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Persistence in the banking industry: Fractional integration and breaks in memory ☆

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ABSTRACT

Certain "spurious long memory" processes mimic the behavior of fractional integration in that the variance of their sample mean behaves like that of a fractionally integrated process of some order $\mathcal{D}$. We show, however, experimentally that a fractional integration test may discriminate between spurious long memory of order $\mathcal{D}$ and integration of order $\mathcal{D}$. Further, we suggest a test for the null hypothesis that the order of integration does not change from one subperiod to another. It simply builds on the difference of the estimates from the respective subsamples that are split exogenously. Upon appropriate normalization a limiting standard normal distribution arises. With these methods we tackle the question whether international and sectoral bank equity index returns are fractionally integrated and whether the memory parameters have changed. The daily data are split into three regimes: one pre-crises subsample, a second including the collapse of the Lehman Brothers bank, and a third covering the Euro area sovereign debt crisis. In particular, we provide evidence that both turmoils had differing international effects.

1. Introduction

Ding et al. (1993) documented the existence of long-range dependence in several transformations of the absolute value of daily returns, noting that these proxies of volatility exhibit autocorrelation functions characterized by a slow decay to zero. Granger and Ding (1996) found this form of persistence to be conformable with a fractionally integrated process (also known as long-memory process) with characteristic coefficient of around $\hat{d} = 0.47$. This evidence has been extended to realized volatility measures, for which the estimates of the fractionally integrated parameter tend to lie around this value; see, for instance, Andersen et al. (2003) and Hassler et al. (2012). Nevertheless, the evidence of long-memory in volatility and other time series may arise spuriously from a number of considerations. Lobato and Savin (1998) addressed this issue by analyzing whether the rejection of the hypothesis of short memory dynamics in squared and absolute returns may be attributed to "true long memory" or to other causes termed "spurious long memory" including, for instance, parameter instability. This topic has attracted

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considerable attention in the econometric literature; see, among others, Diebold and Inoue (2001), Granger and Hyung (2004), Ohanissian et al. (2008), Perron and Qu (2010), Qu (2011) and Smith (2005).[1] The recent literature on long-memory has focused on the stability of the long-memory coefficient, reporting evidence suggesting that the degree of persistence may vary over time; see Bos et al. (2012), Hassler and Meller (2014), Kumar and Okimoto (2007) and Martins and Rodrigues (2012).

In this paper, we discuss several diagnostic tools to address the suitability of a fractionally integrated model with constant order of integration in the time-series context. We then implement these procedures on returns of representative stock portfolios of the banking industry in different regions and economic areas aiming to analyze whether the characteristic degree of persistence in the volatility of these series has remained stable or whether it has changed as a consequence of the global financial crisis. This issue, which is particularly relevant for both analysts and forecasters, has not been addressed in the extant literature. After the collapse of Lehman Brothers in 2008 and the subsequent shocks that featured the Great Recession and the European sovereign debt crisis, financial institutions worldwide have faced an extremely uncertain operating environment. Repeated rating downgrades, sharp regulatory changes, and widening funding-spreads have led to unprecedented levels of market volatility in the sector, particularly, in peripheral Europe. While it is perfectly clear that the mean of the volatility process shifted as a consequence of the financial crisis, it is possible that other characteristics of the data generating process, such as the degree of persistence, may have changed as well. Under extreme market circumstances, shocks on the variability of returns may become more persistent because investors become more risk-averse. As a result, the long-memory parameter that characterizes the long-term dynamics of the volatility process of returns may take larger values and exhibit non-stationary features. The severity of the consequences on the banking industry provides us with the perfect ground to detect potential changes in the degree of persistence, bringing new evidence to the field.

To this end, we proceed as follows. We first analyze the resilience of the regression-based test proposed by Demetrescu et al. (2008) [DKH henceforth] to detect true long memory against a backdrop of spurious long memory. This test can exhibit more power than alternative procedures, while retaining a considerable degree of tractability and methodological simplicity. More specifically, we analyze the frequency of rejection of this test when the data generation process is driven by a variety of spurious long memory models that have been discussed in previous literature as well as a novel specification based on an unobserved components model proposed in this paper. Monte Carlo analysis shows that the DKH test has considerable power to reject spurious long memory in realistic settings. Additionally, we suggest a simple test for the null hypothesis that the memory estimates of two non-overlapping subsamples are equal, building on an approach discussed by Shimotsu (2006). The test statistic follows asymptotically a standard normal distribution. Finally, we use this testing procedure and the DKH test to characterize the persistence of the log transform of daily absolute returns of different bank equity indices over different periods. More specifically, we consider daily returns representative of different countries, regions and international areas (*e.g.*, the US, Asia and Southern Europe) and economic zones (*e.g.*, "Emerging Markets" or G7). Since our main interest lies in characterizing the effects on persistence of different episodes related to the recent financial crisis, we split the total sample into three disjoint periods: the first one being a period where banks have operated without major global events; the second one containing the global financial crisis following the collapse of the Lehman Brothers bank in September 2008; and the third one including the Euro area sovereign debt crisis starting in early 2010.

We provide confidence intervals for the order of integration based on the DKH procedure by inverting the range of values not rejected by the integration test. We also report point estimates using semiparametric procedures and their corresponding confidence intervals and analyze the difference over the subperiods. The overall evidence from this analysis suggests the existence of true long memory dynamics driving the volatility of these series. The suitability of a model with constant parameter over the total period is generally rejected, showing that shocks in volatility tend to be more persistent during the turmoil period. Although a common picture emerges, there are important differences among the different countries, regions and economic areas considered. The effects of the crisis were more pronounced in areas with direct exposure. This evidence is consistent with the hypothesis that long-range persistence may be linked to economic fundamentals.

The rest of the paper is organized as follows. Section 2 introduces the standard notation of true fractionally integrated series and becomes precise on the class of models featuring spurious long memory of a certain degree denoted as $\mathcal{D}$ throughout the paper. Some prominent examples are discussed. In Section 3 we report Monte Carlo evidence on how well the DKH procedure discriminates between spurious long memory of degree $\mathcal{D}$ and fractional integration of the same order. In Section 4, we briefly introduce and discuss the test for the null hypothesis that non-overlapping subsamples are integrated of the same order, while Section 5 contains the results of our empirical analysis. The final section summarizes our main findings.

2. Notation and definitions

We start our analysis by introducing notation, the formal definition of (true) long memory analyzed in this paper, and the statistical implications of the class of fractionally integrated models. We then discuss alternative specifications that give rise to spurious long memory within a class of shift-in-mean models. All these specifications will be used in the Monte Carlo section to address the resilience of the DKH test.

[1] There is an older, related literature on the potential confusion of slowly varying trends and long memory, see *e.g.* Bhattacharya et al. (1983), Giraitis et al. (2001), or Künsch (1986).