Exchange Rate Regime Analysis for the Indian Rupee

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Abstract

We investigate the Indian exchange rate regime starting from 1993 when trading in the Indian rupee began. This reproduces the analysis from Zeileis, Shah, and Patnaik (2007) which includes a more detailed discussion.

1 Analysis

Exchange rate regime analysis is based on a linear regression model for cross-currency returns. A large data set derived from exchange rates available online from the US Federal Reserve at `http://www.federalreserve.gov/releases/h10/Hist/` is provided in the `FXRatesCHF` data set in **fxregime**. It is a "`zoo`" series containing 25 daily time series from 1971-01-04 to 2006-11-29. The columns correspond to the prices for various currencies (in ISO 4217 format) with respect to CHF as the unit currency.

```
> library("fxregime")
> data("FXRatesCHF", package = "fxregime")
```

India is an expanding economy with a currency that has been receiving increased interest over the last years. India is in the process of evolving away from a closed economy towards a greater integration with the world on both the current account and the capital account. This has brought considerable stress upon the pegged exchange rate regime. Therefore, we try to track the evolution of the INR exchange rate regime since trading in the INR began in about 1993. The currency basket employed consists of the most important floating currencies (USD, JPY, EUR, GBP) as well as two further important Asian currencies (KRW, MYR). Because EUR can only be used for the time after its introduction as official euro-zone currency in 1999, we employ the exchange rates of the German mark (DEM, the most important currency in the EUR zone) adjusted to EUR rates. The combined returns are denoted DUR below in `FXRatesCHF`:

```
> inr <- fxreturns("INR", frequency = "weekly",
+   start = as.Date("1993-04-01"), end = as.Date("2007-06-07"),
+   other = c("USD", "JPY", "DUR", "GBP", "KRW", "MYR"), data = FXRatesCHF)
```

Weekly rather than daily returns are employed to reduce the noise in the data and alleviate the computational burden of the dating algorithm of order $O(n^2)$.

Using the full sample, we establish a single exchange rate regression only to show that there is not a single stable regime and to gain some exploratory insights from the associated fluctuation process.

```
> inr_lm <- fxlm(INR ~ USD + JPY + DUR + GBP + KRW + MYR, data = inr)
```

As we do not expect to be able to draw valid conclusions from the coefficients of a single regression, we do not report the coefficients and rather move on directly to assessing its stability using the associated empirical fluctuation process.

```
> inr_efp <- gefp(inr_lm, fit = NULL)
> plot(inr_efp, aggregate = FALSE, ylim = c(-1.85, 1.85))
```

Its visualization in Figure 1 shows that there is significant instability because two processes (intercept and variance) exceed their 5% level boundaries. More formally, the corresponding double maximum can be performed by

```
> sctest(inr_efp)

        M-fluctuation test

data:  inr_efp
f(efp) = 1.764, p-value = 0.03128
```

This p value is not very small because there seem to be several changes in various parameters. A more suitable test in such a situation would be the Nyblom-Hansen test

```
> sctest(inr_efp, functional = meanL2BB)

        M-fluctuation test

data:  inr_efp
f(efp) = 2.8055, p-value = 0.005
```

However, the multivariate fluctuation process is interesting as a visualization of the changes in the different parameters. The process for the variance σ^2 has the most distinctive shape revealing at least four different regimes: at first, a variance that is lower than the overall average (and hence a decreasing process), then a much larger variance (up to the boundary crossing), a much smaller variance again and finally a period where the variance is roughly the full-sample average. Other interesting processes are the intercept and maybe the USD and DUR. The latter two are not significant but have some peaks revealing a decrease and increase, respectively, in the corresponding coefficients.

To capture this exploratory assessment in a formal way, a dating procedure is conducted for $1, \ldots, 10$ breaks and a minimal segment size of 20 observations.

