

Forecasting the Chinese Yuan-US Dollar Exchange Rate under the New Chinese Exchange Rate Regime

Imad A. Moosa*

Department of Accounting and Finance, Monash University, Australia

Abstract

Two models are specified, estimated, and used to generate out-of-sample forecasts over the period since China announced a shift in exchange rate policy from a simple peg to the US dollar to a basket peg. The results show that the model that is based on a crawling peg is far superior to the model that is based on a basket peg. It is also shown that trading the Chinese yuan versus the US dollar is more profitable than otherwise when trading is based on the assumption of a crawling peg, in which case buy and hold is the best strategy. It is concluded that China must be using a crawling peg, which is not good news for the US but may be good news for foreign exchange traders.

Key words: Chinese yuan; exchange rate regimes; forecasting

JEL classification: F31; F33

1. Introduction

Exchange rate forecasting is a hazardous endeavor, but indulging in this exercise is inevitable for financial decision making in this era of globalization. The importance of forecasting exchange rates, as difficult as it is, stems from the fact that the outcome of a financial decision taken today is contingent upon, among other things, the value of the underlying exchange rate that will prevail in the future. This is why exchange rate forecasting is needed for a variety of international financial operations, including hedging, speculation, and capital budgeting (see, for example, Moosa, 2000, 2003).

An essential element of any exchange rate forecasting exercise is the identification of the underlying exchange rate regime, which can be problematic because it has become an undisputed fact of life that, with respect to exchange rate regime choice, countries do not necessarily practice what they declare. This phenomenon has led to the emergence of a new strand of research in international

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*Correspondence to: Department of Accounting and Finance, Monash University, P O Box 197, Caulfield East, Victoria 3145, Australia. E-mail: imad.moosa@buseco.monash.edu.au. I am grateful to an anonymous referee for useful comments.

finance, appearing under the headings “exchange rate regime verification,” “de facto versus de jure regimes,” and “fear of floating” (also “fear of fixing” or “fear of pegging”). Countries do not adhere to the declared regime for a number of reasons, but we are not concerned with this issue here. For a detailed discussion of exchange rate regime verification, see Moosa (2005).

The objective of this paper is to specify and test a forecasting model of the exchange rate between the Chinese yuan and the US dollar under the post-July 2005 Chinese exchange rate regime. The long-awaited change in China’s exchange rate policy was implemented on July 21, 2005, when the Chinese authorities announced a 2.1% revaluation of the yuan against the dollar, followed (allegedly) by a shift from a currency peg to a basket peg. The announced policy shift would have marked a change from the previous regime (lasting some 10 years) whereby the yuan was pegged to the US dollar at the fixed exchange rate of 8.28. The Chinese authorities described the policy shift as a “switch to a managed float regime with reference to a basket of currencies,” while allowing $\pm 0.3\%$ variation in bilateral exchange rates on any one day (subsequently, the band was widened to $\pm 0.5\%$).

The problem is that it is not obvious that China is actually following a basket peg (or a basket peg with a band). If China is not following the exchange rate regime it declared in July 2005, then any forecasting model that is based on the assumption that China is adhering to the declared regime will be misspecified (thus producing poor forecasts). This is why this paper considers two forecasting models: (i) a model that is based on a basket peg, which is the declared regime and (ii) a model that is based on a crawling peg, which is what China may be using in reality as some evidence indicates. The two models are compared with respect to their ability to predict the yuan-dollar exchange rate out of sample and also on the basis of the profitability of trading based on the forecasts generated by the two models. This exercise will not only produce a model that can be used to predict the yuan-dollar exchange rate but also provide evidence about the actual regime used by China, hence making a contribution to the literature on exchange rate regime verification.

The motivation for conducting this research is the desire to present results that can be useful for currency speculators and hedgers, since exchange rate forecasting is an essential input in decisions pertaining to speculation and hedging. The hedging decision assumes greater importance as China’s role in international trade expands. The motivation is also to use a different approach (based on forecasting rather than hypothesis testing) to shed light on an issue that is attracting significant attention from academics, the media, and policy makers: whether or not China has actually moved to a basket peg, as announced in July 2005. The widespread interest in China’s exchange rate regime is attributed to the rise of China as an economic and trading power. The starting point of this analysis is a review of the literature on exchange rate regime verification as applied to China.

