Regression Analysis: Case Study 2

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1 Linear Regression Models for Exchange Rate Regimes

1.1 Exchange Rate Data

The Federal Reserve Economic Database (FRED) provides historical daily exchange rates of all major currencies in the world.

An R script ("fm_casestudy_fx_1.r") collects these data and stores them in the R workspace "fm_casestudy_fx_1.RData".

The following commands re-load the data and provide details explaining the data.

> # 0.1 Install/load libraries
> source(file="fm_casestudy_0.InstallOrLoadLibraries.r")
> # 0.2 Load R workspace created by script fm_casestudy_fx_1.r
> load(file="fm_casestudy_fx_1.Rdata")
> # 1.0 Extract time series matrix of exchange rates for symbols given by list.symbol0 ----
> list.symbol0<-c("DEXCHUS", "DEXJPUS", "DEXKOUS", "DEXMAUS",
+ "DEXUSEU", "DEXUSUK", "DEXTHUS", "DEXSZUS")
> fxrates000<-fred.fxrates.00[,list.symbol0]
> dim(fxrates000)
[1] 3704 8

> head(fxrates000)

<table>
<thead>
<tr>
<th>DEXCHUS</th>
<th>DEXJPUS</th>
<th>DEXKOUS</th>
<th>DEXMAUS</th>
<th>DEXUSEU</th>
<th>DEXUSUK</th>
<th>DEXTHUS</th>
<th>DEXSZUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-01-04</td>
<td>8.2793</td>
<td>112.15</td>
<td>1187.5</td>
<td>3.8</td>
<td>1.1812</td>
<td>1.6581</td>
<td>36.20</td>
</tr>
<tr>
<td>1999-01-05</td>
<td>8.2795</td>
<td>111.15</td>
<td>1166.0</td>
<td>3.8</td>
<td>1.1760</td>
<td>1.6566</td>
<td>36.18</td>
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<tr>
<td>1999-01-06</td>
<td>8.2795</td>
<td>112.78</td>
<td>1160.0</td>
<td>3.8</td>
<td>1.1636</td>
<td>1.6547</td>
<td>36.50</td>
</tr>
<tr>
<td>1999-01-07</td>
<td>8.2798</td>
<td>111.69</td>
<td>1151.0</td>
<td>3.8</td>
<td>1.1672</td>
<td>1.6495</td>
<td>36.30</td>
</tr>
<tr>
<td>1999-01-08</td>
<td>8.2796</td>
<td>111.52</td>
<td>1174.0</td>
<td>3.8</td>
<td>1.1554</td>
<td>1.6405</td>
<td>36.45</td>
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<tr>
<td>1999-01-11</td>
<td>8.2797</td>
<td>108.83</td>
<td>1175.0</td>
<td>3.8</td>
<td>1.1534</td>
<td>1.6375</td>
<td>36.28</td>
</tr>
</tbody>
</table>

> tail(fxrates000)

<table>
<thead>
<tr>
<th>DEXCHUS</th>
<th>DEXJPUS</th>
<th>DEXKOUS</th>
<th>DEXMAUS</th>
<th>DEXUSEU</th>
<th>DEXUSUK</th>
<th>DEXTHUS</th>
<th>DEXSZUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-09-13</td>
<td>6.1186</td>
<td>99.38</td>
<td>1085.88</td>
<td>3.2880</td>
<td>1.3276</td>
<td>1.5861</td>
<td>31.81</td>
</tr>
<tr>
<td>2013-09-16</td>
<td>6.1198</td>
<td>98.98</td>
<td>1081.34</td>
<td>3.2880</td>
<td>1.3350</td>
<td>1.5927</td>
<td>31.66</td>
</tr>
<tr>
<td>2013-09-17</td>
<td>6.1213</td>
<td>99.16</td>
<td>1082.15</td>
<td>3.2455</td>
<td>1.3357</td>
<td>1.5901</td>
<td>31.68</td>
</tr>
<tr>
<td>2013-09-18</td>
<td>6.1210</td>
<td>99.04</td>
<td>1081.40</td>
<td>3.2320</td>
<td>1.3351</td>
<td>1.5965</td>
<td>31.65</td>
</tr>
<tr>
<td>2013-09-19</td>
<td>6.1210</td>
<td>99.33</td>
<td>1070.88</td>
<td>3.1455</td>
<td>1.3527</td>
<td>1.6043</td>
<td>31.03</td>
</tr>
<tr>
<td>2013-09-20</td>
<td>6.1210</td>
<td>99.38</td>
<td>1076.02</td>
<td>3.1640</td>
<td>1.3522</td>
<td>1.6021</td>
<td>31.04</td>
</tr>
</tbody>
</table>

