Market microstructure approach to the exchange rate determination puzzle

Prepared by T M Mokoena, Research Department, South African Reserve Bank
R Gupta, and R van Eyden, University of Pretoria

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Abstract

The market microstructure approach has been applied to the three major puzzles of exchange rate economics: The forward bias puzzle, the excess volatility puzzle, and the exchange rate determination puzzle. It claims that the imbalances between "buyer-initiated and seller-initiated trades" in foreign-exchange markets are indicative of the transmission link between exchange rates and fundamental determinants of exchange rates. In the context of the exchange rate determination puzzle, this paper discusses the market microstructure approach from the viewpoint of hybrid models that integrate order flow, fundamentals and non-fundamental variables to establish the determinants of the rand-dollar exchange rate. Among the non-fundamentals considered is the *Economist* commodity price index, the relevance of which is based on Chen and Rogoff (2002). Another non-fundamental variable is a proxy for country risk – the differential between the Emerging Market Bond Index Global and the South African long-term bond.

The paper relies on the autoregressive distributed lag (ARDL) model of Persaran, Shin and Smith (2001) as also explained in Persaran and Persaran (1997). The ARDL approach to cointegration does not require pre-testing of the integration properties of the individual series used in the empirical analysis. Instead, it relies on a bounds-testing procedure. In this setting, inference is based on an F-test on the significance of lagged levels of variables in the error-correction form. The results, based on the Schwarz Bayesian Criterion for choosing a model's lag length, show that the there is a long-run relationship between the rand-dollar real exchange rate, the fundamentals, non-fundamental variables and the proxy for order flow, which is the dollar-denominated daily net turnover on the South African markets.

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Corresponding author's e-mail address: thabo.mokoena@resbank.co.za

Introduction

The market microstructure approach has been applied to the three major puzzles of exchange rate economics: The forward bias puzzle, the excess volatility puzzle, and the exchange rate determination puzzle. The details of how the microstructure approach addresses the first two puzzles are found in Chapter 7 of Lyons (2001). In this paper the focus is on the market microstructure approach to the exchange rate determination puzzle. The exchange rate determination puzzle is as follows: In the short run there seems to be no reliable determinants of exchange rates such that there is a disconnect between economic fundamentals and the exchange rate. In point of fact, Meese and Rogoff (1983) found that the out-of-sample performance of fundamentals-based monetary models have been unable to outperform a random walk model. This is problematic for the simple reason that a random walk cannot possibly be regarded as an economic model.

This finding has remained largely robust ever since. In a survey, Frankel and Rose (1995) concluded that no model based on standard fundamentals such as money supplies, real income, interest rates, inflation rates, and current-account balances would succeed in predicting a high percentage of the variation in the exchange rate with short or medium-term frequencies. Moreover, Evans and Lyons (1999) have pointed out that the main weaknesses of the fundamentals-based models are that these models assume that all information relevant for exchange rate determination is common knowledge and that the transmission from that information to equilibrium prices is also common knowledge.

In some economic models regarding South Africa, an expansionary monetary policy is supposed to raise domestic demand while lowering the exchange value of the rand. This implies the existence of a correlation between exchange rate changes and business-cycle expansions and contractions. However, in real life, it is debatable whether such a strong relationship exists. For instance, Fedderke and Flamand (2005) examine the question of whether unanticipated macroeconomic news-- based on the fundamentals such as CPI inflation rates, industrial production, and interest rates – can account for the volatility of the rand/dollar exchange rate between June 2001 and June 2004. The authors found asymmetries in the relationship between news and exchange rate movements, especially with regard to the way the US news events impact on the exchange rate. They pointed out that there was little evidence of South African news having any significant impact on the daily rand/dollar rate. In addition, they found that good news appeared to impact the exchange rate statistically more strongly than bad news and that the impact of news events was time-varying. The news events that impacted on the markets change over time, suggesting that traders at any given time put more weight to some specific variables rather than all potentially relevant news. It should be pointed out that the adjusted R^2 for all the reported results was less than 0,026.

Moreover, in an unpublished South African Reserve Bank Discussion Paper concerning the relationship between exchange rate volatility and exports, Todani and Munyama (2006) found a statistically insignificant relationship between South African export flows and exchange rate volatility.

With this evidence in mind, it nevertheless seems implausible that, for instance, central bankers' large data sets on economic fundamentals, as well as their understanding of the state of the economy, can be considered useless information when forecasting future movements of exchange rates over relatively short intervals. In their defence of the relevance of fundamentals, Sarno and Valente (2005) argue that it is likely that exchange rate models perform poorly not because the information in the fundamentals is deficient, but "because volatile expectations or departures from rationality are likely to account for the failure of exchange rate models." Consistent with this line of reasoning, Frankel (1999) argues that exchange rates are detached from fundamentals because of the volatility of expectations about the expected changes of the exchange rate. In essence, these authors ague that it is the expectations that are responsible for the disconnection.