2. The Chinese Exchange Rate Regime

Frankel and Wei (2007) investigate the Chinese exchange rate regime by stating the underlying research question as follows: “Is the precise exchange rate regime that China has put into place since 2005 a genuine departure from the earlier dollar peg, in the direction of flexibility?” They seem to believe that China’s exchange rate policy has recently started to give weight to other currencies with the result that the cumulating trend against the dollar has gradually accelerated but that the process is very slow. So, they seem to believe that the answer is “no” initially and “yes, but ...” subsequently. They summarize their findings by stating that “the Chinese currency continues to assign heavy weight to the US dollar” and that “there are signs of some modest but steady increase in flexibility since the spring of 2006.”

By taking at face value the claim that China has indeed moved to a basket peg, attempts have been made to calculate the weights of the basket components (or at least to assess the weight of the dollar) to obtain an indication as to whether or not it is a pure dollar peg. Jen (2005), for example, estimates the weight of the dollar to be 85%. The problem with these studies, however, is the failure to question the proposition that China has actually moved to a basket peg. For example, Frankel and Wei (2007) start by assuming that “the value of the RMB is indeed determined by a currency basket” and proceed to unravel its structure by calculating the weights of the components. Astonishingly, even when their results produce no evidence for a basket peg, they do not acknowledge the possibility that China may still be on a dollar peg.

Shah et al. (2005) concluded that the yuan was still pegged to the dollar even after July 21, 2005. Frankel and Wei (2007) cast doubt on the validity of this result, arguing that it may be due to the use of four (out of 11) currencies in the basket (US dollar, Japanese yen, Euro, and British pound). The problem with this argument is that if none of these three non-dollar currencies shows any effect on the yuan, it is unlikely that any of the other seven would. Similarly, Eichengreen (2006) used daily observations over the period July 22, 2005, to March 21, 2006, and found the weight of the dollar to be 0.9, no evidence for a downward trend in this weight, and insignificant weights on the non-dollar currencies. Yamazaki (2006) found that some weight had shifted to the Euro, Japanese yen, and Korean won.

In a more recent paper, Moosa et al. (2008) present results that support the announced exchange rate regime shift of China in the period since July 21, 2005, but they present more support for the proposition that China has shifted to a discretionary crawling peg than to a basket peg. They argue that the proposition that China has shifted to a discretionary crawling peg is supported not only by their empirical results but also by intuition and a number of observations, including the following: (i) the Chinese have not declared a shift to a basket peg in the strict sense, but rather to a “managed floating regime with reference to a basket of currencies”; (ii) the actual behavior of exchange rates since the policy shift is not reflective of any sort of floating, managed or otherwise; (iii) a discretionary crawling peg seems

to be the optimal regime for China, given that the Chinese authorities want to maintain competitiveness while avoiding a trade war with the US; and (iv) a discretionary crawling peg is consistent with the practice of stabilizing exchange rates against the dollar without a strong commitment mechanism, which is what Asian countries indulged in following the Asian crisis of the 1990s.

The proposition that China is following a crawling peg seems to be supported by both Roubini (2007) and McKinnon (2007), who hold diametrically opposite views on the normative issue of whether a dollar peg is good or bad for China. While Roubini believes that China “should abandon its dollar peg,” McKinnon argues that China should “keep its dollar peg.” What is important for this paper is that both of them believe that China is currently following a dollar peg. Roubini believes that the current Chinese exchange rate regime is a crawling peg because he argues that “China has pegged the renminbi (RMB) to the United States dollar since 1994, only recently allowing a very slow rate of upward crawl after a small revaluation in July 2005.” Likewise, McKinnon argues that “since 21 July 2005, when the PBC unhooked the renminbi and allowed a discrete appreciation of 2.1%, the mainland’s policy makers have allowed the currency to crawl slowly upwards.” McKinnon suggests that exchange rate movements are “randomized so that speculators do not get any free lunches.” These arguments boil down to the proposition that China is following a discretionary (stochastic), rather than an exact (deterministic), crawling peg. This point is crucial for model specification.

