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How are Exchange Rates Managed? Evidence of Error-correction Around a Reference

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How are Exchange Rates Managed? Evidence of Error-correction Around a Reference

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ABSTRACT

In managed floats, central banks often intervene in the foreign exchange market to obtain politically desirable exchange rates. How this is done has remained totally opaque although central banks are likely to adopt a satisficing rather than optimizing strategy since they need to intervene frequently in a timely manner under incomplete information. In this paper, we propose a simple exchange rate management rule that balances the amount of variation between currency pairs around a reference rate. We test out this rule using the Chinese Yuan as a case study before extending the study to 9 other currencies. Empirical results are consistent with the hypothesis that central banks follow the error correction rule in exchange rate management.

JEL CODES: F31, O24, P21

KEYWORDS: Exchange rate policy, Managed float, Error correction model.

1. Introduction

Following the collapse of the Bretton Woods System, floating exchange rate became the new 'norm', and the concept of letting the market determine the 'fair' or 'equilibrium' rate also gained popularity. However, the academic literature suggests that few countries actually follow a pure float, despite what may be claimed[1].

Cohen (1998) argues that currencies can be grouped according to the anchor currencies and the satellite currencies captured by them in the respective "authoritative domains". Kocenda *et al* (2008) show that the existing world monetary system is inherently unstable because it is dominated by three anchor currencies: the U.S. dollar, the Japanese yen, and the euro. It is therefore understandable that central banks would want to practise some variant of manage float to smooth exchange rate volatilities imposed on them by rapid changes in the relative values of anchor currencies[2].

How a managed float is conducted has remained totally opaque, although central banks are unlikely to adopt any actual optimisation strategy in their policy formulation since they need to intervene frequently in a timely manner under incomplete information. Frey and Schneider (1981) argue that central banks are unable to formally solve the dynamic optimization problem because they have neither the requisite capacity nor the necessary information; they instead adopt a strategy which keeps the conflict with voters and government below a certain level.

Furthermore, the trilemma of international finance says that a central bank typically has three primary objectives: to maintain exchange rate stability, to allow free

[1] Examples include Reinhart (2000), Calvo and Reinhart (2002), Calvo and Mishkin (2003) and Reinhart and Rogoff (2004).

[2] There are a variety of arguments justifying why a central bank or government would want to this. For example, McKinnon and Schnabl (2004) argue that in spite of what is viewed as the benefits of floating exchange rates, managed regimes were actually rational policy choices as they help provide some degree of macroeconomic stability. See also Hoffmann (2007). With particular reference to China, McKinnon (2007) and McKinnon and Schnabl (2011) further contend that the stability arising from fixed or managed exchange rate regimes also extend further to a wider global level.

international capital mobility, and to implement monetary policy for domestic stability. However, policymakers can only allow for two of the three objectives as at least one of the three will be in conflict with the other two. For example, Mankiw (2010) suggests that the USA chooses to sacrifice exchange rate stability in favour of the latter two objectives. Conversely, China opts to limit the level of capital mobility by controlling both monetary policy and the exchange rate. Therefore, regardless whether the central bank is trying to keep the government-voter conflict low or trying to resolve the trilemma, it is likely that any policy implemented by the central bank is one which is satisficing rather than optimising[3].

In this paper, we propose a satisficing strategy which seeks to balance the amount of variation between currency pairs. We use China as an example to illustrate this management strategy. When the Chinese Yuan (CNY) was pegged to the U.S. dollar (USD), all volatilities in the exchange rate between the dollar and the euro (EUR) is imposed on the *CNY/EUR* rate. This could not be a satisficing strategy when the euro was gaining importance in facilitating transactions as the eurozone became China's largest export market in recent years. It is very likely that the People's Bank of China (PBoC), China's central bank, would want to balance the degree of variability of *CNY/USD* and *CNY/EUR* against the reference rate USD/EUR using a weighted apportionment rule. Specifically, the PBoC can set the desired target rate as

$$\log\left(\frac{CNY}{USD}\right)_t = \alpha_0 - \alpha \log\left(\frac{USD}{EUR}\right)_t . \qquad (1)$$

where $0 < \alpha < 1$. Differentiating Eq. (1) with respect to time, we have

[3] Historical evidence by Obstfeld *et al* (2005) indicates two points clearly. The first is that free float regimes are rarely unbridled, and vice versa. The second is that the exchange rate stance is typically linked closely to one particular objective of the trilemma. Thus, the textbook paradigm of an optimal policy is clearly not the case in reality, and there seems little reason to dispute a satisficing approach to policymaking.