The poor explanatory power of macro-based models, coupled with the empirical evidence that microstructural aspects of the functioning of financial markets are a significant consideration in explaining short-term movements, have swayed the attention of economists toward what has been termed "order flow" in foreign-exchange markets. In fact, order flow constitutes the mainstay of the market microstructure approach to the exchange rate puzzles. Order flow, as defined by

Vitale (2006), is the difference between buyer-initiated and seller-initiated orders in a securities market.

The market microstructure approach has gained popularity because it recognises that, in the short run, any news associated with macroeconomic variables has an impact on the exchange rates. In other words, the arrival of news condition market expectations of future values of the exchange rate fundamentals, leading to immediate reactions by the markets in anticipation of possible shifts in the fundamentals. In this context, the market microstructure approach claims that the imbalances between "buyer-initiated and seller-initiated trades" in foreign-exchange markets are indicative of the transmission link between exchange rates and fundamental determinants of exchange rates (Vitale, 2006).

To reinforce the usefulness of the microstructure approach, Love and Payne (2002) utilise 10 months of transaction-level exchange rate data on the dollar-euro, pound-euro and dollar-pound exchange rates and data on the euro area to test whether announcement surprises have a systematic and significant effect on both the order flow and prices. They find that at a one-minute sampling frequency, macroeconomic data releases have systematic effects on order flow and exchange rate transaction prices. Their results show that the release of positive news tends to lead to exchange rate appreciation and that order flow tends to be positive, reflecting excessive buying pressure relative to aggressive selling. Furthermore, Love and Payne (2002) show that in periods just after announcements on macroeconomic issues, the significance of order flow in exchange rate determination is much greater than in normal times. The results suggest that between 50 and 66 per cent of the final price reaction to news comes via this order flow mechanism.

With regard to the relationship between macro-based models and microstructure approaches, the authors conclude as follows:

> Within the context of exchange rate determination our results suggest that the recent distinctions drawn between macroeconomic and microstructure models are not clear cut; the modelling of exchange rates should incorporate both elements of macro and microstructure. Further effort needs to be expended on theoretical and empirical work to merge the two sides of exchange rate determination in an attempt to more accurately explain how exchange rates are determined. (Love and Payne, 2002: 2-3).

Another relevant study supportive of the microstructure approach is by Danielsson, Payne and Luo (2002), who assess the forecasting ability of the order flows in forecasting exchange rates. The authors use the Meese and Rogoff (1983) framework[1] to establish whether the order flow model yields a better forecast in mean square error terms than does a random walk model. The authors find that the order flow model passes the Meese–Rogoff test that macroeconomic models have failed.

The above analysis suggests that while a microstructure approach represents a clear paradigm shift, it cannot substitute the fundamentals-based monetary models. In fact, Evans and Lyons, who are at the vanguard of the microstructure frontier, emphatically clarify this point as follows:

> Note that order flow being a proximate determinant of exchange rates does not preclude macro fundamentals from being the underlying determinant. Macro fundamentals in exchange rate equations may be so imprecisely measured that order-flow provides a better "proxy" of their variation. This interpretation of order flow as a proxy for macro fundamentals is particularly plausible with respect to expectations: standard empirical measures of expected future fundamentals are obviously imprecise. Orders, on the other hand, reflect a willingness to back one's beliefs with real money (unlike survey-based measures of expectations). Measuring order flow under this interpretation is akin to counting the backed-by-money expectational votes (Evans and Lyons, 1999:5).

In a recent paper, Abhyankar, Sarno and Valente (2004) investigate the ability of a monetary-fundamentals model to predict exchange rates by measuring the economic value to an investor who relies on the model to allocate wealth between two assets that are identical in all respects except the currency of denomination. The novelty of the authors' analysis is that they avoid the statistical measures such as mean-square error in determining the forecasting ability of models. The authors wished to determine how the exchange rate predictability affected optimal portfolio choice for investors with a range of horizons up to ten years. In addition, they aimed to establish whether there was any *additional economic value* to a utility-maximizing investor who used exchange rate forecasts from a monetary-fundamentals model relative to an investor who used forecasts from a naive random walk model. They quantified the economic value of predictability in a Bayesian framework that allowed them to account for uncertainty surrounding parameter estimates in the forecasting model. Abhyankar, Sarno and Valente (2004) found that exchange rate predictability substantially affects the choice between domestic and foreign assets for all

[1] See Rossi (2005) for the details of the Meese-Rogoff framework.

currencies and across different levels of risk aversion. Specifically, the authors emphatically point out that “the exchange rate predictability can generate optimal weights to the foreign asset that are substantially different from the optimal weights generated under a random walk model.” Moreover, the main result was that they found evidence of economic value to exchange rate predictability across all exchange rates. They conclude that they regard their “findings as suggesting that the case against the predictive power of monetary fundamentals may be overstated.”