Given the mixed evidence on what the Chinese are actually doing, it seems that the best way to proceed is to specify two models and test them for predictive accuracy. The first model is specified following the proposition that the Chinese have shifted to a basket peg, whereas the second model assumes that the underlying exchange rate regime is a crawling peg against the dollar. The specification of the two models is presented in the following section.

3. Model Specification and Methodology

Let E_0 be the exchange rate of the base currency (yuan) against the numeraire, which is the US dollar (measured as the price of one dollar, which is direct quotation from the Chinese perspective). The basket can be represented by the equation:

$$E_{0,t} = \alpha_1 + \sum_{j=2}^n \alpha_j E_{j,t} + \varepsilon_t, \quad (1)$$

where $j = 2, 3, \dots, n$ represents the non-dollar currencies in the basket and $j = 1$ represents the dollar. Equation (1) says that the exchange rate between the yuan and the dollar is determined by the exchange rates (against the dollar) of the currencies in the basket. In August 2005 the Chinese central bank governor, Zhou Xiaochuan, disclosed a list of 11 currencies as the constituents of the basket: US dollar, Euro, Japanese yen, Korean won, Singapore dollar, British pound, Malaysian ringgit,

Russian ruble, Australian dollar, Thai bhat, and Canadian dollar (Zhou, 2005). The first four currencies are believed to be the main currencies in the basket.

Under a basket peg, the exchange rate of the domestic currency against the dollar (the numeraire) is determined by the movements of the dollar exchange rates of the currencies included in the basket. A currency's weight in the basket determines the strength of the comovements of that currency and the domestic currency (both measured against the numeraire). Although the weights are unknown, they can be estimated. In equation (1), α_j reflects the weight assigned to currency j , whereas α_1 reflects the weight of the numeraire. Weights can be calculated as elasticities at the means in a linear specification or straight from the estimated coefficients from log-log or first-difference models (for more details on these issues, see Moosa et al., 2008).

The structural time series model of Harvey (1985, 1989) is used to represent a discretionary crawling peg against the dollar. This model can be written as:

$$E_{0,t} = \mu_t + \varepsilon_t, \quad (2)$$

where μ_t is the trend, which represents the long-term movement of the exchange rate. The trend is assumed to follow the specification:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \quad (3)$$

$$\beta_t = \beta_{t-1} + \zeta_t, \quad (4)$$

where $\eta_t \sim NID(0, \sigma_\eta^2)$ and $\zeta_t \sim NID(0, \sigma_\zeta^2)$. Here μ_t is a random walk with a drift factor β_t , which follows a first order autoregressive process as represented by equation (4). This process collapses to a simple random walk with drift if $\sigma_\zeta^2 = 0$, and to a deterministic linear trend if $\sigma_\eta^2 = 0$ as well. If, on the other hand, $\sigma_\eta^2 = 0$ while $\sigma_\zeta^2 \neq 0$, the process will have a trend that changes relatively smoothly. The specification represented by equations (2)-(4) is appropriate for a discretionary crawling peg, as discussed in the previous section.

Measuring the predictive accuracy of the two models is based on out-of-sample forecasting errors. To generate the error series, equations (1) and (2) are estimated over some part of the sample period, then forecasts are generated for the remaining part of the sample. These errors are then calculated as the difference between the actual and predicted values. Hence, we have:

$$w_t = E_{0,t} - \hat{E}_{0,t}, \quad (5)$$

where $\hat{E}_{0,t}$ is the predicted exchange rate. Based on the error series, the following measures of predictive accuracy are calculated: mean absolute deviation (*MAD*), mean square error (*MSE*), root mean square error (*RMSE*), Theil's inequality coefficient (*U*), direction accuracy (*DA*), and the confusion rate (*CR*). On the basis of n out-of-sample point forecasts, measures of the magnitude of error are calculated as follows:

$$MAE = \frac{1}{n} \sum_{t=1}^n |w_t|, \quad (6)$$

$$MSE = \frac{1}{n} \sum_{t=1}^n w_t^2, \quad (7)$$

$$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{n} \sum_{t=1}^n w_t^2}, \quad (8)$$

