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Markov regimes switching with monetary fundamental-based exchange rate model

Jing-Tung Wu*

Department of Finance, Ming Chuan University, Taiwan

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ABSTRACT

This paper examines whether the exchange rates of the Asia-Pacific countries can be captured by the Markov switching model (MSM). Using data from January 2000 to December 2011, the real interest differential (RID) model is tested first. However, supporting evidence is limited, and results are markedly different across the countries. It is worth noting that the signs on the coefficients for fundamental factors are mostly wrong from the RID model perspective. By using the MSM-RID model, the results identify that two regimes exist and persist, which is consistent with earlier literature indicating that there are complex influences in exchange rate determination. This leads to the conclusion that the results are strongly in favor of a nonlinear relationship between exchange rate volatility and fundamental factors. When the probabilities transition matrixes of MSM are allowed to change [MSM-RID-time varying transition probabilities model (TVTP)], it is found that MSM-RID-TVTP outperforms the MSM-RID model. MSM classifies the currencies regimes and provides information about the change of currency prices in some Asian-Pacific currencies.

1. Introduction

The Asia-Pacific economies use a variety of exchange rate systems; they commonly peg their exchange rate to the US Dollar. After the 1997 Asian crisis, their monetary authorities loosened the control of exchange rates and let them become more "floating". The linkage between exchange rates and fundamentals has been extensively analyzed in international finance literature. However, earlier studies found little evidence of linear serial dependence in exchange rates. Exchange rates are often regarded as moving accidentally, because no permanent factors can be detected.

The failure of exchange rate models initiated the use of the Markov switching model (MSM) by Engle and Hamilton (1990) . They developed a new statistical model of exchange rate dynamics as a sequence of stochastic, segmented time trends. The conditional distribution of quarterly exchange rate returns simultaneously switches in both mean and variance. They found long swings in the data, and the model generated better forecasts than a random walk.

Marsh (2000) added the fundamental factor to the model, using interest rates to investigate the daily variation of exchange rates. Dewachter (2001) extended the MSM by introducing separate and independence latent variables for the dynamics in mean and variance. The applications of the MSM captured some major dynamics that characterize exchange rate behavior, although the structure may vary over time. Caporale and Spagnolo (2004) modeled East Asian exchange rates using the MSM, and their results shown that the behavior of exchange rates is nonlinear. Frömmel, MacDonald, and Menkhoff (2005a, 2005b) modified the real interest differential (RID) model with a switching process in the underlying fundamentals. They found that the factors that were proved to be closely related to regime switches were short-term interest rates, inflation differentials, and differences in economic growth. The forecasting ability of MSM is good. Kumah (2011) used a three-regime MSM to capture the Kyrgyz Republic foreign exchange market pressure.

In this paper, I suggest that the exchange rates of Asia-Pacific economies are generated by a two-regime Markov switching autoregressive model. Hence, this paper extends earlier literature and goes beyond the content of Engle and Hamilton (1990) and Frömmel et al. (2005a, 2005b) by using the Asia-Pacific market currencies in comparing the difference between them.

* Corresponding author. 250 Sec. 5, Chung Shan N. Road, Taipei, Taiwan.
E-mail address: jtwu@mail.mcu.edu.tw.

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The remainder of the paper is structured in the following manner. Section 2 presents the traditional monetary fundamental-based exchange rate model. In Section 3, I introduce the MSM. Section 4 presents the empirical analysis. Finally, Section 5 concludes this paper.

2. Monetary fundamental-based exchange rate model

The monetary exchange rate model relied on a single state relationship between fundamentals and the exchange rate. One application of the monetary exchange rate model is the UIP hypothesis. It stated that the change in the exchange rate should incorporate any interest rate differentials between the two currencies. UIP suggested that when we borrowed money in our home country and lent it to another country with a higher (or lower) interest rate, we should expect a zero return due to the appreciation (or depreciation) in the domestic currency. Frankel (1979) assumed that higher interest rates reflect lower money demand. Therefore, a higher domestic interest rate is related to an increase of the price of foreign currency. The UIP hypothesis stated that high interest rate currencies appreciate over time and therefore pay a positive expected return. The relationship can be expressed as follows:

$$\varDelta e_t = i_t - i_t^* \tag{1}$$

where $\varDelta e_t$ denotes the log of the exchange rate volatility at time t, i_t is the interest rate, and the asterisk refers to a foreign country.