$$\frac{d}{dt}\log\left(\frac{CNY}{USD}\right)_t = -\alpha\frac{d}{dt}\log\left(\frac{USD}{EUR}\right)_t \tag{2}$$

Eq. (2) says that the rate of change of the *CNY/USD* rate is proportional to a factor, α, of the rate of change of the *USD/EUR* rate. Eq. (1) and the cross rate between CNY and EUR imply:

$$\log\left(\frac{CNY}{EUR}\right)_t = \alpha_0 + (1-\alpha)\log\left(\frac{USD}{EUR}\right)_t . \tag{3}$$

Differentiating Eq. (3) with respect to time, we also have

$$\frac{d}{dt}\log\left(\frac{CNY}{EUR}\right)_t = (1-\alpha)\frac{d}{dt}\log\left(\frac{USD}{EUR}\right)_t , \tag{4}$$

which means that the rate of change of the *CNY/EUR* rate is proportional to a factor, $1-\alpha$, of the rate of change of the *USD/EUR* rate. Therefore, by setting the desired target rate, the PBoC can apportion variation in the *USD/EUR* rate to two exchange rates (*CNY/USD* and *CNY/EUR*) and smooth the volatilities for exporters and other market players.

The proposed heuristic approach to exchange rate management can be summarized in the following three-step procedure:

1. Identify the exchange rate between two anchor currencies (*USD/EUR*) as the reference rate;
2. Identify the exchange rate between one anchor currency and the domestic currency (*CNY/USD*) as the target rate, and set the desired proportion (α) of variation in the reference rate to be passed to the target rate as in Eq. (1);
3. Follow an error correction mechanism to achieve the desired target rate, leaving the *CNY/EUR* rate to adjust itself through market arbitrage.

In this paper, empirical verification of the management rule is carried out using the

CNY/USD exchange rate as a special case. The exercise is then extended to several other countries. The results suggest that our proposed exchange rate management rule has been in practice and is more widely used than one may expect.

The rest of the paper is organised as follows. In the next section, we lay out the proposed exchange rate determination and management rules, and the corresponding estimating equations using the CNY, USD and EUR for illustration, and report our empirical results for the Chinese case. Section 3 extends the study to 9 selected currencies. Section 4 concludes the paper.

2. The Case of China

2.1 The existing literature

A seemingly natural starting point for our analysis would be to draw on the literature pertaining to exchange rate determination and prediction. Recent surveys and discussions of this area can be found in Pavlidis *et al* (2009) and Altaville and de Grauwe (2010). However, the basic starting assumption of this literature builds on the premises of a floating exchange rate regime where the spot rate is defined as the result of the market equilibrium, and managed float is not given enough attention. Moreover, few studies in the literature provide positive analysis on central bank behaviour at both theoretical and empirical levels.

Another thread of literature that helps us build some priors is the seminal contributions trying to uncover the weights of constituent currencies in a basket, starting from Frankel and Wei (1994). With regards to China, the amount of relevant existing literature is comparatively small. Frankel and Wei (2007), Frankel (2009) and Moosa *et al* (2009) form the key seminal contributions. The methodology of Frankel and Wei (2007) and Frankel (2009) are essentially identical. To uncover the exact currency

weights, the following equation was estimated:

$$\Delta \log e_{0t} = \sum_{i=1}^{n} \beta_i \Delta \log e_{it} , \tag{5}$$

where e_0 is the domestic currency and e_i is each potential or stipulated currency in the basket, all denominated in a common numeraire currency. β_i, the resulting coefficients for e_i, were interpreted as the individual weights in the basket.