> # Print symbol/description/units of these rates from data frame fred.fxrates.doc
> options(width=120)
> print(fred.fxrates.doc[match(list.symbol0, fred.fxrates.doc$symbol),
+        c("symbol0", "fx.desc", "fx.units")])

<table>
<thead>
<tr>
<th>symbol0</th>
<th>fx.desc</th>
<th>fx.units</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>DEXCHUS China / U.S. Foreign Exchange Rate</td>
<td>Chinese Yuan to 1 U.S. $</td>
</tr>
<tr>
<td>7</td>
<td>DEXJPUS Japan / U.S. Foreign Exchange Rate</td>
<td>Japanese Yen to 1 U.S. $</td>
</tr>
<tr>
<td>8</td>
<td>DEXKOUS South Korea / U.S. Foreign Exchange Rate</td>
<td>South Korean Won to 1 U.S. $</td>
</tr>
<tr>
<td>9</td>
<td>DEXMAUS Malaysia / U.S. Foreign Exchange Rate</td>
<td>Malaysian Ringgit to 1 U.S. $</td>
</tr>
<tr>
<td>20</td>
<td>DEXUSEU U.S. / Euro Foreign Exchange Rate</td>
<td>U.S. $ to 1 Euro</td>
</tr>
<tr>
<td>22</td>
<td>DEXUSUK U.S. / U.K. Foreign Exchange Rate</td>
<td>U.S. $ to 1 British Pound</td>
</tr>
<tr>
<td>18</td>
<td>DEXTHUS Thailand / U.S. Foreign Exchange Rate</td>
<td>Thai Baht to 1 U.S. $</td>
</tr>
<tr>
<td>16</td>
<td>DEXSZUS Switzerland / U.S. Foreign Exchange Rate</td>
<td>Swiss Francs to 1 U.S. $</td>
</tr>
</tbody>
</table>

> # Plot exchange rate time series in 2x2 panels
> par(mfcol=c(2,2))
> for (j0 in c(1:ncol(fxrates000))){
+    plot(fxrates000[,j0],
+          main=dimnames(fxrates000)[[2]][j0])
+  }
The time series matrix $fxrates$ has data directly from the FRED website.

1.2 Exchange Rate Regimes for the Chinese Yuan

The Chinese Yuan was pegged to the US Dollar prior to July 2005. Then, China announced that the exchange rate would be set with reference to a basket of other currencies, allowing for a movement of up to 0.3% movement within any given day. The actual currencies and their basket weights are unannounced by China.

From an empirical standpoint, there are several important questions

- For any given period, what is the implicit reference basket for the Chinese currency?
- Has the reference basket changed over time?
- Has the Chinese currency depreciated with respect to the dollar?
  If so, how much and when?

Frankel and Wei (1994) detail methodology for evaluating the implicit exchange rate regime of a currency. The approach regresses changes in the target currency on changes in the values of possible currencies in the reference basket.

To apply this methodology we re-express the dollar-based exchange rates using another currency, the Swiss Franc. This allows currency moves of the
dollar to be used to explain moves in the Yuan. The choice of Swiss Franc is consistent with evaluations with respect to a stable, developed-market currency.

