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Measuring persistence in stock market volatility using the FIGARCH approach

Sónia R. Bentes *

ISCAL, Av. Miguel Bombarda 20, 1069-035 Lisbon, Portugal
BRU-IUL, Av. das Forças Armadas, 1649-025 Lisbon, Portugal

HIGHLIGHTS

- This paper examines long memory in the G7's major stock market indices.
- We use the FIGARCH model and compare the results with the ARCH and IGARCH models.
- We find evidence of long memory in the conditional variance of all return series.
- DAX 30 is the most persistent volatility series and NIKKEI 225 is the least one.
- FIGARCH is the best model to capture the dependence in the conditional variance.

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ABSTRACT

This paper examines the long memory property in the conditional variance of the G7's major stock market indices, using the FIGARCH model. The GARCH and IGARCH frameworks are also estimated for comparative purposes.

To this end, a dataset encompassing the daily returns of the S&P/TSX 60, CAC 40, DAX 30, MIB 30, NIKKEI 225, FTSE 100 and S&P 500 indices from January 4th 1999 to January 21st 2009 is employed. Our results show evidence of long memory in the conditional variance, which is more pronounced for DAX 30, MIB 30 and CAC 40. However, NIKKEI 225 is found to be the less persistent. This may be explained by the fact that smaller markets, like DAX 30, are less liquid, less efficient, and more prone to experiencing correlated fluctuations and, therefore, more susceptible to being influenced by aggressive investors. On the other hand, bigger markets tend to exhibit lower correlations, thus favoring lower persistence levels.

Finally, we use the log likelihood, Schwarz and Akaike Information Criteria to discriminate between models and found that FIGARCH is the most suitable model to capture the persistence.

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1. Introduction

A common finding in most empirical studies in Finance is the apparent persistence, or long memory, in stock market volatility. This implies that the market does not respond immediately to information arriving into the financial system, but reacts to it gradually over time. As a result, past price changes can be used to predict future price changes. In this context, shocks to the volatility process tend to have long-lasting effects, thus, providing negative evidence as well as a new perspective to the Efficient Market Hypothesis (EMH) (Fama [1]; Sharpe [2]).

However, the interest in long memory does not find its origins in Economics/Finance but falls instead in the domain of a very distinct branch of knowledge called Hydrology and was first documented by Hurst [3] while studying the flow of the

* Correspondence to: ISCAL, Av. Miguel Bombarda 20, 1069-035 Lisbon, Portugal. Tel.: +351 21 798 45 00; fax: +351 21 797 70 79.
E-mail address: smbentes@iscal.ipl.pt.

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River Nile. Motivated by the desire to understand the persistence of the steam flow and therefore the design of reservoirs Hurst [3,4] analyzed 900 geophysical time series and found significant long-term correlations among the fluctuation of the river outflow. Interestingly, after his seminal work, several authors have found the same pattern in many other domains of science, such as Biology, Geophysics, Climatology and some other natural sciences [5,6]. This phenomenon was first observed in Economics by Mandelbrot and van Ness [7] while describing asset price dynamics. Since then, the Hurst exponent H, has been estimated for many financial time series, such as stock prices, stock indices, exchange rates, commodities, real estate, options, etc. [8–10]. A Hurst exponent $1/2 < H < 1$ is in general found and this reveals long memory correlations in the dataset [10]. More specifically, an interesting picture seems to emerge [10,11] when analyzing stock market returns: large and more developed markets (e.g., NYSE and LSE), usually tend to exhibit an Hurst exponent equal to, or slightly less than 1/2, whereas less developed markets evidence $1/2 < H < 1$. In other words, large markets seem to be efficient given that $H \simeq 1/2$ but less developed markets tend to exhibit long-range correlations. A possible explanation for this lies in the fact that smaller markets are more likely to experience correlated oscillations and are therefore more predisposed to being influenced by aggressive investors.

In light of the above, several reasons have been advanced for the apparent widespread finding of persistence in financial time series. Porteba and Summers [12], for instance, argued that shocks have to persist for a long period for a time-varying risk premium to be able to explain the large fluctuations observed in the stock market. In fact, if volatility changes are only momentary, no relevant adjustments to the risk premium will be made by the market and, hence, no significant changes occur in the discount factor or in the price of a stock (determined by the net present value of the future expected cash flow). In addition, Schwert and Seguin [13] found a common source of time-varying volatility across the disaggregated stock portfolios suggesting that portfolios might be co-persistent in the terms of Bollerslev and Engle [14]. On the other hand, Engle and Gonzalez-Rivera [15] noticed that the persistence in variance seems to be associated to the business size, with smaller businesses having a lower persistence than the larger corporations studied by Engle and Mustafa [16].

In addition to observing long memory in the volatility of individual stocks and aggregate indices, Chambers [17] also found that the degree of persistence was irrespective of the frequency of the data. Indeed, the null hypothesis of a unit root in variance is not rejected by several authors employing different sets of market data [18–20]. A distinct explanation based on the interaction in the market of agents with different time horizons was also advanced by Muller et al. [21]. According to these authors, long memory arises from the reaction of short-term dealers to the dynamics of a proxy for the expected volatility trend (coarse volatility), which causes persistence in the mean higher frequency volatility process (fine volatility). On the other hand, long-term dealers base their decisions on the fundamentals of the market and ignore short-term movements.

The empirical literature on long memory originally relied mainly on the estimation of the Hurst exponent. However, some other methods were derived to account for persistence. The Autoregressive Conditional Heteroskedasticity (ARCH) type of models is one of these methods and has captured much attention in the literature. This constitutes an innovation when compared to the traditional Hurst approach since long memory is computed here by taking into account the temporal variation of volatility. Tanenbaum et al. [22] presented an interesting study based on this class of models. They found that, like their developed economy counterparts, almost all transition economy stock market indices exhibited ARCH effects in the volatility. Applications of these methods to financial time series include [23–32], *inter alia*.

In the ARCH framework, the Fractionally Integrated GARCH (FIGARCH) process introduced by Baillie et al. [33] seems to be of particular relevance since it is more flexible than the traditional Generalized ARCH (GARCH) or Integrated GARCH (IGARCH) processes and accommodates both of them as special cases. By introducing a fractional difference parameter d this model allows persistence in the observed data to be accounted for. This constitutes its main advantage over the standard GARCH, which only considers short memory. Similarly, it also represents an advance on the IGARCH formulation, which assumes infinite memory—a very unrealistic assumption.

In this study we focus on the G7's major stock market indices with the aim of assessing the extent to which these index returns exhibit long memory. To that end, we collected daily data from DataStream database of the S&P/TSX 60, CAC 40, DAX 30, MIB 30, NIKKEI 225, FTSE 100 and S&P 500 indices. The results point to the presence of long memory for all returns, which is more pronounced for DAX 30 and MIB 30 and less so for NIKKEI 225.

The remainder of the paper is organized as follows. Section 2 presents the methodology. Section 3 describes the data and debates the preliminary results. Section 4 presents the empirical findings and, finally, Section 5 concludes.

2. Methodology

There are several ways of defining long memory. Broadly speaking, this concept is related to a high degree of persistence of the observed data and is therefore used as a synonym of long memory. In particular, long memory can be expressed in either the time or the frequency domain. In the time domain, long memory manifests itself as hyperbolically decaying autocorrelation functions. This means that observations far from each other are still strongly correlated and decays at a slow rate. In other words, a stationary discrete time series process is defined to exhibit long memory if the autocorrelation function ρ_j at lag j satisfies

$$\lim_{j\to\infty} \frac{\rho_j}{c_\rho j^{-\alpha}} = 1, \tag{1}$$

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