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Trends in currency's return

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Abstract. The purpose of this paper is to show that short-ranged dependence prevailed for Singapore-Malaysia exchange. Although, it is perceived that there is some evidence of long-ranged dependence [1,2], it is still unclear whether Singapore-Malaysia exchange indeed exhibits long-ranged dependence. For this paper, we focus on the currency rate for a sixteen-year period ranging from September 2002 to September 2017. We estimate the Hurst parameter using the famous rescaled R/S statistics technique. From our analysis, we showed that the Hurst parameter is approximately 0.5 which indicates short-ranged dependence. This short memory property is further validated by performing a one-tailed z-test whose alternative hypothesis is that the Hurst parameter is not 0.5 at 1% significance level. We conclude that the alternative hypothesis is rejected. The existence of short memory proves that the behaviour of the exchange rate is unpredictable, supporting the efficient market hypothesis, which states that not only is price movement completely random but also tomorrow's prices are predicted by all the information in today's prices.

1. Introduction

Over the last ten years or more, there has been overwhelming evidence [3,4,5] stressing that returns of assets are strongly correlated. More importantly, as the time lags between the observations increase, its autocorrelation function decays at a rate that is too slow to be considered as an exponential rate. In fact, for a very large time lag between observations, a power law decay best describes the decay of its autocorrelation function. This phenomenon is well-known as the long memory effect. However, there is considerably less studies on the properties of the foreign exchange market.

This paper is divided into several sections. In the next section, we introduce short process and explain evidence of its existence. We then give examples of existing short memory process. In the penultimate section, we present numerical results of the R&S statistics and deduce the Hurst parameter from our result.

2. Short memory process and its application

A stochastic process can be categorized as having either short or long memory [6,7]. Define a covariance stationary process, X_t , that has covariance, $\lambda_s = \mathrm{cov}(X_t, X_{t-s})$. If the sum of covariance function is finite, the process is said to have short memory. The covariance of the short memory process decays at a rate best described by exponential decay ie e^{-s} where time lag $s \gg 1$. It should be noted that the exponential rate at which the short memory process decays is much more rapid than the power law decay of the long memory process. For a short memory process, its variance $\mathrm{var}(X_t)$ grows linearly according to $\mathrm{var}(X_t) \sim t$.

In finance, ARCH [8] is the first short memory process used to model the short-ranged dependence of the volatility process although the use of short memory process in finance can be traced back to Bachelier [9] who assumes that change in the asset price is modelled by a simple random process with short memory properties. In 1973, Fischer Black and Myron Scholes [10] derived the first universally accepted option pricing model which was primarily based on the asset price following a Geometric Brownian motion model which is another short memory process.

3. Evidence of short memory in financial market

There is considerable evidence [11,12,13] suggesting that asset price and foreign exchange return exhibit short memory properties. This implies the unpredictability of foreign exchange market in the longer run. It is widely accepted that the foreign exchange market is more unpredictable than before. This can be partly attributed to larger trading volumes in foreign exchange trading which might sometimes render central bank intervention less effective. Moreover, there are numerous unpredictable factors that determine the strength of the currency such as inflation, interest rate, government policies, political events etc. Such developments are occurring with increasing frequency which probably explain the unpredictability of the market.

4. Summary of short memory model

The autoregressive conditional heteroscedasticity (ARCH) family of models has been widely used in the financial time series [8,14]. It does not capture the long memory property. Other short memory process includes ARMA, AR model [15,16] etc.

In continuous time setting, there exists a family of continuous random processes [17] which captures both the short and long memory property known as Fractional Brownian motion, B_H where H is the Hurst parameter. For the case of short memory process, H takes value of 0.5 and this particular Fractional Brownian motion is also known as Standard Brownian motion [18]. Define a standard Brownian motion as a random process $B = \{B_t : t \in [0,\infty)\}$ which has the basic properties as follows

1. $B_t = 0$ with probability 1
2. B_t has stationary and independent increments
3. B_t is normally distributed with mean 0 and variance t for each $t \in (0,\infty)$
4. $\frac{dB_t}{dt} = \eta(t)$ where $\eta(t)$ is the Gaussian White noise

There are various methods to estimate the Hurst parameter H namely the R/S statistic, the correlogram method, variance plot etc [16].

5. Rescaled R&S methodology

We used the rescaled range method to deduce the long memory properties of the Singapore-Malaysia currency exchange. In total, we have 4090 observations spanning 16 years. This method depends on ranges to be analysed. Size of each range is $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$ and $\frac{1}{32}$ of the entire data series.