1 Basic model

This leads to the methodological issues pertaining to microstructure modelling. Evans (2001) develops a hybrid model that combines micro and macro fundamentals as follows:

$$\Delta S_t = f(i,m,o) + g(X,I,Z) \tag{1}$$

where the function $f(i,m,o)$ denotes the macro component of the model, $g(X,I,Z)$ is the microstructure component, and ΔS_t represents the change in the exchange rate. The main variables in the function $f(i,m,o)$ include current and past values of home and foreign nominal interest rates, money supply m, and other macro determinants o. In the function $g(X,I,Z)$ there is the order flow X, a measure of dealer net positions I, and other microdeterminants, denoted by Z. Lyons (2001) notes that $f(i,m,o)$ and $g(X,I,Z)$ depend on the current and past values of their determinants as well as on expectations of determinants’ future values, suggesting that rational markets are forward looking.

When they use the hybrid model, the authors report that their model explains more than 60 per cent of the daily changes in the log of the exchange rate between the Deutsche mark and the United States of America (US) dollar and more than 40 per cent of the daily variations of the log of the exchange rate between the Japanese yen and the US dollar. They also argue that their analysis bridges the gap between previous work on market microstructure, which utilises data transaction by transaction, and the macroeconomic studies utilising monthly data.

An apposite question facing the microstructure approach is whether causality runs strictly from order flow to the exchange rate, rather than in both directions. According to Lyons (2001), causality runs strictly from order flow to price. This observation is based on the study by Killieen, Lyons and Moore (2004) in which the authors test this by estimating the error-correction term in both the exchange rate and order flow equations. They find that the error-correction term to be significant in the exchange rate equation, whereas the error-correction term in the order flow equation was found to be insignificant, implying that the adjustment to long-run equilibrium occurred via the exchange rate. The appropriate conclusion is that order flow is weakly exogenous, meaning it must at least appear on the right-hand side of an exchange rate model.

2 Hybrid regression models

This paper tests empirically the Lyons (2001) model and its variants in the South African foreign-exchange market context. This model is tested on the exchange rate between the South African rand and the US dollar. In particular, a country-risk-augmented and commodity-price index-augmented specification is tested that might add explanatory power to the original model.

The basic test regression takes the following form:

$$\Delta s_t = a_1 \Delta(i_t - i_t^*) + a_2 \Delta x_t + e_t \qquad (2)$$

where Δs_t is the log of exchange rate change, $\Delta(i_t - i_t^*)$ denotes changes in interest rate differentials, a_1 and a_2 are regression parameters, Δx is the order flow, and the subscript t refers to time. From the viewpoint of the sticky price model, the coefficient a_1 is expected to be negative, because an increase in the foreign interest rate i^* requires an immediate increase in the exchange rate to compensate for the depreciation caused by the uncovered interest parity. The coefficient a_2 is also expected to have a negative sign, indicating that net purchases of foreign currency result in a higher price of the domestic currency in terms of the foreign currency.

An important difference between the present study and that of Evans and Lyons (1999) is that the order flow variable used in this paper is the net average daily turnover of foreign-currency exchange transactions in the South African market in dollar terms,[2] whereas in the Evans and Lyons study order flow is based on the net quantity of foreign-exchange transactions. The reason why the transactions monetary flow was adopted in stead of the number of transactions is simply because of the absence of transactions data in the public domain. It is necessary, nonetheless, to point out that preliminary regressions suggested that the transaction money volumes were statistically significant as a measure of the demand and supply pressures for dollar-denominated transactions.

2.1 **Commodity-price-augmented exchange rate model**

The relevance of links between commodity prices to exchange rate determination has been discussed in detail by Chen and Rogoff (2002). The study was based on the recognition that for Australia, Canada and New Zealand, primary commodities constitute a significant component of exports. It was therefore likely that world commodity price movements could potentially explain a major component of their terms-of-trade fluctuations and exchange rates.[3]

This above analysis suggests the following test regression:

$$\Delta s_t = a_1 \Delta(i_t - i_t^*) + a_2 \Delta x_t + a_3 com_t + e_t , \qquad (3)$$

where com signifies the *Economist* commodity price index.