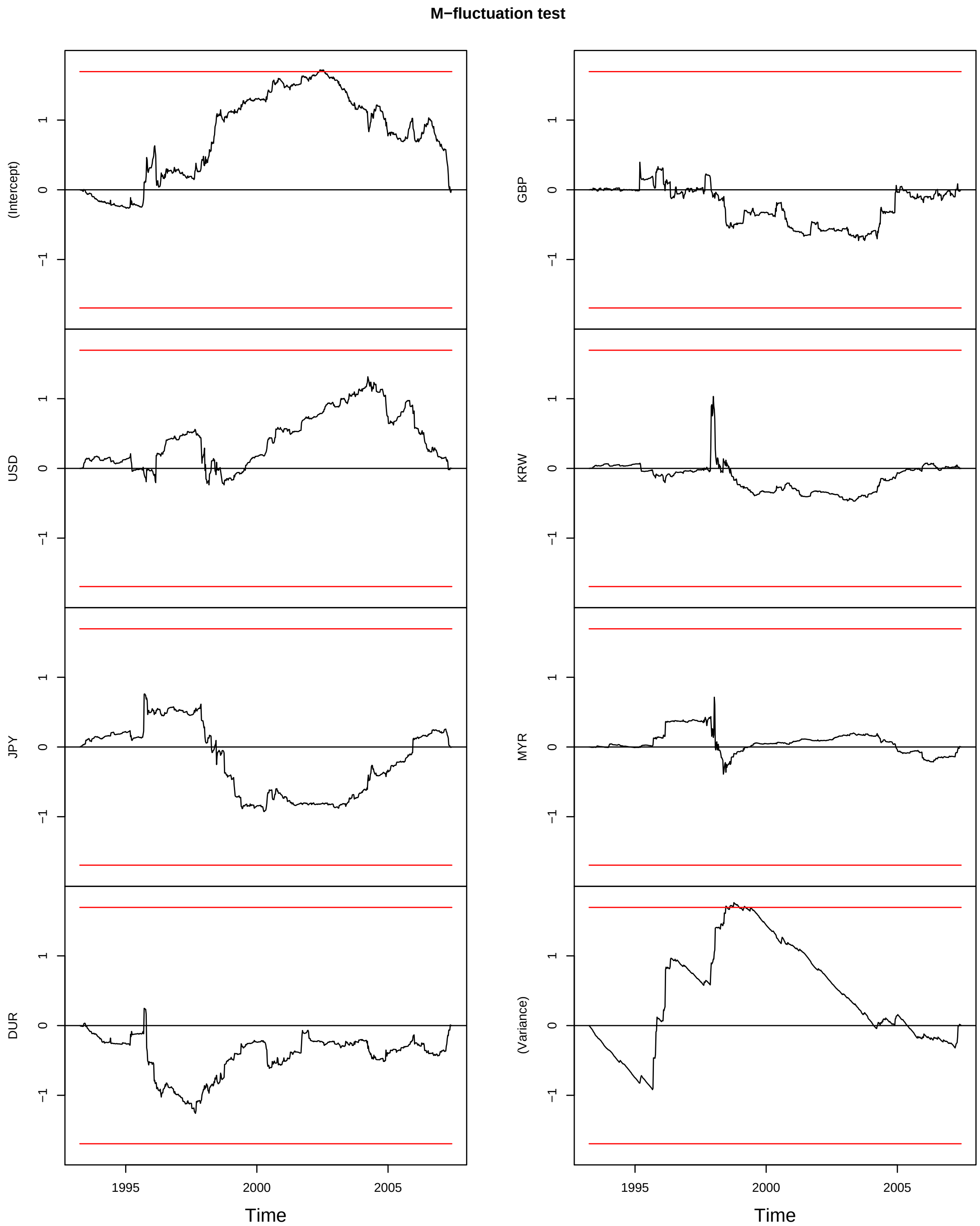

Figure 1: Historical fluctuation process for INR exchange rate regime.

```
> nll <- function(x) -logLik(x)
> inr_reg <- fxregimes(INR ~ USD + JPY + DUR + GBP + KRW + MYR,
+   data = inr, h = 20, breaks = 10, objfun = nll)
```

Using the negative log-likelihood (NLL) as the objective function would be the default in `fxregime()` anyway, however using a more efficient algorithm (based on recursive residuals). This algorithm can only be applied if there are no collinearities in the regressors on every conceivable sub-sample. As this is not the case for some of the currencies under consideration (MYR was closely pegged to USD), a less efficient algorithm needs to be used. As this is too slow to be executed daily on various platforms in CRAN's automatic package checks, we include some results from the segmentation as a binary file in this package. The binary file is contains the `summary()` of the regimes and a list of re-fitted list of "`fxlm`" objects for each of the established sub-samples.

```
> inr_sreg <- summary(inr_reg)
> inr_rf <- refit(inr_reg)
> save(inr_sreg, inr_rf, file = "inr_reg.rda")
```