Moosa *et al* (2009) critiqued the methodology by raising the possibility of an omitted variable bias in Eq. (5). They assert that the obtained coefficients can be considered as weights *only* if no cointegrating relationship was present in the undifferenced log-linear model. If there was already a cointegrating relationship, taking log-differences results in the omission of an error correction term. This biases the subsequent estimates and the coefficients are more appropriately considered as some measure of demand elasticity. Also, they may be considered as weights only when the sum of all the obtained coefficients is restricted to an upper-bound of 1.

2.2 The Policy Rule

The results of Frankel and Wei (2007) and Frankel (2009) found that of all the currencies announced by PBoC, only EUR and USD were found to be statistically significant. Therefore, it is likely that a different exchange rate management rule is in use as opposed to valuation *per se* via a weighted-basket. Following the discussion in Section 1, we assume the central bank sets the desired target rate as

$$\log\left(\frac{CNY}{USD}\right)_t^d = \alpha_0 - \alpha \log\left(\frac{USD}{EUR}\right)_t + \varepsilon_t \tag{6}$$

where ε_t is the white noise error term. Furthermore, we assume the desired target rate is achieved by following the error correction mechanism:

$$\Delta \log\left(\frac{CNY}{USD}\right)_t = \lambda \Delta \log\left(\frac{CNY}{USD}\right)_t^d + \gamma\left(\log\left(\frac{CNY}{USD}\right)_{t-1}^d - \log\left(\frac{CNY}{USD}\right)_{t-1}\right) \quad (7)$$

Substituting Eq. (6) in Eq. (7), we get the final estimation equation:

$$\Delta \log\left(\frac{CNY}{USD}\right)_t = -\alpha\lambda \Delta \log\left(\frac{USD}{EUR}\right)_t + \gamma\left(\alpha_0 - \alpha \log\left(\frac{USD}{EUR}\right)_{t-1} - \log\left(\frac{CNY}{USD}\right)_{t-1}\right) + u_t, \quad (8)$$

where u_t is an error term which follows an AR(1) process.

Eq. (8) implies that the adjustment speed in any one period is in proportion to the change in the reference rate between the two periods. The second term is the short-run error correction, where γ is the short-run speed of adjustment or error correction for $\log(CNY/USD)_t$ to return to the desired level.

2.3 Empirics

We use monthly data for our estimation, all obtained from the CEIC database. Figure 1 shows movement of the *CNY/USD* spot rate since August 2005. It is evident that the CNY was pegged to the USD closely (or the band within which the CNY was allowed to vary was very narrow) during the period between August 2008 and June 2010 when the global financial crisis was unfolding[4].

In Eq. (7), both $\log(CNY/USD)_t$ and $\log(USD/EUR)_t$ are specified in differences. Thus, we want to ensure that they are stationary after first difference before any estimation to guard against the prospect of a spurious regression. We use the Ng and Perron test and the results are reported in Table 1. The results suggest that both $\log(USD/EUR)_t$ and $\log(CNY/USD)_t$ are $I(1)$, i.e. both series are stationary after first differencing.

[4] Statements issued at those dates appear to back this up. See Hu (2008) and the People's Bank of China (2010). We do not claim that these were indicators of a regime change. *Ex post*, we are suggesting that they may have been a signal of the subsequent exchange rate regimes.