2.2 **Country-risk-augmented exchange rate model**

[2] See Table S-101 in the *Quarterly Bulletin* of the South African Reserve Bank.

[3] In the case of South Africa, the relevance of the Australian dollar against the US dollar to the rand-dollar exchange rate was observed by Merrill Lynch (2003). Also, according to Merrill Lynch (2004), the Reserve Bank of Australia has found that the Australian dollar can best be determined using the terms of trade (basically commodity prices) as the main explanatory variable.

Traditional exchange rate models assume risk neutrality. As a result, non-fundamental risk-related variables are excluded from those models. If investors are indeed risk averse, as is usually the case, it becomes necessary to take into account the premium that compensates investors for the risk of holding assets in foreign currency. In this setting, a country risk premium serves to compensate the investor for "emerging-market grouping" and other movements that may affect dollar-denominated returns to investment.

This suggests the following model:

$$\Delta s_t = a_1 \Delta(i_t - i_t^{*}) + a_2 \Delta x_t + a_3 com_t + a_4 risk_t + e_t \tag{4}$$

3 Econometric issues and data analysis

The study utilises the autoregressive distributed lag model (ARDL) of Persaran, Shin and Smith (2001) as also explained by Persaran and Persaran (1997). The ARDL approach to cointegration, which does not require pre-testing for the integration properties of the individual series used in the empirical analysis, relies on a bounds testing procedure. Formally, the ARDL model takes the following form:

$$\left[1 - \sum_{i=1}^{p} \theta_i L^{i}\right] y_t = \sum_{i=1}^{k} \beta_i (L, q_i) x_{it} + \boldsymbol{\delta}'\mathbf{z} + \varepsilon_{\mathbf{t}}, \tag{5}$$

where $\beta_i (L, q_i) = \beta_{i0} + \beta_{i1} L + ... + \beta_{iq} L^{qi}$ for $i = 1,2,...,k$, L is a lag operator such that $Ly_t = y_{t-1}$ and $\mathbf{z_t}$ are vectors of exogenous variables with fixed lags and/or deterministic variables such as time trends and an intercept term.

The error-correction representation takes the following form:

$$\Delta y_t = \sum_{i=1}^{k} \beta_{i0} \Delta x_{it} + \varphi' \mathbf{\Delta z_t} - \sum_{j=1}^{p-1} \gamma \Delta y_{i,t-j} - \phi(1, \hat{p}) EC_{t-1}$$
$$- \sum_{i=1}^{k} \sum_{j=1}^{\hat{q}_i - 1} \lambda \Delta x_{i,t-j} + \varepsilon_t \tag{6}$$

where the error-correction term is given by $EC_t = \left[y_t - \sum^{k} \hat{\theta}_i x_{it} - \Psi' z_t \right]$ and $\phi(1, p) = 1 - \sum_{i=1}^{p} \hat{\phi}_i$ measures the quantitative significance of the error-correction term. The coefficients γ and λ determine the short-run dynamics of the model's convergence to equilibrium.

As a first step, the econometrician determines the lag length of the model. This is done by estimating the model with and without the deterministic trend and the appropriate lag is selected on the basis of the Akaike Information Criterion (AIC), the Schwarz Bayesian Information Criterion (SBC) or the Lagrange Multiplier (LM) test. The author prefers the SBC as recommended by Persaran and Persaran (1997).

The second step is to test the existence of a long-run relationship between the variables. Essentially, the researcher must conduct an F-test on the significance of lagged levels of variables in the error-correction form. As explained in Persaran and Persaran (1997), the F-distribution is non-standard irrespective of the integration order of the variables. Inference is based on the following algorithm:

- The calculated F-statistic is compared with the critical values tabulated by Pesaran, Shin and Smith (2001).
- If the calculated F-statistic *falls above* the upper boundary, then the researcher can draw the conclusion that there exists a long-run relationship, without knowing the order of integration in the underlying variables.
- If the calculated F-statistic_falls below the lower bound, the researcher cannot reject the null hypothesis of no cointegration.
- If the calculated F-statistic falls between the critical value boundaries, the result is inconclusive. In this case, the researcher may have to test the order of integration of the underlying variables by using the standard unit root techniques.