You can reproduce this file by executing the code printed here, but be aware that this can take a few hours (depending on your machine). Alternatively, you can continue with the our pre-computed results by

```
> load("inr_reg.rda")
```

and then study the summary of the estimated exchange rate regimes for INR. The natural first step is to look at

```
> plot(inr_sreg)
```

producing Figure 2. NLL is decreasing quickly up to 3 breaks with a kink in the slope afterwards. Similarly, LWZ takes its minimum for 3 breaks, choosing a 4-segment model. The corresponding parameter estimates can be queried from the re-fitted models.

```
> t(sapply(inr_rf, coef))
```

```
                        (Intercept)       USD         JPY          DUR
1993-04-09--1995-03-03 -0.006249595 1.0759653 0.020035458  0.009510212
1995-03-10--1998-08-21  0.153852786 0.9099384 0.074880505 -0.019347740
1998-08-28--2004-03-19  0.019356040 0.9656143 0.002544930  0.093362742
2004-03-26--2007-06-08 -0.029085826 0.4115663 0.160248741  0.304020900
                                GBP         KRW         MYR (Variance)
1993-04-09--1995-03-03  0.017401392 -0.08151714 -0.02194627 0.02424687
1995-03-10--1998-08-21  0.042987406  0.07013808 -0.05241711 0.81153210
1998-08-28--2004-03-19 -0.003955259  0.02185899  0.01221856 0.07509131
2004-03-26--2007-06-08  0.081983655  0.14953395  0.26841962 0.29647614
```

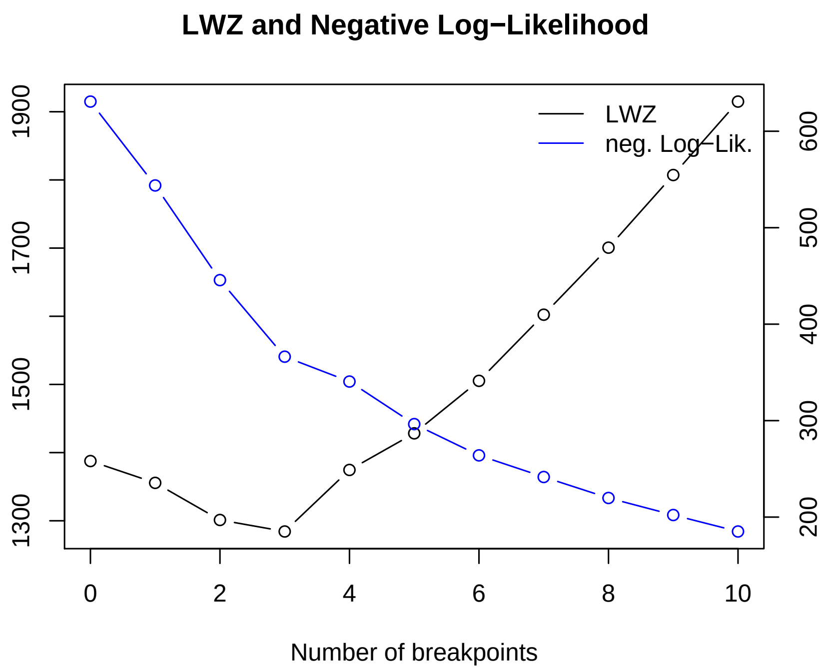

Figure 2: Negative log-likelihood and LWZ information criterion for INR exchange rate regimes.