Figure 1: Log (*CNY/USD*) exchange rate

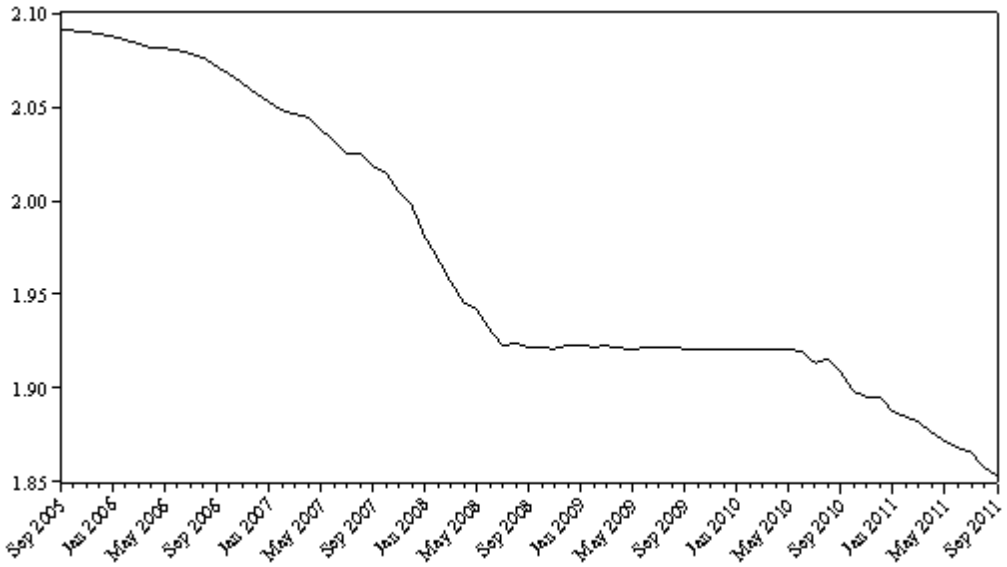


Table 1: Unit root test results (with an intercept)

Sample: Aug 2005 – Sep 2011		MZa	MZt	MSB	MPT
Level					
log *CNY/USD*		- 2.073	-0.752	0.363	9.586
log *USD/EUR*		-5.512	-1.617	0.293	4.570
First difference					
log *CNY/USD*		-5.724	-1.690	0.295	4.285
log *USD/EUR*		-32.607	-3.995	0.123	0.880
Asymptotic critical values*	1%	-13.800	-2.580	0.174	1.780
*Ng-Perron (2001, table 1)	5%	-8.100	-1.980	0.233	3.170
	10%	-5.700	-1.620	0.275	4.450

Next, we proceed to estimate α in Eq. (5). Using the date from September 2005 to September 2011, we estimate Eq. (5) using LIML, and allow both the intercept and the slop to be different within three sub-periods (pre-August 2008, post-June 2010,

and the period in between) [5]. We include two dummy variables: $D_{2008} = 1$ for the months between August 2008 – June 2010 inclusive, and $D_{2010} = 1$ for all months from July 2010 onwards. The slope coefficient for the post-June 2010 period turns out to be insignificantly different from that for the pre-August 2008 period. The final estimated equation gives:

$$\log\left(\frac{CNY}{USD}\right)_t = \underset{(0.009)}{2.231} - \underset{(0.039)}{0.354}D_{2008} - \underset{(0.004)}{0.135}D_{2010} - \underset{(0.031)}{0.603}\log\left(\frac{USD}{EUR}\right)_t - \underset{(0.123)}{0.799}D_{2008}\log\left(\frac{USD}{EUR}\right)_t$$

$$R^2 = 0.975 \qquad (9)$$

standard errors in parentheses. The result indicates that $\alpha = 0.603$ in the periods where the managed float was in place, i.e. 60.3% of the variation in the *USD/EUR* rate was passed to the *CNY/USD* rate. Thus, while a break appears the case between August 2008 and June 2010, there is no evidence to suggest that a change in the management rule/regime had occurred between the pre-August 2008 and post-June 2010 periods.

Given the estimate of a constant α, Eq. (8) is estimated by OLS and allowing intercepts and slopes to be different within the three sub-periods. Using a standard textbook testing down procedure, we finally obtain:

$$\Delta\log\left(\frac{CNY}{USD}\right)_t = \underset{(0.001)}{-0.004} + \underset{(0.001)}{0.004}D_{2008} - \underset{(0.019)}{0.072}\Delta\log\left(\frac{USD}{EUR}\right)_t + \underset{(0.027)}{0.078}D_{2008}\Delta\log\left(\frac{USD}{EUR}\right)_t,$$

$$R^2 = 0.480 \qquad (10)$$

standard errors in parentheses. The error term is of the form: $u_t = \rho u_{t-1} + \varepsilon_t$, and $\rho = 0.370$. From Eq. (8), we can derive that $\lambda = 0.119$, which means about 12% of

[5] OLS or IV can be used as alternatives with α varying marginally. However, LIML is preferred as it was established that the obtained estimates in the presence of unit roots are more consistent and valid for inference (see Phillips, 1991).

changes in the desired target rate within the month is realized within the same month. Furthermore, $\gamma = 0$, which implies that there is no short-run error correction around the desired target rate. This is consistent with Moosa *et al* (2009) who also cannot find any short-run error correction when using daily data.