The dependent variable is the log level of the South African rand/US dollar real exchange rate, denoted RAND. Denote the "forcing" variables included in Equation

(4) in vector form as $x_t = [USSA, TURN]'$ and let the exogenous variables be $z_t = [COMM, EMB, TIME, ITN]'$

The variables are described as follows:

$USSA =$ The short-term interest rate differential between the US and South African interest rates;

$TURN =$ the dollar-denominated net average daily turnover on the South African foreign-exchange market or the South African Reserve Bank's *Quarterly Bulletin* time series number 5478M appearing in Table S101;

$COMM =$ *Economist* commodity price index in dollar terms;

$EMB =$ the spread between South Africa's dollar-denominated bonds and the Emerging Market Bond Index Global, which is used as a measure of country risk;

$TIME =$ time trend; and

$ITN =$ intercept term.

The following are the error-correction model results using *Microfit* software:

Table 1 Error-correction representation for the ARDL model

```
           ARDL(1,0,0) selected based on Schwarz Bayesian Criterion
*******************************************************************************
 Dependent variable is dDRAND
 132 observations used for estimation from 1995M7  to 2006M6
*******************************************************************************
 Regressor              Coefficient       Standard error         T-Ratio[Prob]
 dDTURN                  -.0013712            .019860           -.069044[.945]
 dDUSSA                   -.012146           .0050295            -2.4150[.017]
 dCOMM                    .2626E-3           .2333E-3             1.1259[.262]
 dEMB                     .0037617           .0034334             1.0956[.275]
 dTIME                   -.6057E-4           .8519E-4            -.71102[.478]
 dITN                     -.030322            .034603            -.87628[.383]
 ecm(-1)                   -.74180            .090553            -8.1919[.000]
*******************************************************************************
 List of additional temporary variables created:
 dDRAND = DRAND-DRAND(-1)
 dDTURN = DTURN-DTURN(-1)
 dDUSSA = DUSSA-DUSSA(-1)
 dCOMM = COMM-COMM(-1)
 dEMB = EMB-EMB(-1)
 dTIME = TIME-TIME(-1)
 dITN = ITN-ITN(-1)
 ecm = DRAND + .0018485*DTURN +  .016374*DUSSA -.3540E-3*COMM -.0050711*EMB +
.8165E-4*TIME +  .040876*ITN
*******************************************************************************
 R-squared                    .35699   R-Bar-squared                      .32613
 S.E. of Regression          .035141   F-stat.    F(  6, 125)   11.5666[.000]
 Mean of dependent variable  .7862E-3   S.D. of dependent variable     .042808
 Residual sum of squares      .15436   Equation log-likelihood      258.2842
 Akaike Info. Criterion     251.2842   Schwarz Bayesian Criterion    241.1944
 DW-statistic                 1.8451
*******************************************************************************
 R-Squared and R-Bar-squared measures refer to the dependent variable
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dDRAND and in cases where the error correction model is highly restricted, these measures could become negative.

4 Conclusions

The inference is based on the results appearing in Table 2. The most consistent results are based on the SBC. In this context, a long-run relationship is confirmed at a ten-per-cent significance level. The results, based on the SBC and ten-per-cent significance level, show that there is a long-run relationship between the rand-dollar real exchange rate and the interest differential and the proxy for order flow, which is proxied by the dollar-denominated daily net turnover on South African markets. Short-term dynamics, as represented by the coefficient of the ECM variable, show speedy convergence toward equilibrium. This is confirmed by the additional results appearing in Appendix A. The specification favoured by SBC and AIC is the one that includes the intercept term with no time trend.

Table 2 Bounds-testing results for the rand-dollar real exchange rate

Results of ARDL model based on Akaike Information Criterion			
The number of forcing variables is 2			
	10-per-cent significance level		
	F-stat	I(0) Critical bounds	I(1) Critical bounds
Including time trend and intercept	4.77	4.19	5.06
Including intercept and no time trend	4.70	3.17	4.14
Excluding intercept and time trend	1.57	2.17	3.19

Results of ARDL model based on Schwarz Bayesian Criterion			
The number of forcing variables is 2			
	10-per-cent significance level		
	F-stat	I(0) Critical bounds	I(1) Critical bounds
Including time trend and intercept	9.10	4.19	5.06
Including intercept and no time trend	6.22	3.17	4.14
Excluding intercept and time trend	2.96	2.17	3.19

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Appendix A

Bayesian Schwarz Criterion
Time trend and intercept