$$U = \frac{\sqrt{\frac{1}{n-1} \sum_{t=1}^n w_{t+1}^2}}{\sqrt{\frac{1}{n-1} \sum_{t=1}^n (\Delta E_{0,t+1})^2}}, \quad (9)$$

$$DA = \frac{1}{n-1} \sum_{t=1}^n a_{t+1}, \quad (10)$$

where $a_{t+1} = 1$ if $(E_{0,t+1} - E_{0,t})(\hat{E}_{0,t+1} - E_{0,t}) > 0$ and $a_{t+1} = 0$ otherwise. This means that a takes the value 1 if the actual and predicted changes have the same sign and 0 if they have the opposite signs. If $(E_{0,t+1} - E_{0,t})(\hat{E}_{0,t+1} - E_{0,t}) > 0$ for all t , then the value of DA will be 1, implying that the model predicts the change correctly on all occasions. In this case there is a zero confusion rate (that is, confusing the direction of the change in the exchange rate). In general, the confusion rate (CR) is related to the measure of direction accuracy as follows:

$$CR = 1 - DA. \quad (11)$$

While the MAD , MSE , and $RMSE$ are measures of the absolute predictive power, U is a measure of the predictive power relative to that of a random walk. DA and CR are measures of the ability of a model to predict the direction of change. It is noteworthy that in some financial decision making situations, predicting the direction of change is more important than producing a small (absolute) error; that is, predicting the direction of change is more important than predicting the absolute magnitude of change. On this issue, see Moosa (2006).

To test formally the predictive accuracy of the basket model against that of the crawling peg model, the AGS test, designed by Ashley et al. (1980), is used. The test requires the estimation of the linear regression:

$$D_t = \gamma_0 + \gamma_1(M_t - \bar{M}) + u_t, \quad (12)$$

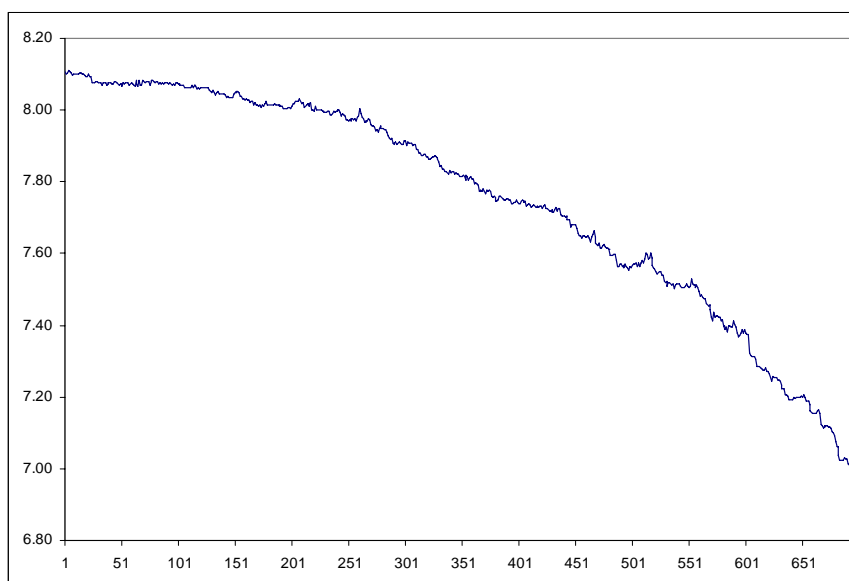
where $D_t = w_{1t} - w_{2t}$, $M_t = w_{1t} + w_{2t}$, \bar{M} is the mean of M , w_{1t} is the forecasting error at time t of the model with the higher $RMSE$, and w_{2t} is the forecasting error at time t of the model with the lower $RMSE$. If the sample mean of the errors is negative, the observations of the series must be multiplied by -1 before running the regression. The estimates of the intercept (γ_0) and the slope (γ_1) are used to test the statistical difference between the $RMSE$ s of the two models. If the estimates of γ_0 and γ_1 are both positive, then a Wald test of the joint hypothesis $H_0: \gamma_0 = \gamma_1 = 0$ is

appropriate. If one of the estimates is negative and statistically significant, then the test is inconclusive. But if the estimate is negative and statistically insignificant, the test remains conclusive, in which case significance is determined by the upper-tail t -test of the positive coefficient estimate.