1.3 Converting from USD Base to Swiss Franc Base

The following R commands convert the dollar-based rates in *fxrates000* to Swiss-Franc-based rates in *fxrates000.0*

```r
# 2.0 Convert currencies to base rate of DEXSZUS, Swiss Franc
fxrates000.0<-fxrates000
# For exchange rates with 1 U.S. $ in base, divide by DEXSZUS
for (jcol0 in c(1,2,3,4,7)){
  coredata(fxrates000.0)[,jcol0]<- coredata(fxrates000.0[,jcol0])/coredata(fxrates000[,8])
}
# For exchange rates with 1 U.S. $ in numerator, divide inverse by DEXSZUS
for (jcol0 in c(5,6)){
  coredata(fxrates000.0)[,jcol0]<- coredata(1./fxrates000.0[,jcol0])/coredata(fxrates000.0[,8])
}
# For USD, divide $1 by the DEXSZUS rate
dimnames(fxrates000.0)[[2]]
```

```
1.3 Converting from USD Base to Swiss Franc Base

The following R commands convert the dollar-based rates in *fxrates000* to Swiss-Franc-based rates in *fxrates000.0*

```
1.4 Linear Regression Models of Currency Returns

> # 3.0 Compute daily price changes on the log scale
> # Due to missing data, fill in missing values with previous non-NA
> # To check for presence of missing values, execute
> # apply(is.na(fxrates000.0),2,sum)
> # If necessary apply
> # fxrates000.0<-na.locf(fxrates000.0)
> fxrates000.0.logret<-diff(log(fxrates000.0))
> dimnames(fxrates000.0.logret)[[2]]

[1] "CNY_SFR" "YEN_SFR" "WON_SFR" "MYR_SFR" "EUR_SFR" "GBP_SFR" "THB_SFR" "USD_SFR"

> par(mfcol=c(2,2))
> for (j0 in c(1:ncol(fxrates000.0.logret))){
+ plot(fxrates000.0.logret[,j0],
+ main=dimnames(fxrates000.0.logret)[[2]][j0])
+ }

>
First, we fit the regression model for the period prior to July 2005 when the Chinese currency was pegged to the US dollar.

```r
> lmfit.period1<-lm( CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR,
+                   data=window(fxrates000.0.logret,
+                   start=as.Date("2001-01-01"), end=as.Date("2005-06-30"))
+ > summary.lm(lmfit.period1)
```

```
Call:
  lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR,
      data = window(fxrates000.0.logret, start = as.Date("2001-01-01"),
                  end = as.Date("2005-06-30")))

Residuals: 
  Min       1Q   Median       3Q      Max 
-1.086e-03 -1.136e-05  1.500e-07  1.103e-05  1.137e-03 

Coefficients: 
                Estimate Std. Error t value Pr(>|t|) 
(Intercept)    -1.170e-07  2.486e-06  -0.047   0.962     
USD_SFR        1.000e+00  5.440e-04 1838.910  <2e-16     
YEN_SFR        -3.226e-04  4.712e-04  -0.685   0.494     
EUR_SFR        -5.396e-04  1.210e-03  -0.446   0.656     
```
GBP_SFR  -2.183e-05  7.075e-04  -0.031  0.975

Residual standard error: 8.354e-05 on 1126 degrees of freedom
Multiple R-squared: 0.9999,   Adjusted R-squared: 0.9999
F-statistic: 1.894e+06 on 4 and 1126 DF,  p-value: < 2.2e-16

The regression fit identifies the pegging of the Yuan (CNR_SFR) to the US Dollar (USD_SFR). The $R^2$ is nearly 1.0.