```
                      Variable Addition Test (ARDL case)
*******************************************************************************
 Dependent variable is DRAND
 List of the variables added to the regression:
 TURN(-1)        USSA(-1)
 132 observations used for estimation from 1995M7  to 2006M6
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 DRAND(-1)                  .14398            .089455             1.6095[.110]
 DTURN                    .0097432            .020220             .48186[.631]
 DUSSA                   -.0079980           .0048598            -1.6457[.102]
 COMM                    -.1624E-3           .2596E-3            -.62565[.533]
 EMB                      .0017466           .0035456             .49260[.623]
 TIME                    -.7742E-4           .1119E-3            -.69201[.490]
 ITN                       -.26156             .10577            -2.4731[.015]
 TURN(-1)                  .042440            .015294             2.7750[.006]
 USSA(-1)                 .0020815           .0014359             1.4496[.150]
*******************************************************************************
 Joint test of zero restrictions on the coefficients of additional variables:
 Lagrange Multiplier Statistic     CHSQ( 2)=  17.0201[.000]
 Likelihood Ratio Statistic        CHSQ( 2)=  18.2219[.000]
 F Statistic                    F(  2, 123)=   9.1036[.000]
*******************************************************************************
```

Bayesian Schwarz Criterion
Intercept and no time trend

```
                      Variable Addition Test (ARDL case)
*******************************************************************************
 Dependent variable is DRAND
 List of the variables added to the regression:
 TURN(-1)        USSA(-1)
 132 observations used for estimation from 1995M7  to 2006M6
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 DRAND(-1)                  .15180            .088552             1.7142[.089]
 DTURN                     .013417            .019470             .68910[.492]
 DUSSA                   -.0079480           .0048491            -1.6391[.104]
 COMM                    -.1966E-3           .2544E-3            -.77274[.441]
 EMB                      .0014921           .0035191             .42401[.672]
 ITN                       -.30615            .083696            -3.6579[.000]
 TURN(-1)                  .047799            .013161             3.6320[.000]
```

USSA(-1)	.0014184	.0010672	1.3291[.186]

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Joint test of zero restrictions on the coefficients of additional variables:

Lagrange Multiplier Statistic	CHSQ(2)=	17.0374[.000]
Likelihood Ratio Statistic	CHSQ(2)=	18.2418[.000]
F Statistic	F(2, 124)=	9.1884[.000]

Bayesian Schwarz Criterion
Excluding intercept and time trend

Variable Addition Test (ARDL case)

****

Dependent variable is DRAND
List of the variables added to the regression:
TURN(-1) USSA(-1)
132 observations used for estimation from 1995M7 to 2006M6

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DRAND(-1)	.23731	.089540	2.6504[.009]
DTURN	-.0039886	.019792	-.20153[.841]
DUSSA	-.011506	.0049802	-2.3103[.023]
COMM	-.4139E-4	.2629E-3	-.15743[.875]
EMB	.0029133	.0036667	.79454[.428]
TURN(-1)	.0031840	.0051827	.61434[.540]
USSA(-1)	.0025645	.0010695	2.3979[.018]

****

Joint test of zero restrictions on the coefficients of additional variables:

Lagrange Multiplier Statistic	CHSQ(2)=	5.9726[.050]
Likelihood Ratio Statistic	CHSQ(2)=	6.1119[.047]
F Statistic	F(2, 125)=	2.9619[.055]

****

Akaike Information Criterion
Time trend and intercept

Variable Addition Test (ARDL case)

****

Dependent variable is DRAND
List of the variables added to the regression:
TURN(-1) USSA(-1)
132 observations used for estimation from 1995M7 to 2006M6

****

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DRAND(-1)	.14427	.091677	1.5737[.118]
DTURN	.011338	.020305	.55838[.578]
DTURN(-1)	.029062	.021664	1.3415[.182]
DTURN(-2)	.034488	.020625	1.6721[.097]
DTURN(-3)	.022757	.020063	1.1343[.259]
DUSSA	-.0071016	.0049731	-1.4280[.156]
COMM	-.7517E-4	.2640E-3	-.28471[.776]
EMB	.0038368	.0037104	1.0341[.303]
ITN	-.17929	.11472	-1.5629[.121]
TIME	-.1111E-3	.1129E-3	-.98435[.327]

```
 TURN(-1)                 .029169            .016925             1.7234[.087]
 USSA(-1)                .0021515           .0014318             1.5026[.136]
*******************************************************************************
 Joint test of zero restrictions on the coefficients of additional variables:
 Lagrange Multiplier Statistic     CHSQ( 2)=   9.7315[.008]
 Likelihood Ratio Statistic        CHSQ( 2)=  10.1089[.006]
 F Statistic                    F(  2, 120)=   4.7755[.010]
*******************************************************************************
```

Akaike Information Criterion
Excluding intercept and time trend