4. Data and Empirical Results

The empirical results are based on a sample of daily data covering the period August 3, 2005, to May 7, 2008 (694 observations). The data were obtained from the Pacific Exchange Rate Service of the Sauder School of Business (<http://fx.sauder.ubc.ca>). Figure 1 displays the time path of the yuan-dollar exchange rate over the entire sample period. The graph clearly shows a downward trend in the exchange rate (appreciation of the yuan against the dollar), but the time path is not smooth. This simply indicates a policy of discretionary crawling peg. The behavior of the exchange rate shown in Figure 1 by no means resembles that of an exchange rate that is determined by a basket peg.

Figure 1. The Yuan-Dollar Exchange Rate over the Sample Period



The models represented by equations (1) and (2) are estimated by maximum likelihood, using the Kalman filter to update the estimates when a time-varying trend is specified, as in equation (2). To generate one-period-ahead forecasts, the models are estimated 100 times for samples ranging between $t = 1$ and $t = 594 + i$ for $i = 0, 1, 2, \dots, 99$ to obtain 100 point forecasts represented by $\hat{E}_{0, j+594+i+1}$. Likewise, the generation of five-period-ahead forecasts requires the estimation of the models 20 times for samples ranging between $t = 1$ and $t = 594 + i$ for $i = 0, 5, 10, \dots, 95$ to

obtain 20 point forecasts represented by $\hat{E}_{0,t+594+i+5}$. To generate the first one-period-ahead forecast for observation 595, the models are estimated over the period 1 to 594. The last forecast point for observation 694 is obtained by estimating the models over the period 1 to 693. Likewise, the first five-period-ahead forecast is for observation 599, requiring the estimation of models over the period 1 to 594, whereas the last one (observation 694) requires the estimation of models over the period 1 to 599.

The actual and predicted values of the exchange rate are displayed in Figures 2-5. As we can see, the crawling peg model is more successful than the basket model in tracking the actual values of the exchange rate, irrespective of whether the forecasts are one-period-ahead or five-period-ahead. Since the direction of change is judged by the signs of actual and predicted changes relative to the actual values in the previous period, these graphs cannot tell us much about the ability of the two models to predict the direction of change. For this purpose we need prediction-realization diagrams, which are scatter plots of predicted against actual changes. These are not shown here because the same message is conveyed by *DA* and *CR*, which measure the ability to predict the direction of change.

Figure 2. One-Period-Ahead Forecasts (Basket Peg Model)

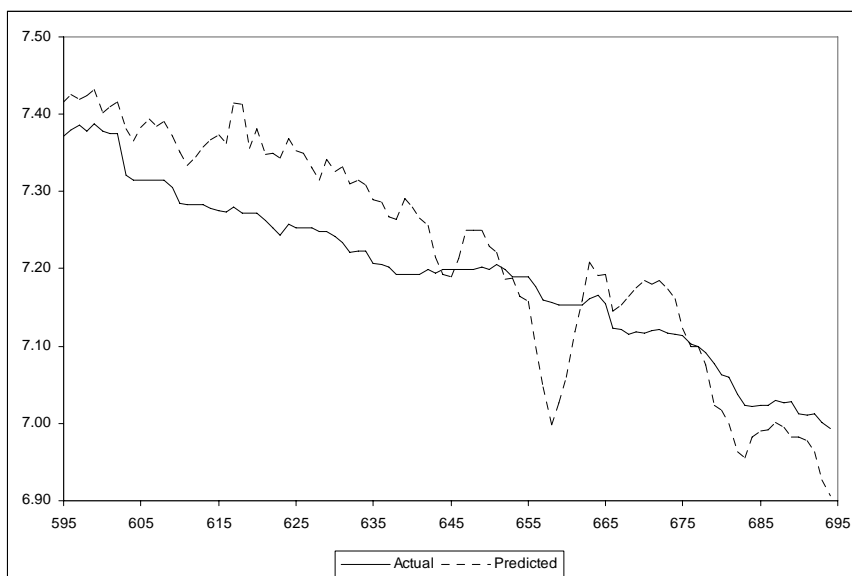


Figure 3. One-Period-Ahead Forecasts (Crawling Peg Model)