The foregoing empirical analysis therefore, indicates that our proposed exchange rate management rule is both plausible and realistically practical as evidenced by the results obtained for China.

3. Extensions

3.1 Sample

In this section, we extend the empirical model to a sample of developed and developing economies. The purpose of the exercise is to examine if this type of exchange rate management has also been practised in other countries.

Hoffman (2007) provides a relatively large sample consisting of countries that all practice some form of exchange rate management. We therefore select a sample of countries that we feel and believe to be sufficiently representative.

We include Brazil, India, Russia, South Africa and Malaysia to represent the bloc of developing economies and Japan, Korea, Singapore and Switzerland form the developed group. The latter two have the further implication that they are also small open economies. The respective currency codes are listed in Table 2.

Table 2: Country sample and currency codes

Brazil (real)	BRL	Korea (won)	KRW	Singapore (dollar)	SGD
India (rupee)	INR	Malaysia (ringgit)	MYR	South Africa (rand)	ZAR
Japan (yen)	JPY	Russia (ruble)	RUB	Switzerland (franc)	CHF

We need to first mention something about the time frame under consideration. In the case of China, the period from September 2005 to September 2011 is used as this was the time where the CNY showed some semblance of a managed float.

For the other countries in Table 2, Figure 2 illustrates that they were all already on some type of a floating regime apart from Malaysia prior to 2005[6]. It is thus not necessary to keep to a similar time frame following the Chinese case. Instead, we estimate for the entire period from 2000 to latest available date.

The existing literature points clearly to a strong influence of the U.S. dollar and the euro on the Chinese exchange rate, but for other economies, it is ambiguous what they choose as the anchor currencies. We return to the idea of a 'vehicle currency' to resolve this. As the US dollar, the euro, the Japanese yen and the Sterling pound (GBP) are the four most traded currencies globally (Bank of International Settlements, 2010), it is reasonable to assume that at least two are the most important anchor currencies for the country and the exchange rate between them can be used as the reference rate. We therefore restrict to combinations of these four for the choice of the reference rate[7].

3.2 Results

We determine the reference rate by running individual pair-wise regressions of each currency denominated in one of the possible anchor currencies against each of the other pairs to determine which gives the largest α. It needs to be noted that the condition of $\alpha \leq 1$ has to hold as it is unreasonable to pass more than 100% of volatilities of the reference rate to other exchange rates.

[6] Malaysia was on a fixed peg to the US dollar until late July 2005. Similar to China, the estimation period begins from September 2005.

[7] A possible way to determine the numeraire is to use the currency of the largest bilateral trading partner as the base currency. However, much of global trade is not conducted using domestic currencies, but via an intermediary such as the US dollar, the Euro or the Japanese yen. Hong Kong is a good example of such.

We consolidate and report only the target rate and the reference rate, the corresponding weights, α, the speeds of adjustment for the target rate, λ, and the short-run error correction parameter, γ, in Table 3[8].

Table 3: Consolidated results

Target Rate	Reference Rate	α	λ	γ	R^2
BRL/USD	*USD/EUR*	-0.542	0.624	0.238	0.208
INR/USD	*USD/GBP*	-0.373	0.601	0.145	0.204
JPY/USD	*USD/EUR*	-0.457	0.663	0.118	0.129
KRW/USD	*USD/GBP*	-0.852	0.526	0.123	0.316
MYR/USD[*]	*USD/EUR*	-0.554	0.590	0.151	0.423
RUB/USD	*USD/GBP*	-0.513	0.532	0.221	0.317
SGD/USD	*USD/JPY*	-0.713	0.309	0.100	0.238
ZAR/EUR	*EUR/USD*	-0.645	0.538	0.130	0.094
CHF/EUR	*EUR/JPY*	-0.274	0.704	0.000	0.160

[*]Malaysia was estimated from Sep 2005 onwards.