```
                      Variable Addition Test (ARDL case)
*******************************************************************************
 Dependent variable is DRAND
 List of the variables added to the regression:
 TURN(-1)        USSA(-1)
 132 observations used for estimation from 1995M7  to 2006M6
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 DRAND(-1)                  .15477            .091043             1.6999[.092]
 DTURN                     .016319            .019662             .82998[.408]
 DTURN(-1)                 .026449            .021498             1.2303[.221]
 DTURN(-2)                 .032116            .020481             1.5681[.119]
 DTURN(-3)                 .020863            .019968             1.0448[.298]
 DUSSA                   -.0071152           .0049724            -1.4309[.155]
 COMM                    -.1300E-3           .2580E-3            -.50382[.615]
 EMB                      .0033134           .0036716             .90245[.369]
 ITN                       -.24846            .090660            -2.7406[.007]
 TURN(-1)                  .037758            .014501             2.6038[.010]
 USSA(-1)                 .0012178           .0010724             1.1356[.258]
*******************************************************************************
 Joint test of zero restrictions on the coefficients of additional variables:
 Lagrange Multiplier Statistic     CHSQ( 2)=   9.5128[.009]
 Likelihood Ratio Statistic        CHSQ( 2)=   9.8730[.007]
 F Statistic                    F(  2, 121)=   4.6986[.011]
-------------------------------------------------------------------------------
```

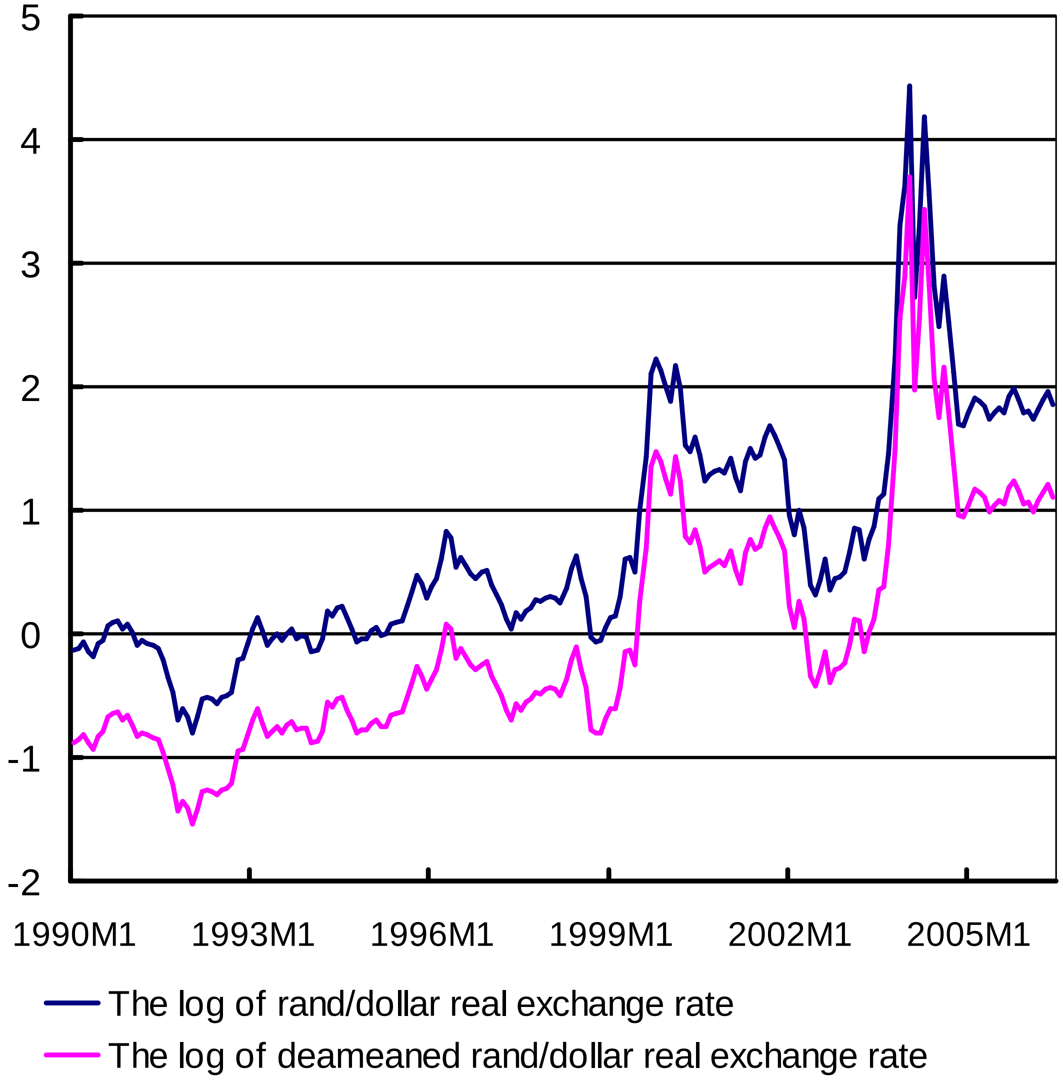
Akaike Information Criterion
Excluding trend and time

