crisis sub-samples, and there is no evidence of long memory in the crisis sub-sample periods; however the reverse pattern occurs for the 2005–2009 period. This highlights the unique characteristics of the 2007 sub-prime crisis.

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1. Introduction

Gold has always been viewed as a refuge in times of financial distress given its stable price behavior. However, the demand for this commodity increased sharply during the recent economic crisis, which exhibited unprecedented levels of volatility only comparable in magnitude to the Great Depression of the 1930s [1]. Although both these crises pertain to the financial domain, the similarities between them end there. In fact, while the Great Depression erupted in the stock market, the last financial crisis (the full implications of which are yet to be determined) had its roots in the US sub-prime mortgage crisis and was aggravated by the collapse of the Lehman Brothers on September 15th, 2008. The effects of this crisis rapidly spread

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beyond the US and especially to the EU. Governments began absorbing private debt in an unparalleled manner to avoid the risk of imminent bankruptcies in the banking system, but this just shifted the crisis from the private to the public sector. As a result, the Eurozone sovereign debt crisis is usually regarded as a byproduct of the US sub-prime crisis [2]. This context made investors turn to metal commodities, particularly gold, to diversify the risk. Though gold has always been understood as a hedge or safe heaven, it was not until Baur and Lucey [3] that the distinction between these two concepts was made clear. They defined a hedge as an asset that is uncorrelated or negatively correlated with another asset or portfolio on average, whereas a safe heaven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market turmoil. Using data from 1979 to 2009, they found that gold was both a hedge and a safe heaven for the US and major EU countries but not for emerging markets.

On the other hand, the versatility of gold had previously been highlighted by Refs. [4,5], who stressed its unique characteristics as a store of wealth, medium of exchange and unit of value. Moreover, it also has well-known applications in the dental industry and jewelry [1,6]. These features, associated with the hedge and safe heaven properties, make gold especially attractive in times of turmoil and have stimulated the interest in its volatility process.

A common empirical finding in many financial time series is the long memory behavior of volatility returns, which refers to low decay rates of long-lag autocorrelations [7]. This implies some degree of predictability of the time series that may lead to the violation of the weak-form informational efficiency of markets, as stressed by Elder and Serletis [8]. In addition, a strong level of long memory suggests that there is little tendency for the volatility process to revert toward the volatility mean and therefore, long positive or negative strays from the equilibrium should be expected.

While extensive literature on this topic is devoted to the stock markets, not many studies address the long memory behavior in the volatility of gold returns. Refs. [6,7,9,10] are one of the few exceptions to this. In view of this and bearing in mind that long memory may be different according to the singularities of the period under consideration, our objectives are as follows: (i) First, we use a long period of 24 years covering 1985–2009 to investigate the long memory behavior of the volatility in overall time series; (ii) Second, in order to analyze the sensitivity of the long memory findings, we separate the full sample into eight sub-periods encompassing four stable periods, which we termed the pre-crisis periods, and another four turbulent periods designated as the crisis periods. Our aim is to examine the differences in these periods in terms of the long memory process when this property manifests itself. To this end, we cover four major world events; (iii) Third, we compare the results of the overall period with those obtained for the sub-periods. As such, the main goal of our paper is to gauge the robustness and consistency of the results. To the best of our knowledge, it is the first time this approach has been taken and it therefore constitutes the novelty brought by our research.

To perform our analysis we rely on the Fractionally Integrated GARCH—FIGARCH(p, d, q) methodology proposed by Bailie et al. [11], which considers an intermediate range of long memory pertaining to the interval [0,1]. This stylized fact is measured through the d parameter, denoting the long memory magnitude. The main advantage of this methodology over previous ones is that it not only nests the GARCH(p, q) $(d = 0)$ and IGARCH(p, q) $(d = 1)$ models as special cases, but also overcomes some of their limitations. In fact, the standard GARCH(p, q) has come under criticism since it only accounts for short memory processes as it implies that the volatility shocks decay over time at an exponential rate. Similarly, the IGARCH(p, q) formulation is not fully satisfactory in describing the unconditional volatility as it assumes infinite memory and therefore considers that shocks should persist indefinitely in the market. In contrast, the FIGARCH model postulates that variance follows a hyperbolic rate of decay and so describes a more realistic situation.

Our findings reveal that the overall sample exhibits long memory in the return series. However, distinct patterns seem to arise when analyzing the results of the sub-periods. This emphasizes the fact that this property is not uniformly found across the various sub-periods.

The remaining part of the paper is organized as follows. Section 2 presents the econometric methodology while the empirical results are discussed in Section 3. Finally, Section 4 concludes.

2. Econometric methodology

In this section, we provide a description of the FIGARCH(p, d, q) model and highlight its main advantages over the standard GARCH(p, q) and IGARCH(p, q) processes. The adoption of the FIGARCH(p, d, q) model is justified in the empirical analysis as it overcomes some of the main limitations of the standard GARCH(p, q) and IGARCH(p, q) models.

2.1. GARCH(p, q) *model*

ARCH-type models became quite popular in the literature as they capture significant stylized facts of volatility (for an overview on the subject, see Bollerslev et al. [12] and references therein). The innovation of the seminal ARCH framework introduced by Engle [13] was that it allowed the conditional variance of a time series to depend on the past squared errors, thus making it particularly attractive to describe situations where volatility clustering is present. In his formulation, Engle [13] considered a time series y_t and the associated prediction error $\varepsilon_t = y_t - E_{t-1}[y_t]$, where $E_{t-1}[\cdot]$ is the expectation of the conditional mean on the information set at time $t - 1$. He defined an ARCH(q) process as follows:

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 = \omega + \alpha(L)\,\varepsilon_t^2, \tag{1}$$

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