Second, we fit the regression model for the first six months following the announcement of the change in currency policy.

```r
> lmfit.period2<-lm( CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
+             WON_SFR + MYR_SFR + THB_SFR,
+             data=window(fxrates000.0.logret,
+             start=as.Date("2005-07-01"), end=as.Date("2005-12-31")))
> summary.lm(lmfit.period2)

Call:
  lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
      WON_SFR + MYR_SFR + THB_SFR, data = window(fxrates000.0.logret,
      start = as.Date("2005-07-01"), end = as.Date("2005-12-31")))

Residuals:
        Min       1Q   Median       3Q      Max
-0.0132690 -0.0004520  0.0000850  0.0005842  0.0032820

Coefficients:                  Estimate  Std. Error   t value   Pr(>|t|)
(Intercept)            -0.0001198   0.0001382  -0.867  0.387
USD_SFR                0.1948616   0.1528495   1.275  0.205
YEN_SFR                -0.0082667   0.0381872  -0.216  0.829
EUR_SFR                 0.0697740   0.0937341   0.744  0.458
GBP_SFR                 -0.0255185   0.0455883  -0.560  0.577
WON_SFR                 0.1785894   0.0362880   4.921 2.84e-06
MYR_SFR                 0.7526919   0.1471344   5.116 1.24e-06
THB_SFR                 -0.0693646   0.0609775  -1.138  0.258

Residual standard error: 0.001522 on 117 degrees of freedom
Multiple R-squared: 0.9491,   Adjusted R-squared: 0.946
F-statistic: 311.4 on 7 and 117 DF,  p-value: < 2.2e-16

During this six-month period, there is evidence of the Yuan departing from a US Dollar peg. The exchange rates with the statistically significant regression parameters are for the Korean Won (WON_SFR) and the Malaysian Ringgit (MYR_SFR).

To examine for further changes in the implicit reference basket, we fit the same model for the annual periods from 2006 through 2012 and for the first 6 months of 2013.
> for (year0 in as.character(c(2006:2013))){
  # year0<="2012"
  lmfit.year0<-lm( CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
                   WON_SFR + MYR_SFR + THB_SFR,
                   data=fxrates000.0.logret[year0])
  cat("\n\n--------------------------------
");cat(year0);cat(":
")
  print(summary.lm(lmfit.year0))
  cat("\nrate.appreciation.usd<-round( exp(252*log(1+ lmfit.year0$coefficients[1])) -1,digits=3)
  cat("\n"); cat(year0); cat(" Annualized appreciation rate to implied reference basket:"); cat(rate.appreciation.usd); cat(" 
"")
+ }

--------------------------------

2006:

Call:
  lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
      WON_SFR + MYR_SFR + THB_SFR, data = fxrates000.0.logret[year0])

Residuals:
   Min     1Q   Median     3Q    Max
-2.413e-03 -2.625e-04  5.131e-05  3.899e-04  2.504e-03

Coefficients:  Estimate Std. Error t value Pr(>|t|)
(Intercept)  -1.173e-04  4.228e-05  -2.773  0.005979
USD_SFR      9.222e-01  1.859e-02   49.614 < 2e-16
YEN_SFR     -5.226e-03  1.121e-02  -0.466  0.641520
EUR_SFR     -1.841e-02  2.927e-02  -0.629  0.529985
GBP_SFR     -1.693e-02  1.695e-02  -0.999  0.318732
WON_SFR      2.906e-02  1.201e-02   2.420  0.016245
MYR_SFR     6.909e-02  1.904e-02   3.628  0.000348
THB_SFR    -8.371e-03  1.100e-02  -0.761  0.447360

Residual standard error: 0.0006512 on 243 degrees of freedom
Multiple R-squared: 0.9866,    Adjusted R-squared: 0.9862
F-statistic: 2553 on 7 and 243 DF,  p-value: < 2.2e-16

2006 Annualized appreciation rate to implied reference basket: -0.029

--------------------------------

2007:

Call:
lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
    WON_SFR + MYR_SFR + THB_SFR, data = fxrates000.0.logret[year0])

Residuals:
          Min       1Q   Median       3Q      Max
-0.0043388 -0.0006900  0.0001165  0.0006523  0.0035492

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept) -2.477e-04    7.111e-05  -3.484  0.000585
USD_SFR     9.201e-01    3.655e-02  25.172 < 2e-16
YEN_SFR    -1.847e-02    1.774e-02  -1.041  0.298850
