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Full Length Article

Testing for martingale difference hypothesis with structural breaks: Evidence from Asia–Pacific foreign exchange markets

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Abstract

This study tests for martingale difference hypothesis (MDH) in nine selected Foreign Exchange (FX) markets from Asia–Pacific countries. Its main contributions to the literature include: (i) it adopts recent techniques in both the Autocorrelation based and Spectrum based tests for MDH, namely; the Wild Bootstrap Automatic Variance Ratio test by Kim (2009) and the Wild Bootstrap Generalized Spectral test by Escanciano and Velasco (2006); (ii) it determines structural breaks endogenously for all the returns series using Perron (2006) unit root test with structural break, and (iii) based on the Perron results, it obtains two sub-samples and thereafter tests for MDH. Empirical result from this study shows that FX market efficiency could be inconsistent over time due to changes in policies and events. Thus, a preliminary test for the presence significant structural break may be necessary when testing for MDH.

JEL codes: C12; F31

Keywords: Martingale difference hypothesis (MDH); Structural breaks; Asia–Pacific; FX market

1. Introduction

The main objective of this study is to investigate whether Asia–Pacific Foreign Exchange (FX) markets satisfy martingale difference hypothesis (MDH) and to also verify whether accounting for structural breaks matters. The MDH plays a central role in economic models where expectations are assumed to be rational (Escanciano & Lobato, 2009). Given the current information set, the martingale hypothesis implies that the best predictor of future values of a time series, in the sense of least mean squared error, is simply the current value of the time series (Escanciano & Lobato, 2009). Empirical literature testing the MDH has adopted different methodology ranging from the linear measures to the non-linear ones. Examples of the linear measures are the portmanteau test by Ljung and Box (1978) and variance ratio test by Lo and MacKinlay (1988, 1989). Recently however, more sophisticated techniques have been developed with better power and size properties under each category. Prominent among these new linear measures are automatic portmanteau (AQ) test of Escanciano and Lobato (2009); and the automatic variance ratio (AVR) test of Kim (2009) which extends the earlier work of Choi (1999). For the non-linear measures, the notable recent tests are the generalized spectral (GS) test of Escanciano and Velasco (2006) and the consistent tests of Domínguez and Lobato (2003). Charles, Darné, and Kim (2011) provide for a review of the recent tests while a survey of their applications on foreign exchange markets is detailed in a related paper by Azad (2009).

With the increasing proliferation of tests, Charles et al. (2011) conduct a Monte Carlo experiment to compare power

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properties of alternative tests for the MDH. Overall, they find that the Wild Bootstrap AVR test shows the highest power against linear dependence; while the GS test performs most desirably under nonlinear dependence. Thus, in this study, we adopt both the Wild Bootstrap AVR and Wild Bootstrap GS tests for the MDH. More so, we define martingale as following random work 2,[1] which states that the best forecast of tomorrow's asset price is today's price. However, since asset prices are usually non-stationary, we carry out the hypothesis testing on the FX returns, which are expected to form a martingale difference sequence (Escanciano & Lobato, 2009). Notably, the MDH test is predicated only on past information about asset returns; hence, the outcome of this study would be used to examine and analyze the weak form efficiency of the Asia–Pacific FX market.[2]

Basically, our study covers nine Asia–Pacific FX markets, consisting of China, Hong Kong, Indonesia, Japan, Malaysia, Philippine, Singapore, South Korea and Thailand. The currencies of these countries are among the thirty (30) most traded currencies in the world. Unlike Al-Khazali, Pyun, and Kim (2012) which conducted a similar study, we distinguish our study by also accounting for structural breaks in the MDH tests using the Perron (2006) generalized structure for analyzing structural breaks with unit roots. Consequently, we obtain two sub-samples based on the break point and thereafter test for MDH under the pre-break and post-break periods. The resulting statistics are compared with the full sample in order to ascertain the possibility of any significant changes as a result of structural breaks. All these analyses combined distinguish this paper from the previous works.

Following this introductory section, Section 2 describes the data and also provides some preliminary analyses. Section 3 presents the econometric methodology implemented in the study. Section 4 discusses the empirical results. Policy implications are discussed under Section 5, while Section 6 concludes the study.

2. Preliminary analyses

This section describes data and provides some preliminary information about the FX markets of the nine Asia–Pacific countries earlier mentioned. Asia–Pacific countries are operating different foreign exchange rate policies; this ranges from Hong Kong's currency board system which “pegged” the Hong Kong dollar to the U.S. dollar; the “soft peg” arrangement of China and Singapore; to “floating” arrangement of Japan, Indonesia, Philippines, and South Korea. Table 1 summarizes the exchange rate policies operated by these countries as of April, 2014.

Exchange rate is defined here as the domestic currencies of the selected countries relative to Euro. This is due to the large volume of transactions recorded between these countries and Europe. Also, the increasing economic integration between the Asia–Pacific and Europe which has continued to foster economic ties including trade relations between them justifies the need for an efficient FX market in terms of the demand for and supply of their currencies. For convenience, we use CNY for Chinese Yuan Renminbi, HKD for Hong Kong Dollar, IDR for Indonesian Rupiah, JPY for Japanese Yen, KRW for South Korean Won, MYR for Malaysian Ringgit, PHP for Philippine Peso, SGD for Singapore Dollar and THB for Thai Baht relative to Euro. Therefore, an increase in exchange rate will mean depreciation in the domestic currency relative to Euro while a decrease will mean appreciation. Weekly data for the period from April 1, 2005 to September 12, 2014 were obtained from the database of the Central Bank of Ireland. Exchange rate return is described as the continuously compounded exchange rate percentage returns at time t calculated as below:

$$R_t^i = 100*\ln\left(E_t^i/E_{t-1}^i\right) \tag{1}$$

where R_t^i is the exchange rate returns of a given country i at time t, E_t^i is the exchange rate of that country at time t, while E_{t-1}^i represents one period lag in exchange rate of a chosen country. We carry out preliminary analyses on the FX returns of the selected Asia–Pacific countries in order to examine and understand the inherent statistical behavior of these series. Table 2 presents the descriptive statistics of the return series. The mean value represents average FX returns for the period under review. From the table, it is observed that most of the currencies have negative average returns, with the exception of Indonesian rupiah (IDR) and South Korean won (KRW) returns. This implies that FX returns of seven out of the nine selected countries appreciated on the average over the period under consideration; with the Chinese Yuan Renminbi (CNY_R) being the currency with the highest rate of exchange rate returns appreciation. This may partly be attributable to the

Table 1
Exchange rate policies of Asia–Pacific countries.

Countries	*De facto* exchange rate policies (as of April 30, 2014)
China	Crawling Peg
Hong Kong	Currency board
Indonesia	Floating
Japan	Free floating
Malaysia	Other managed arrangement
Philippine	Floating
Singapore	Stabilized arrangement
South Korea	Floating
Thailand	Floating

Source: International Monetary Fund, *De Facto Classification of Exchange Rate Regimes and Monetary Policy Framework*, https://www.imf.org/external/pubs/nft/2014/areaers/ar2014.pdf.

[1] In Campbell, Lo and MacKinlay (1997) textbook, they distinguish three types of random walks according to the dependence structure of the increment series, and martingale has been found to be suitably explained by random work 2.

[2] Market efficient can be categorized into three levels based on the definition of the available information set; namely weak form, semi-strong form, and the strong form (Fama, 1970). However, weak-form efficiency is the most important being the lowest level of EMH; because if MDH is rejected for the weak-form of market efficiency, it is not necessary to examine the EMH at the stricter levels of semi-strong and strong form (Wong & Kwong, 1984).

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