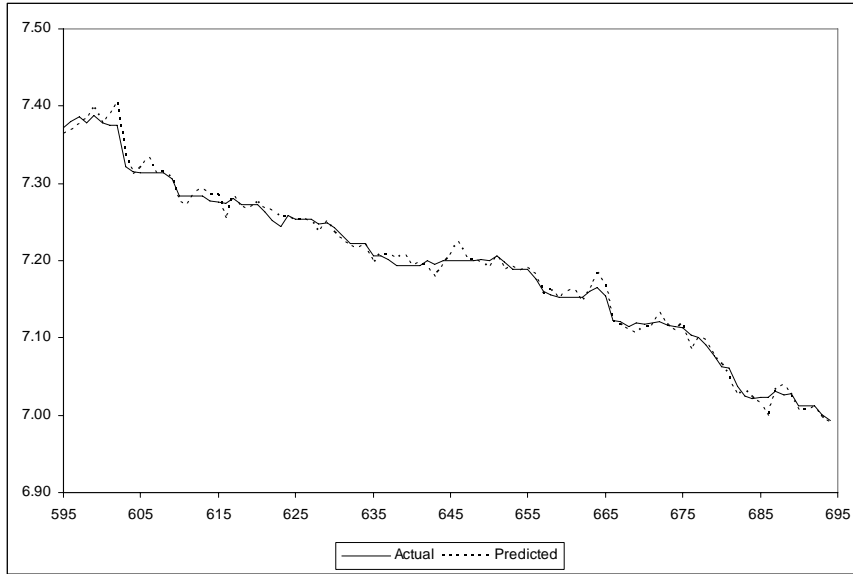


Figure 4. Five-Period-Ahead Forecasts (Basket Peg Model)

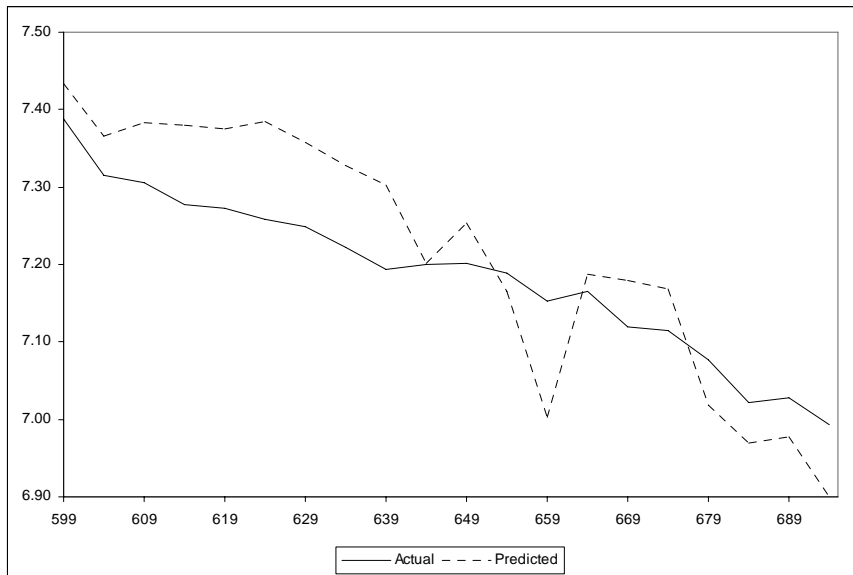


Figure 5. Five-Period-Ahead Forecasts (Crawling Peg Model)