The most striking observation from the segmented coefficients is that INR was closely pegged to USD up to March 2004 when it shifted to a basket peg in which USD has still the highest weight but considerably less than before. Furthermore, the changes in σ are remarkable, roughly matching the exploratory observations from the empirical fluctuation process. A more detailed look at the full summaries provided below shows that the first period is a clear and tight USD peg. During that time, pressure to appreciate was blocked by purchases of USD by the central bank. The second period, including the time of the East Asian crisis, saw a highly increased flexibility in the exchange rates. Although the Reserve Bank of India (RBI) made public statements about managing volatility on the currency market, the credibility of these statements were low in the eyes of the market. The third period exposes much tighter pegging again with low volatility, some appreciation and some small (but significant) weight on DUR. In the fourth period after March 2004, India moved away from the tight USD peg to a basket peg involving several currencies with greater flexibility (but smaller than in the second period). In this period, reserves in excess of 20% of GDP were held by the RBI, and a modest pace of reserves accumulation has continued.

```
> lapply(inr_rf, summary)

$`1993-04-09--1995-03-03`

Call:
```

```
fxlm(formula = object$formula, data = window(object$data, start = sbp[i],
    end = ebp[i]))

Residuals:
      Min        1Q    Median        3Q       Max
-0.887415 -0.031943  0.004108  0.042578  0.889662

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.00625    0.01653  -0.378    0.706
USD          1.07597    0.08129  13.236   <2e-16 ***
JPY          0.02004    0.01428   1.403    0.164
DUR          0.00951    0.03238   0.294    0.770
GBP          0.01740    0.02486   0.700    0.486
KRW         -0.08152    0.07252  -1.124    0.264
MYR         -0.02195    0.02131  -1.030    0.306
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1615 on 93 degrees of freedom
Multiple R-Squared: 0.9896,       Adjusted R-squared: 0.9889
F-statistic:  1470 on 6 and 93 DF,  p-value: < 2.2e-16


$`1995-03-10--1998-08-21`

Call:
fxlm(formula = object$formula, data = window(object$data, start = sbp[i],
    end = ebp[i]))

Residuals:
    Min      1Q  Median      3Q     Max
-4.9276 -0.3443 -0.1175  0.2225  4.5261

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.15385    0.06950   2.214  0.02815 *
USD          0.90994    0.07418  12.267  < 2e-16 ***
JPY          0.07488    0.04931   1.519  0.13070
DUR         -0.01935    0.15228  -0.127  0.89904
GBP          0.04299    0.07975   0.539  0.59057
KRW          0.07014    0.02446   2.868  0.00465 **
MYR         -0.05242    0.02904  -1.805  0.07285 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9188 on 174 degrees of freedom
```

```
Multiple R-Squared: 0.7423,        Adjusted R-squared: 0.7334
F-statistic: 83.55 on 6 and 174 DF,  p-value: < 2.2e-16


$‘1998-08-28--2004-03-19‘

Call:
fxlm(formula = object$formula, data = window(object$data, start = sbp[i],
    end = ebp[i]))

Residuals:
     Min       1Q   Median       3Q      Max
-0.94754 -0.12374 -0.02370  0.08414  1.11381

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.019356   0.016329   1.185  0.23686
USD          0.965614   0.035275  27.374  < 2e-16 ***
JPY          0.002545   0.011318   0.225  0.82225
DUR          0.093363   0.034126   2.736  0.00661 **
GBP         -0.003955   0.020626  -0.192  0.84807
KRW          0.021859   0.016957   1.289  0.19843
MYR          0.012219   0.028523   0.428  0.66871
---
Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1

Residual standard error: 0.2774 on 284 degrees of freedom
Multiple R-Squared: 0.969,        Adjusted R-squared: 0.9684
F-statistic:  1480 on 6 and 284 DF,  p-value: < 2.2e-16


$‘2004-03-26--2007-06-08‘

Call:
fxlm(formula = object$formula, data = window(object$data, start = sbp[i],
    end = ebp[i]))

Residuals:
     Min       1Q   Median       3Q      Max
-2.27976 -0.27110  0.01281  0.32783  1.44305

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.02909    0.04465  -0.651  0.51572
USD          0.41157    0.13129   3.135  0.00204 **
JPY          0.16025    0.04909   3.264  0.00134 **
DUR          0.30402    0.12560   2.421  0.01661 *
```

```
GBP          0.08198    0.06153   1.332  0.18458
KRW          0.14953    0.06207   2.409  0.01712 *
MYR          0.26842    0.13506   1.987  0.04857 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5562 on 161 degrees of freedom
Multiple R-Squared: 0.8209,        Adjusted R-squared: 0.8142
F-statistic:   123 on 6 and 161 DF,  p-value: < 2.2e-16
```

2 Summary

For the Indian rupee, a 4-segment model is found with a close linkage of INR to USD in the first three periods (with tight/flexible/tight pegging, respectively) before moving to a more flexible basket peg in spring 2004.

The existing literature classifies the INR is a *de facto* pegged exchange rate to the USD in the period after April 1993. The results above show the fine structure of this pegged exchange rate; it supplies dates demarcating the four phases of the exchange rate regime; and it finds that by the fourth period, there was a basket peg in operation.

References

Zeileis A, Shah A, Patnaik I (2007). "Exchange Rate Regime Analysis Using Structural Change Methods." *Report 56*, Department of Statistics and Mathematics, Wirtschaftsuniversität Wien, Research Report Series. URL http://epub.wu-wien.ac.at/.