The monetary view may use several fundamental factors to describe the fluctuation of exchange rates. Frenkel (1976) and Mussa (1976) brought up this idea and applied it to their research. Its fundamental building block is absolute purchasing power parity. It starts from the definition of the exchange rate as the relative price in terms of the relative supply and demand for their monies. Frankel (1979) extended other versions of the monetary models, and proposed the RID model:

$$\varDelta e_t = \alpha + \beta_1(\varDelta m_t - \varDelta m_t^*) + \beta_2(\varDelta y_t - \varDelta y_t^*) + \beta_3\left(\varDelta si_t - \varDelta si_t^*\right) + \beta_4\left(\varDelta li_t - \varDelta li_t^*\right) + \varepsilon_t \tag{2}$$

where m_t is the log of the money supply at time t, y_t is the log of national production, si_t is the short-term interest rate, and li_t is the long-term interest rate. The RID model combined some traditional concepts on determinations of exchange rates. It is referred to as a hybrid monetary model by MacDonald and Marsh (1999). Earlier empirical studies of the RID model have found that its performance is good, especially when applied to free floating currencies.

Each currency return and fundamental factor is calculated as the difference of the log percentage change with the last year. Taking money supply as an example, the calculated equation is as follows:

$$\varDelta m_t = \frac{m_t^{\text{home}} - m_{t-12}^{\text{home}}}{m_{t-12}^{\text{home}}} - \frac{m_t^{foreign} - m_{t-12}^{foreign}}{m_{t-12}^{foreign}} \tag{3}$$

The use of 1-year changes could reduce the seasonal effect and noise from short-term exchange rate fluctuation. Central bank and government statistics also rely on this approach to monitor the change of fundamental factors. There is another method that uses the difference of the change with last month. The benefit is that it adopts recent information, but the shortage is it causes a seasonal effect. In this paper, I show the results of yearly change only and omit the results of monthly change data.

Monthly data for six major Asia-Pacific currencies are employed: Japanese Yen (JPY), Hong Kong Dollar (HKD), South Korea Won (KRW), New Taiwan Dollar (NTD), Chinese Yuan (RMB), and Singapore Dollar (SGD), over the period from January 2000 to December 2011, for a total of 144 observations. The exchange rates are all against the US Dollar (USD). Data are obtained from the Taiwan Economic Journal (TEJ), specifically for JPY (January 2000–December 2011), HKD (January 2001–December 2011), KRW (October 2001–December 2011), NTD (January 2000–December 2011), RMB (July 2005–December 2011), and SGD (January 2000–December 2011). The estimation process was performed using MATLAB (3 Apple Hill Drive Natick, Massachusetts 01760 USA).

Table 1 shows the results. HKD is the only currency for which the coefficients have the same sign as the RID model expected. KRW has two coefficients performing as the same sign, which are industrial production and long-term interest rate. However, all the coefficients of JPY are against the RID model expectations. There is only one coefficient that performs as the RID model expected, the industrial production, while the signs of the currencies are all the same.

The explanation power of the RID model is higher than the UIP hypothesis. Of the six currencies (except the JPY) which have an R^2 above 0.250, the highest is RMB, for which the value is 0.405. Compared with the UIP hypothesis, the RID model performs much better.

The simplicity of the monetary model is very attractive. However, it requires many assumptions, such as assuming perfect substitutability of domestic and foreign assets, free adjustment of the exchange rate to equilibrate supply, and demand in the foreign exchange market. From Table 1, it can be seen that the RID model is not easily applied to all countries. It should be noted that the signs of the coefficients are mostly not in accordance with the expected values from the RID. Every currency faces different economic situations and their behaviors are not alike. This may be the reason why Meese and Rogoff (1983) mentioned that the exchange rate changes cannot be forecast by fundamentals at horizons of less than a year. Engle (2000) had stated that money demand, purchasing power parity, and UIP do not work well. The monetary fundamentals do not help to predict exchange rates retain conventional wisdom. This can be seen as another motivation for applying MSM. Indeed, Engle and Hamilton (1990) have also challenged this, reporting evidence in favor of a Markov switching regimes process for exchange rate changes.

Table 1
The real interest differential (RID) model.

Currency	JPY	HKD	KRW	NTD	RMB	SGD	Expected signs
Intercept	−4.813	0.171	2.111	−0.644	0.602	−1.672	n.a.
Money supply	−0.550	0.015		−0.529		−0.371	>0
Industrial production		n.a.	−0.439	−0.136	−0.159		<0
Short-term interest rate	0.002	−0.001	0.431			0.137	<0
Long-term interest rate	−0.503		2.574	−0.875	−0.523		>0
R^2	0.067	0.282	0.250	0.326	0.405	0.250	

Data sources: Taiwan Economic Journal (TEJ). Only significant coefficients are exhibited in Table 1. Black screen tones are applied in these diagrams for differentiation.
HKD = Hong Kong Dollar; JPY = Japanese Yen; KRW = South Korea Won; NTD = New Taiwan Dollar; RMB = Chinese Yuan; SGD = Singapore Dollar.