EUR_SFR     1.629e-02    4.971e-02   0.328  0.743357
GBP_SFR     4.861e-03    2.268e-02   0.214  0.830452
WON_SFR     2.148e-02    2.709e-02   0.793  0.428514
MYR_SFR     1.227e-02    2.907e-02   0.422  0.673389
THB_SFR     1.411e-03    8.770e-03   0.161  0.872287

Residual standard error: 0.001109 on 246 degrees of freedom
Multiple R-squared: 0.9332, Adjusted R-squared: 0.9313
F-statistic: 491.2 on 7 and 246 DF, p-value: < 2.2e-16

2007       Annualized appreciation rate to implied reference basket: -0.061

--------------------------------

2008:

Call:
  lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
  WON_SFR + MYR_SFR + THB_SFR, data = fxrates000.0.logret[year0])

Residuals:
          Min       1Q   Median       3Q      Max
-0.0103217 -0.0008105  0.0001620  0.0007503  0.0098093

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.0002996    0.0001222  -2.452  0.01492
USD_SFR     0.9124811    0.0369556  24.691 < 2e-16
YEN_SFR    -0.0010178    0.0173259  -0.059  0.95320
EUR_SFR     0.0415111    0.0342314   1.213  0.22643
GBP_SFR     0.0163507    0.0193508   0.845  0.39896
WON_SFR    -0.0192298    0.0073131  -2.629  0.00909
MYR_SFR     0.0739607    0.0307166   2.408  0.01679

11
2008 Annualized appreciation rate to implied reference basket: -0.073

2009:

Call:

\[
\text{lm(formula = CNY\_SFR ~ USD\_SFR + YEN\_SFR + EUR\_SFR + GBP\_SFR + \\
WON\_SFR + MYR\_SFR + THB\_SFR, data = fxrates000.0.logret[year0])}
\]

Residuals:

<table>
<thead>
<tr>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.994e-03</td>
<td>-1.400e-04</td>
<td>1.770e-06</td>
<td>1.305e-04</td>
<td>1.221e-03</td>
</tr>
</tbody>
</table>

Coefficients:

|                      | Estimate | Std. Error | t value | Pr(>|t|) |
|----------------------|----------|------------|---------|----------|
| (Intercept)          | 7.771e-06| 2.176e-05  | 0.357   | 0.721273 |
| USD\_SFR             | 9.405e-01| 9.676e-03  | 97.201  | < 2e-16  |
| YEN\_SFR             | 5.974e-03| 2.960e-03  | 2.018   | 0.044641 |
| EUR\_SFR             | -1.549e-02| 6.958e-03| -2.227  | 0.026879 |
| GBP\_SFR             | 4.148e-03| 3.014e-03  | 1.376   | 0.170055 |
| WON\_SFR             | -1.672e-03| 2.669e-03| -0.626  | 0.531606 |
| MYR\_SFR             | 2.530e-02| 6.950e-03  | 3.640   | 0.000333 |
| THB\_SFR             | 3.102e-02| 1.239e-02  | 2.504   | 0.012946 |

Residual standard error: 0.0003438 on 244 degrees of freedom
Multiple R-squared: 0.9984, Adjusted R-squared: 0.9983
F-statistic: 2.165e+04 on 7 and 244 DF, p-value: < 2.2e-16

2009 Annualized appreciation rate to implied reference basket: 0.002

2010:

Call:

\[
\text{lm(formula = CNY\_SFR ~ USD\_SFR + YEN\_SFR + EUR\_SFR + GBP\_SFR + \\
WON\_SFR + MYR\_SFR + THB\_SFR, data = fxrates000.0.logret[year0])}
\]
Residuals:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.0051398</td>
<td>-0.0002402</td>
<td>0.0000951</td>
<td>0.0003745</td>
<td>0.0036134</td>
</tr>
</tbody>
</table>

Coefficients:

|                | Estimate | Std. Error | t value | Pr(>|t|) |
|----------------|----------|------------|---------|----------|
| (Intercept)    | -9.527e-05 | 6.374e-05  | -1.495  | 0.1363   |
| USD_SFR        | 9.116e-01  | 3.078e-02  | 29.613  | <2e-16   |
| YEN_SFR        | 1.170e-03  | 1.048e-02  | 0.112   | 0.9112   |
| EUR_SFR        | 2.072e-02  | 1.441e-02  | 1.439   | 0.1516   |
| GBP_SFR        | -3.160e-02 | 1.248e-02  | -2.532  | 0.0120   |
| WON_SFR        | 2.656e-03  | 1.066e-02  | 0.249   | 0.8035   |
| MYR_SFR        | 2.359e-02  | 1.081e-02  | 1.310   | 0.1915   |
| THB_SFR        | 6.507e-02  | 3.372e-02  | 1.930   | 0.0548   |

Residual standard error: 0.0009746 on 242 degrees of freedom
Multiple R-squared: 0.9805, Adjusted R-squared: 0.9799
F-statistic: 1739 on 7 and 242 DF, p-value: < 2.2e-16

2010 Annualized appreciation rate to implied reference basket: -0.024

2011:

Call:

