Physica A 410 (2014) 345–358

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

A wavelet-based evaluation of time-varying long memory of equity markets: A paradigm in crisis

Pei P. Tan [a,*], Cheong W. Chin [b], Don U.A. Galagedera [c]

[a] Department of Applied Statistics, Faculty of Economics & Administration, University of Malaya, 50603, Kuala Lumpur, Malaysia
[b] Faculty of Computing and Informatics, Multimedia University, 63100 Cyberjaya, Selangor, Malaysia
[c] Department of Econometrics and Business Statistics, Monash University, 900 Dandenong Road, Caulfield East, Victoria 3145, Australia

HIGHLIGHTS

- There is evidence of long memory in stock returns and volatility series.
- Long memory is observed in both emerging markets and developed markets.
- Emerging markets are more vulnerable to crisis than developed markets.
- There will be no stock return predictability during crisis period.

ARTICLE INFO

Article history:
Received 21 February 2014
Available online 22 May 2014

Keywords:
Wavelet fractional integration
Long range dependence
Stock return predictability

ABSTRACT

This study, using wavelet-based method investigates the dynamics of long memory in the returns and volatility of equity markets. In the sample of five developed and five emerging markets we find that the daily return series from January 1988 to June 2013 may be considered as a mix of weak long memory and mean-reverting processes. In the case of volatility in the returns, there is evidence of long memory, which is stronger in emerging markets than in developed markets. We find that although the long memory parameter may vary during crisis periods (1997 Asian financial crisis, 2001 US recession and 2008 subprime crisis) the direction of change may not be consistent across all equity markets. The degree of return predictability is likely to diminish during crisis periods. Robustness of the results is checked with de-trended fluctuation analysis approach.

1. Introduction

Long memory of financial time series is a contentious issue encountered in risk and portfolio management. A risk management strategy that relies to some extent on long memory of financial time series is hedging. Long memory in financial time series has other implications. Evidence of long memory suggests predictability and therefore contradicts the conceptual framework that underlies efficient market hypothesis. Empirical studies report that the shocks to stock and foreign exchange markets and even to macroeconomic time series may have slow hyperbolic decay property. Therefore, modeling long memory is important for proper estimation and accurate forecasting with financial time series. An example where long memory may affect estimation is value-at-risk. Value-at-risk estimated with incorrectly specified time series models may result in unexpected losses and lead to increased risk.

* Corresponding author. Tel.: +61 3 79673681; fax: +61 3 79673738.
E-mail addresses: peipei@um.edu.my (P.P. Tan), wcchin@mmu.edu.my (C.W. Chin), Tissa.Galagedera@monash.edu (D.U.A. Galagedera).

http://dx.doi.org/10.1016/j.physa.2014.05.044
0378-4371/

Long memory in stock returns is observed in developed and emerging markets. See, for example Cajueiro and Tabak [1], Tan et al. [2] and the references therein. In the case of stock market returns, long memory may be explained with the heterogeneous market hypothesis. Market participants possess different characteristics and therefore may react to new information differently. Investors generally differ in many ways including in terms of their endowments, interests, risk-profiles, access to information, contractual constraints, trading patterns and reactions to news. Investors may also have different investment horizons such as short-term, medium-term and long-term. Short-term investors tend to trade over very short time horizons such as seconds to hours with the aim of gaining profit or minimizing losses quickly. The investors who deal with hedge funds and invest in portfolios may be considered as those with medium-term investment horizons. They generally trade over periods spanning a few days, weeks or months. Portfolio adjustment according to market conditions and price movement of benchmark indices may take weeks or even months. Long-term investors such as central banks and pension funds may trade over longer periods such as few years and even decades. An investment horizon is another characteristic that contributes to investor heterogeneity. Investors with different investment horizons may also interpret new market information differently. In addition to that, heterogeneous beliefs can also influence the trading activity of investors. Trading activities of investors with diverse interests and attitudes to risk may trigger price movement leading to volatility in the returns. Market participants with different reaction times to market news may also contribute to market volatility. Combination of volatility at dissimilar time horizons is argued to produce hyperbolic autocorrelation decays or long memory in financial markets.