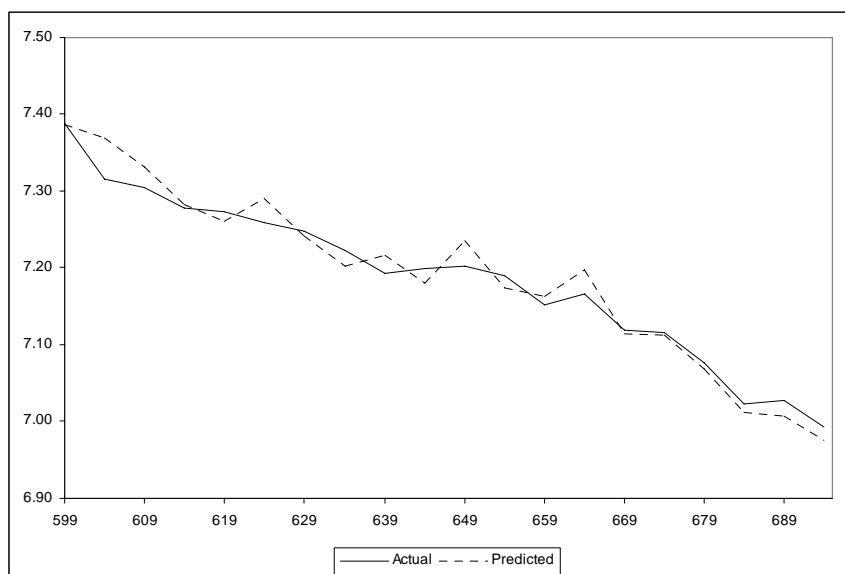


Table 1 reports measures of predictive accuracy. The crawling peg model is superior to the basket model because it has lower MAD , MSE , $RMSE$, and U . What is more important, however, is that $U > 1$ for the basket model, indicating that it is worse than a random walk in out-of-sample forecasting, a result that is often found in exchange rate forecasting exercises. Conversely, $U < 1$ for the crawling peg model, which indicates that it outperforms the random walk model in out-of-sample forecasting. As far as the ability to predict the direction of change is concerned, the crawling peg model outperforms the basket peg model as it has higher (lower) DA (CR). The crawling peg model predicts the direction of change correctly in 79% of the 20 five-period-ahead forecasts and in 59% of the 100 one-period-ahead forecasts. The reason why the model does a better job in predicting the direction of change in five-period-ahead forecasts is that there is less volatility in the exchange rate when it is observed at five-day intervals. Daily volatility results from the randomization of the rate of crawl and perhaps the effect of market forces. This can be seen clearly in Figure 5.

It is common practice in the forecasting literature to derive inference on performance of one model relative to another by comparing the numerical values of the MSE and $RMSE$. This is fine if the numerical difference is large, as it is in this case, but it may not be so if the difference is small. This is because measures of forecasting accuracy are estimated with standard errors, which makes it necessary to conduct a formal test of the equality of the $RMSE$ s. This is why the AGS is employed for this purpose. The results of this test (for the null that the $RMSE$ of the basket peg model is not higher than the $RMSE$ of the crawling peg model) are

presented in Table 2. These results consist of the estimated values of the coefficients γ_0 and γ_1 , their t -statistics (in parentheses) and the Wald test for $H_0 : \gamma_0 = \gamma_1 = 0$. Since all of the estimated coefficients are positive, the test should be based on the Wald statistic, which is statistically significant. This means that the null that the $RMSE$ of the basket peg model is not higher than the $RMSE$ of the crawling peg model is rejected. Hence, the crawling peg model is superior to the basket peg model in out-of-sample forecasting.

Table 1. Measures of Predictive Accuracy

	One-Period-Ahead		Five-Period-Ahead	
	Basket Peg	Crawling Peg	Basket Peg	Crawling Peg
<i>MAD</i>	0.0597	0.0070	0.0722	0.0177
<i>MSE</i>	0.004628	0.000056	0.0066	0.0005
<i>RMSE</i>	0.0680	0.0093	0.0815	0.0219
<i>U</i>	7.18	0.93	4.17	0.81
<i>DA</i>	0.40	0.59	0.47	0.79
<i>CR</i>	0.60	0.41	0.53	0.21

Table 2. The AGS Test Results

	One-Period-Ahead	Five-Period-Ahead
γ_0	0.0291 (16.08)	0.0254 (2.93)
γ_1	0.9210 (32.21)	0.7320 (7.19)
Wald ($\gamma_0 = \gamma_1 = 0$)	1296.1	60.30