Of the sample, Switzerland appears to manage its exchange rate in a similar manner as China as there seems to be no evidence of a short-run error correction. This serves to reinforce the point that even small open economies practice some form of exchange rate management.

Several points need to be made with regards to interpreting the results. Firstly, we had 'let the data speak' without seemingly being concerned about stationarity or structural breaks. And secondly, we determined the anchor pair by means of a 'best-fit'. This follows somewhat along the lines of Hall and Brooks (1986) and may be meth-

[8] Unlike the Chinese case, we have no priors if there is the possibility of a short-run error correction term. As a result, it *may* be possible that the exchange rate management rule takes the form of a common factor model. See Eqs. (4), (5) and (8) in Hendry and Mizon (1978) on retrieving γ from ρ.

odologically controversial.

We defend our approach primarily on the illustrative and exploratory objective of the exercise. Our chief concern was whether we are able to find other examples that give estimates reasonable to interpretation, *despite* the fact that they could be non-stationary and/or have structural breaks. The results in Table 5 show clearly that there are other economies who potentially demonstrate application of our proposed exchange rate management rule[9].

What do our results thus far contribute to the literature? For one, we have argued and demonstrated the viability of balancing the amount of variation (volatility) between currency pairs as an exchange rate management rule. We illustrated this using the Chinese exchange rate as a benchmark analysis. Secondly, we found that this is not a rule which is unique to China alone. Not only is there practical usage of this policy, it appears it is applied by both developing, and somewhat counter-intuitively, developed economies as well.

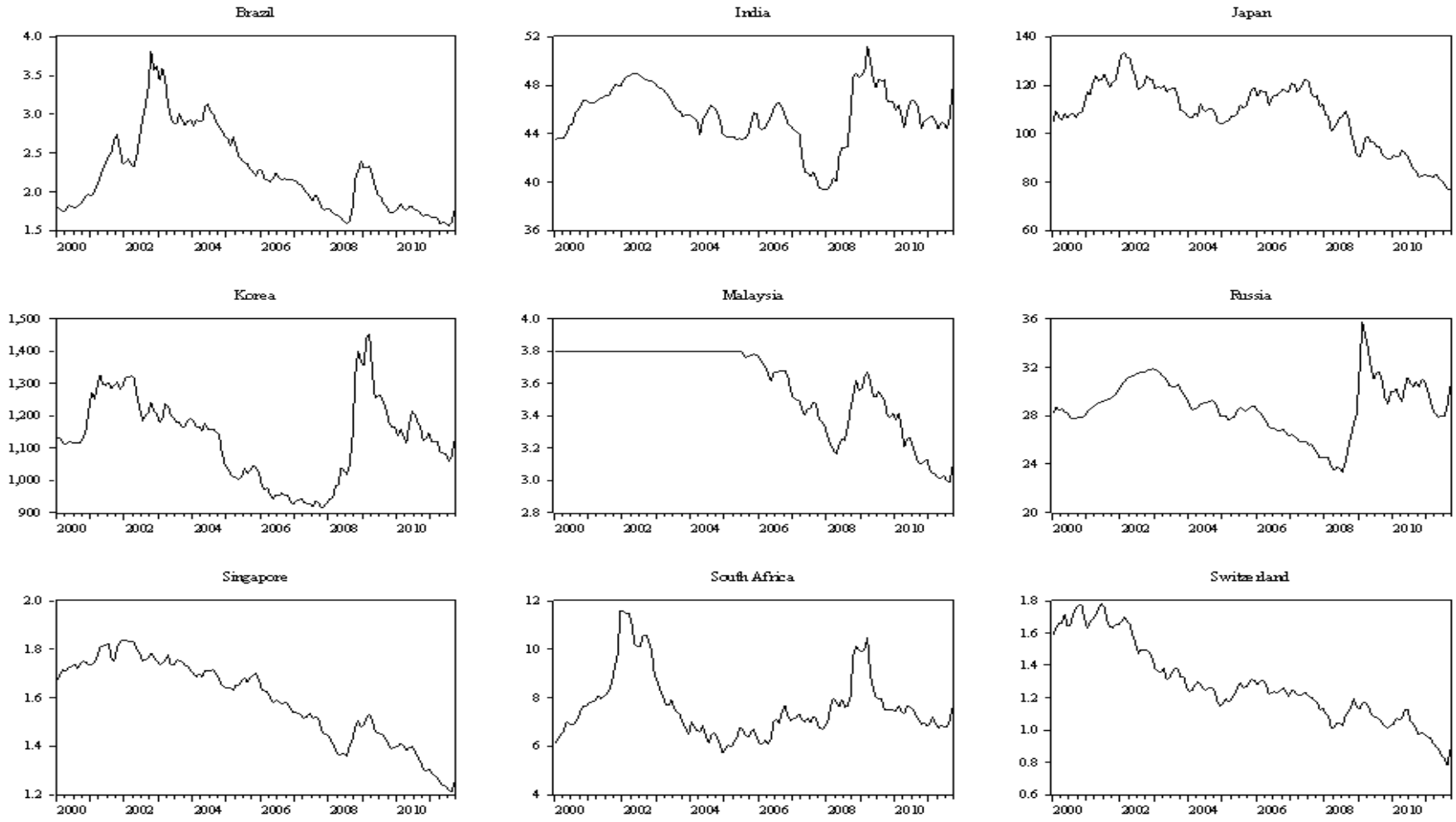
We also showed that current research into trying to disentangle the composition of currency baskets may be mistaken in their approach. Countries under managed floats are attaching weights to their currencies, but these weights are aimed at managing the degree of volatility between other currency pairs.