The methods to detect long memory can be classified under different types. Examples of different types are the spectrum-based methods such as the Whittle estimator, the regression-based methods such as the rescaled-range method and wavelet-based methods. The commonly used methods in long memory detection are modified rescaled-range analysis (see Refs. [3–11]), Hurst exponent (see Refs. [12–16]), de-trended fluctuation analysis (see Refs. [17–21]) and log-periodogram (see Refs. [6],[22–27]). Lobato and Savin [28], Qu [29] and Perron and Qu [30] point out that certain data characteristics can confound long-memory detection. They raise concern over spurious long-memory plausible in nonstationary and aggregated data and in time series with regime change. A method used to mitigate the aggregation problem is rolling windows. In this study, we estimate time-varying long memory in the returns and volatility of five developed and five emerging equity markets in rolling windows and investigate whether long memory is affected by financial and economic crises.

Maharaj, Galagedera and Dark [31] report that, because time-series analysis alone may not be sufficient to study the behavior of stock returns, finance studies use wavelet analysis to uncover relationships that are not readily apparent in the time domain data. Empirical evidence suggests that stock return is generally nonstationary and in that case frequency analysis alone may not capture the salient features in the returns adequately. Hence to test long memory we adopt the method of wavelet-based maximum likelihood estimation (MLE). Through the wavelet-based MLE methodology, we can test long memory with concurrent use of time-based and frequency-based analysis. We have two aims; (1) investigate the effect of financial crises on stock returns and volatility using time–frequency analysis and (2) investigate whether the effect of financial and economic crises on developed market stock returns and volatility is different from that of emerging markets. Previous studies have shown that return volatility is time scale dependent and that dependency may not be associated with the market type; developed and emerging [31]. Our study adds to the knowledge base by investigating a similar issue focusing on long memory. Long memory in the returns and volatility help understand the link between market efficiency and financial crises better.

2. An overview of the investigated financial crises

The sample period is from 1988 to 2013 and covers three major financial and economic crisis periods. Two of the three crises that fall within the sample period are originated in the US and the other in Asia. They are the Asian financial crisis of 1997, the US recession of 2001 and the US subprime mortgage crisis of 2008. Given that Asian stock markets are generally susceptible to the movements of the US stock market, these three crises would shed light on whether the effect of crises on persistence in the returns and volatility of Asian equity markets depends on the origin of the crisis: regional and global. To ascertain whether the effect of crises on persistence is associated with the maturity of the stock market, we compare the results obtained for developed markets with that of emerging markets. The equity markets that we selected for our investigation belongs to the Asia region. They are Hong Kong, Japan, Korea and Singapore (all are developed markets) and Indonesia, Malaysia, Philippines, Taiwan and Thailand (all are emerging markets). The US market (S&P 500 index) is the chosen benchmark.

The Asian financial crisis of 1997 started with the fall of Thailand currency, Baht. The effect of the Thai Baht fall spread quickly to South Korea and Indonesia culminating in financial contagion to other Asian countries including Malaysia. The 1997 financial crisis did not spare the developed markets in Asia. It affected a slump in the currency of Singapore, Hong Kong and Japan. The 1997 currency crisis however, did not spread to the European and North American financial markets.

Fig. 1 gives the graph of the stock price indices of the selected five developed markets including the US. Due to the large difference in the scales Panel A of Fig. 1 gives the graph for Hong Kong, Korea, Singapore and the US and Panel B of Fig. 1 gives the graph for Japan. The price indices are calculated with 1 January 1988 as the base period. There is no much movement in the price indices from the base period until 1992 and therefore we plot the horizontal axis of Fig. 1 from 1 January 1992. According to Fig. 1, the stock markets of Hong Kong, Singapore, Korea (see Panel A of Fig. 1) and Japan (see Panel B of Fig. 1) begins to plunge from about mid-1997. The price indices of the selected emerging markets shown in Fig. 2 also reveal a