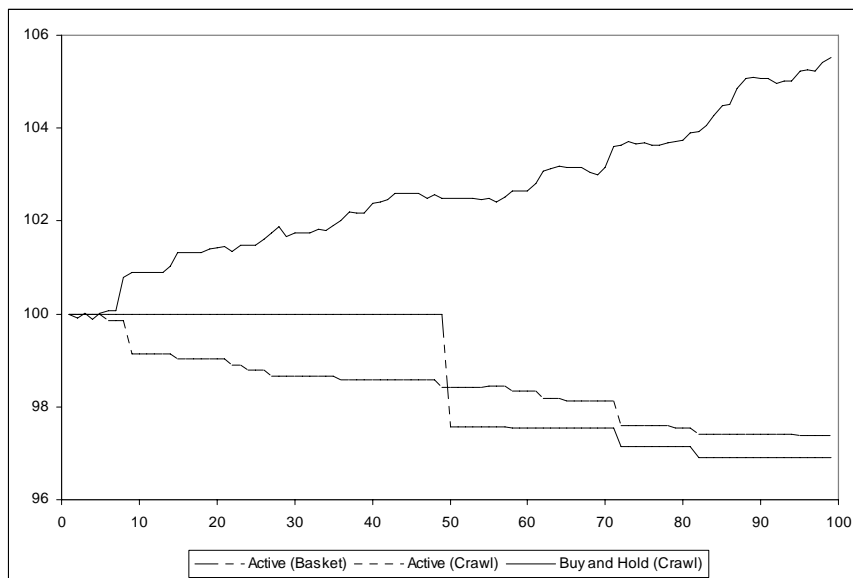
Note: The Wald statistic is distributed $\chi^2(2)$.

Perhaps the ultimate measure of predictive accuracy is the profitability of trading based on the generated forecasts. For this purpose, we imagine a hypothetical trader, starting with 100 yuan, actively buying and selling the dollar on signals generated by the forecasts. The trading strategy goes as follows: buy the dollar when the predicted change in the exchange rate is positive (because it means that the dollar is expected to appreciate against the yuan) and sell the dollar when the predicted change is negative. The operation is repeated when there is another buy signal and so on until we come to the end of the forecasting period.

The problem with this active trading strategy is that it is not appropriate if the exchange rate regime is a crawling peg, in which case the most profitable strategy is to buy the dollar at the beginning of the period and hold the position until the end of the period. Thus, if the Chinese are truly following a crawling peg, the third strategy must be the most profitable. The results of the trading strategies (active trading under a basket peg, active trading under a crawling peg, and buy and hold under a crawling peg) are shown in Figure 6, which traces over 100 days the time path of the principal amount (100 yuan) and the accumulated profits or losses. As we can see, both of the active strategies produce losses; by far the most profitable strategy is that of buy and hold. Because only one buy and one sell transaction is involved in this strategy, the unrealized market value of the position throughout the period is shown.

This is yet another piece of evidence that the Chinese are following a crawling peg, not a basket peg, unlike what they claim and what most people believe.

Figure 6. Profits and Losses Generated by Trading on the Basis of Forecasts



5. Conclusion

Although the Chinese government claims that China's exchange rate regime is a basket peg, which many observers (and academics) take for granted, there is ample evidence indicating that China is actually following a discretionary crawling peg against the dollar. To find out whether China is practicing what it has declared, two forecasting models are specified and estimated over the post-July 2005 period, one based on a basket peg and the other on a crawling peg. Model comparison is based on out-of-sample accuracy of the two models using both one-period-ahead and five-period-ahead forecasting. All measures of forecasting accuracy support the crawling peg model with respect to forecasting the magnitude and direction of change.

The two models are also compared on the basis of trading strategies utilizing forecasts generated from the two models. The results again support the crawling peg model, particularly because a buy-and-hold strategy turns out to be the most profitable. There seems to be no evidence to support the proposition that China has decided to peg the yuan to a basket of currencies. This is a classical case of divergence between de facto and de jure exchange rate regimes. Although US politicians and policy makers may not like this finding for political reasons, foreign exchange traders may find these results interesting from a practical perspective.

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