4. Concluding Comments

A critique here may be that we had simply assumed that policy-makers arbitrarily decide to manage their domestic currencies relative to others. Another could just be

[9] It may not be intuitive at a glance why this is the case, especially when λ is as high as 70% (CHF). However, what is important is the long-run weighted speed of adjustment, $\alpha\lambda$. While the CHF has a high λ, its weighted adjustment is 19.3%. Relatively speaking, if a large economy such as China has a weighted adjustment of 11.9%, 19.3% can be argued to be low for a small open economy which is, theoretically, a price-taker on the world market. In comparison, the other small open economy in the sample, Singapore, has a similarly weighted adjustment of 22%.

Figure 2: Currency movement paths: Jan 2000 - Sep 2011



that the estimation techniques and assumptions used in this paper were too simplistic.

We do not contest both, but we base the legitimacy of our approach on the following grounds. Firstly, policy making in practice often follows some rules-of-thumb or guiding heuristics. It is not difficult for one to find examples of policy decisions made under similar circumstances and the management rule we proposed is arguably consistent with such a practice. Secondly, we obtained a set of results and conclusions that were both analytically interesting and believable. This was *despite* the supposed lack of sophistication and with potentially controversial assumptions and methodological techniques.

Overall, the approach in this paper was to "keep it sensibly simple" (Kennedy, 2003). Our objective was to look for a simple but practical model of exchange rate management that performs reasonably well on the following fronts: (i) simple and intuitive; and (ii) empirically valid. In that, we feel that these were all adequately achieved.

In summary, we proposed an exchange rate management rule that aims to balance the level of variation (volatility) between currency pairs using China as a benchmark analytical case. The policy rule takes the form of an error correction model where the policy maker seeks to manage the speed of adjustment between two periods. In the benchmark analysis, we find that the *CNY/USD* spot rate is managed by controlling its level of realised volatility using the *USD/ EUR* as the reference currency pair.

Empirically, we find evidence to conclude that the Chinese Yuan (CNY)-US Dollar (USD) exchange rate management is a rule-based policy from the use of an error correction model. We subsequently extended the model and methodology to a sample of developing and developed economies with similar results. This suggests that such a form of exchange rate management is likely to be more prevalent than just China.

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