Subsequently, we calculated the mean for each range. For instance, the range with 2 intervals will require two means to be deduced. In total, there will be 1+2+4+8+16+32=63 means to be deduced.

The formula for mean, m, is $m = \frac{1}{n}\sum_{i=1}^{i=n} x_i$, where x_i is the observation. In the next step, we create a new series of deviation for each range by subtracting its corresponding mean from the range as follows:

$y_t = x_t - m$ where

y_t is the new time series adjusted from deviation from mean. Having created 63 new series, we will work out the running total of each range's deviation from its mean as follows

$$y = \sum_{i=1}^{n} y_i$$

We will the calculate the widest difference between the largest and smallest running total for each series denoted as R_i which is given as follows

$$R_i = \max(y_1, y_2, \dots, y_n) - \min(y_1, y_2, \dots, y_n)$$

We also calculated the standard deviation, S, of each range and subsequently deduce the $\log(R/S)$ for each range. For range with more than one interval, we averaged out the values of $\log(R/S)$. To deduce the Hurst parameter, we plot the graphs of the averaged $\log(R/S)$ against its corresponding log intervals. The gradient of the graph will actually give us the Hurst parameter.

6. Analysis

Table of $\log(\text{interval})$ and $\log(R/S)$ is shown below (Table 1). Graph of $\log(R/S)$ against $\log(\text{interval})$ are plotted in Figure 1. We plot best-fit straight line and deduce that the gradient of the straight line is 0.46327 thus proving that the currency return does not exhibit any long memory properties.

Table 1. $\log(\text{interval})$ and $\log(R/S)$

$\log(\text{interval})$	$\log(R/S)$
3.61161	1.71437
3.31059	1.37076
3.00945	1.19455
2.70842	1.15628
2.40654	1.05241
2.10721	0.93695

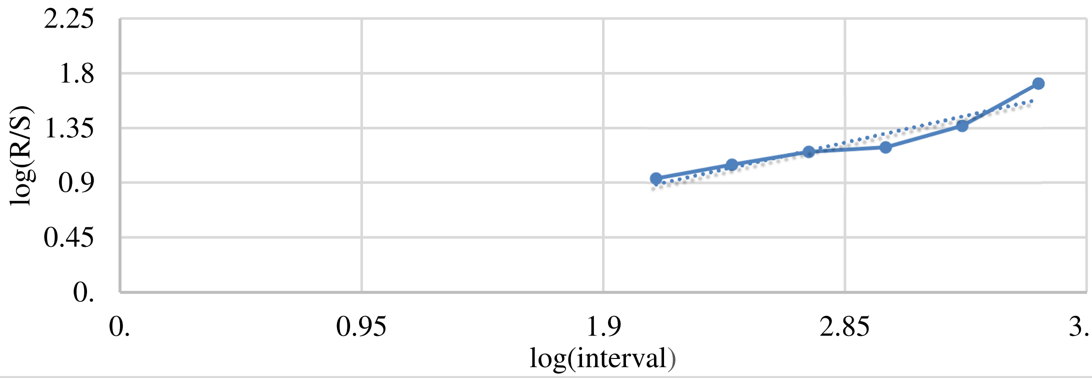

Figure 1. Plot of log(*R*/*S*) against log(interval)

Other properties of this plot are as follows:
Slope coefficient: 0.463265047
Intercept coefficient: -0.086907537
Standard error of slope: 0.077309364
Standard error of intercept: 0.224569686
R-squared: 0.899770228
Standard error of regression: 0.097347598
F-test overall: 35.90830186
Degrees of freedom (n-k): 4
Regression SS: 0.34028699
Residual SS: 0.037906219

Lastly, we want to show that the Hurst parameter is not different from 0.5 by performing a statistical test. We found that the scatter plot is roughly linear and the residual plot does not exhibit any pattern and has equal variance. We conduct a two-tailed *t*-test on the Hurst parameter at 1% significance level with 4 degrees of freedom. Define null and alternative hypothesis as follows:
Null hypothesis, H_0: $H = 0.5$
Alternative hypothesis, H_1: $H \neq 0.5$

The test statistics, t is given by $t = \frac{0.463265047-0.5}{0.077309364.} = -0.47$ which is greater than the *t*-critical value of -4.604. Thus, we do not reject the null hypothesis.

7. Conclusion

It is proven that the return of Singapore-Malaysia exchange rate does not exhibit long ranged-dependence. This result is consistent with [11,12,13] which strongly suggests that the exchange rate exhibits an unpredictable pattern and will revert to its long-term mean.

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