```
lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
    WON_SFR + MYR_SFR + THB_SFR, data = fxrates000.0.logret[year0])
```

Residuals:

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.0048725</td>
<td>-0.0005380</td>
<td>0.0000138</td>
<td>0.0005746</td>
<td>0.0061446</td>
</tr>
</tbody>
</table>

Coefficients:

|                | Estimate | Std. Error | t value | Pr(>|t|) |
|----------------|----------|------------|---------|----------|
| (Intercept)    | -1.968e-04 | 8.079e-05  | -2.436  | 0.0156   |
| USD_SFR        | 8.702e-01  | 2.834e-02  | 30.705  | <2e-16   |
| YEN_SFR        | 7.857e-03  | 1.519e-02  | 0.517   | 0.6054   |
| EUR_SFR        | -3.959e-04 | 1.670e-02  | -0.024  | 0.9811   |
| GBP_SFR        | 4.297e-02  | 2.092e-02  | 2.054   | 0.0410   |
| WON_SFR        | -2.590e-02 | 1.696e-02  | -1.527  | 0.1281   |
| MYR_SFR        | 9.535e-02  | 2.351e-02  | 4.056   | 6.73e-05 |
| THB_SFR        | 1.743e-02  | 3.329e-02  | 0.523   | 0.6011   |
Residual standard error: 0.001275 on 243 degrees of freedom
Multiple R-squared: 0.9837, Adjusted R-squared: 0.9832
F-statistic: 2097 on 7 and 243 DF, p-value: < 2.2e-16

2011
Annualized appreciation rate to implied reference basket: -0.048

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2012:

Call:
  lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
      WON_SFR + MYR_SFR + THB_SFR, data = fxrates000.0.logret[year0])

Residuals:
       Min      1Q  Median      3Q     Max
-0.0042900 -0.0003965  0.0000060  0.0004424  0.0044475

Coefficients:
                          Estimate  Std. Error   t value Pr(>|t|)
(Intercept)            -1.951e-05   6.105e-05   -0.320   0.7495
USD_SFR                 9.064e-01   2.669e-02   33.957  < 2e-16
YEN_SFR                -5.759e-03   1.323e-02   -0.435   0.6637
EUR_SFR                -1.320e-01   5.985e-02   -2.205   0.0284
GBP_SFR                -8.758e-03   2.132e-02   -0.411   0.6816
WON_SFR                 1.777e-03   2.282e-02    0.078   0.9380
MYR_SFR                 1.103e-01   2.216e-02    4.979  1.21e-06
THB_SFR                 1.895e-03   2.880e-02    0.066   0.9476

Residual standard error: 0.0009568 on 243 degrees of freedom
Multiple R-squared: 0.9711, Adjusted R-squared: 0.9702
F-statistic: 1165 on 7 and 243 DF, p-value: < 2.2e-16

2012
Annualized appreciation rate to implied reference basket: -0.005

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2013:

Call:
  lm(formula = CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
      WON_SFR + MYR_SFR + THB_SFR, data = fxrates000.0.logret[year0])

Residuals:
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<th>Min</th>
<th>1Q</th>
<th>Median</th>
<th>3Q</th>
<th>Max</th>
</tr>
</thead>
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<td>-3.606e-04</td>
<td>2.782e-05</td>
<td>3.593e-04</td>
<td>2.042e-03</td>
</tr>
</tbody>
</table>

Coefficients:

|                      | Estimate | Std. Error | t value | Pr(>|t|) |
|----------------------|----------|------------|---------|----------|
| (Intercept)          | -1.040e-04 | 4.941e-05  | -2.106  | 0.03666  |
| USD_SFR              | 9.679e-01  | 1.596e-02  | 60.655  | < 2e-16  |
| YEN_SFR              | 9.051e-03  | 7.594e-03  | 1.192   | 0.23492  |
| EUR_SFR              | 1.581e-02  | 2.138e-02  | 0.740   | 0.46056  |
| GBP_SFR              | -3.526e-03 | 1.366e-02  | -0.258  | 0.79658  |
| WON_SFR              | 3.770e-02  | 1.316e-02  | 2.864   | 0.00469  |
| MYR_SFR              | 4.628e-05  | 1.313e-02  | 0.004   | 0.99719  |
| THB_SFR              | -1.033e-03 | 1.460e-02  | -0.071  | 0.94364  |

Residual standard error: 0.0006637 on 175 degrees of freedom  
Multiple R-squared: 0.9891, Adjusted R-squared: 0.9886  
F-statistic: 2263 on 7 and 175 DF, p-value: < 2.2e-16

2013 Annualized appreciation rate to implied reference basket: -0.026

From these annual results we note:

- These fitted regression models demonstrate that the statistical evidence for the underlying reference basket of currencies changes from year to year.
- Note how the different exchange rates are significant predictors of the daily change in the Yuan exchange rate for different years.
- The computations include a measure of the annualized trend in the Yuan exchange rate relative to the other currencies. Notice that this rate is negative, to varying degrees over the seven-plus years.

We illustrate some additional features of exchange rate regime modelling using the reference basket implied by the data for 2012.

First, we plot the currency returns for the Yuan and all currencies included in the analysis.