```
                      Variable Addition Test (ARDL case)
*******************************************************************************
 Dependent variable is DRAND
 List of the variables added to the regression:
 TURN(-1)        USSA(-1)
 132 observations used for estimation from 1995M7  to 2006M6
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 DRAND(-1)                  .22513            .089648             2.5113[.013]
 DTURN                    .0069401            .019872             .34924[.728]
 DTURN(-1)                 .047524            .020604             2.3066[.023]
 DTURN(-2)                 .046383            .020330             2.2815[.024]
 DTURN(-3)                 .028500            .020293             1.4044[.163]
 DUSSA                   -.0092490           .0050404            -1.8350[.069]
 COMM                     .2292E-4           .2586E-3            .088659[.929]
 EMB                      .0054085           .0036857             1.4674[.145]
 TURN(-1)                 .4814E-3           .0051596            .093295[.926]
```

```
 USSA(-1)                 .0018921           .0010713             1.7661[.080]
*******************************************************************************
 Joint test of zero restrictions on the coefficients of additional variables:
 Lagrange Multiplier Statistic     CHSQ( 2)=   3.3044[.192]
 Likelihood Ratio Statistic        CHSQ( 2)=   3.3464[.188]
 F Statistic                    F(  2, 122)=   1.5662[.213]
-------------------------------------------------------------------------------
```

Appendix B

The rand-dollar real exchange rate



Appendix C

Partial autocorrelation function

Date: 02/23/07 Time: 09:27
Sample: 1990M01 2006M6
Included observations: 199

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|*******|</td><td>.|*******|</td><td>1</td><td>0.963</td><td>0.963</td><td>187.48</td><td>0.000</td></tr>
<tr><td>.|*******|</td><td>*|. |</td><td>2</td><td>0.920</td><td>-0.108</td><td>359.44</td><td>0.000</td></tr>
<tr><td>.|*******|</td><td>.|* |</td><td>3</td><td>0.885</td><td>0.095</td><td>519.27</td><td>0.000</td></tr>
<tr><td>.|*******|</td><td>*|. |</td><td>4</td><td>0.848</td><td>-0.068</td><td>666.67</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>5</td><td>0.799</td><td>-0.167</td><td>798.17</td><td>0.000</td></tr>
<tr><td>.|****** |</td><td>*|. |</td><td>6</td><td>0.742</td><td>-0.116</td><td>912.29</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>7</td><td>0.685</td><td>-0.056</td><td>1010.1</td><td>0.000</td></tr>
<tr><td>.|***** |</td><td>.|. |</td><td>8</td><td>0.633</td><td>0.020</td><td>1093.8</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|* |</td><td>9</td><td>0.588</td><td>0.108</td><td>1166.7</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>10</td><td>0.547</td><td>0.039</td><td>1230.0</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>11</td><td>0.503</td><td>-0.034</td><td>1283.9</td><td>0.000</td></tr>
<tr><td>.|**** |</td><td>.|. |</td><td>12</td><td>0.463</td><td>0.009</td><td>1329.7</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>.|* |</td><td>13</td><td>0.441</td><td>0.188</td><td>1371.5</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>*|. |</td><td>14</td><td>0.419</td><td>-0.087</td><td>1409.5</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>*|. |</td><td>15</td><td>0.390</td><td>-0.090</td><td>1442.6</td><td>0.000</td></tr>
<tr><td>.|*** |</td><td>**|. |</td><td>16</td><td>0.350</td><td>-0.199</td><td>1469.4</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>*|. |</td><td>17</td><td>0.311</td><td>-0.081</td><td>1490.7</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|. |</td><td>18</td><td>0.275</td><td>-0.050</td><td>1507.4</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|* |</td><td>19</td><td>0.243</td><td>0.082</td><td>1520.5</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|*** |</td><td>20</td><td>0.231</td><td>0.412</td><td>1532.5</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|** |</td><td>21</td><td>0.227</td><td>0.274</td><td>1544.0</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|* |</td><td>22</td><td>0.221</td><td>0.103</td><td>1555.0</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>.|. |</td><td>23</td><td>0.219</td><td>-0.031</td><td>1565.9</td><td>0.000</td></tr>
<tr><td>.|** |</td><td>*|. |</td><td>24</td><td>0.226</td><td>-0.159</td><td>1577.6</td><td>0.000</td></tr>
</table>