```r
> year0<"2012"
> par(mfcol=c(1,1))
> ts.plot(cumsum(fxrates000.0.logret["2012"], col=rainbow(NCOL(fxrates000.0.logret)), +
> main="2012 Currency Returns")
> legend(x=150, y=.15, legend=dimnames(fxrates000.0.logret)[[2]], lty=rep(1,times=ncol(fxrates000.0.logret)), col=rainbow(NCOL(fxrates000.0.logret)), cex=0.70)
```
Then, we plot the currency return of the Yuan and that of the implied reference basket specified by the regression:

```r
> lmfit.year0<-lm( CNY_SFR ~ USD_SFR + YEN_SFR + EUR_SFR + GBP_SFR +
+ WON_SFR + MYR_SFR + THB_SFR,
+ data=fxrates000.0.logret[year0])
> y0.actual<-fxrates000.0.logret["2012"][,"CNY_SFR"]
> y0.fit<-y0.actual - lmfit.year0$residuals
> ts.plot(cumsum(cbind(y0.actual, y0.fit)),
+ col=rainbow(NCOL(fxrates000.0.logret))[c(1,5)],
+ main="2012 Currency Returns \nCNY_SFR and Implied Basket")
```
Note how closely the reference basket tracks the Yuan. This is to be expected given the high $R^2$ of the regression.

Finally, we apply the R function `influence.measures()`

```r
> layout(matrix(c(1,2,3,4),2,2)) # optional 4 graphs/page
> plot(lmfit.year0)
```
These diagnostics indicate:

- The residuals appear well-behaved as they relate to the size of the fitted values. The residual variance does not increase with the magnitude of the fitted values.

- The residuals exhibit heavier tails than those of a normal distribution. However for those residuals within two standard deviations of their mean, their distribution is close to that of a normal distribution.
References

