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Market microstructure approach to the exchange rate determination puzzle

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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 stand point 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 included is a proxy for country risk—the differential between the Global Emerging Market Bond Index and the South African long-term bond.

The paper relies on the autoregressive distributed lag (ARDL) model of Persaran, Shin and Smith (2001) and as explained in Persaran and Persaran (1997). The ARDL approach to cointegration does not require pre-testing for 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, nonfundamentals, the fundamentals and the proxy for order flow, which is the dollar-denominated daily net turnover on the South African markets.

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1 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 latter being the same thing as the exchange rate disconnect puzzle. The details of how the microstructure approach addresses the first two puzzles mentioned above are found in Chapter 7 of Lyons (2001). In this paper we focus on the market microstructure approach to the exchange rate determination puzzle. The exchange rate determination puzzle is that in the short run there seem to be no reliable determinants of exchange rates. 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 (1994) concluded that no model based on standard fundamentals like 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 in the 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. The poor explanatory power of macro-based models, coupled with the empirical evidence that micro-structural 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 point of 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, the news associated with macroeconomic variables has an impact on the exchange rates. In different 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 the 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 euro-area to test whether announcement surprises have a systematic and significant effect on both the order flow and prices.[1] They find that, at a 1 minute sampling frequency, macroeconomic data releases have systematic effects on order flow and on exchange rate transaction prices. Their results show that the release of positive news tend 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 macroeconomic announcements, 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, pp.2-3)

[1] See also Payne (2003) and Payne and Vitale (2003)

Another relevant study supportive of the microstructure approach is Danielsson, Payne and Luo (2002), which assesses the forecasting ability of the order flows in forecasting exchange rates. The authors use the Meese and Rogoff (1983) framework[2] 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 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, have emphatically clarified this point:

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, p.5).

2 The basic model

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

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

where the function $f(i,m,o)$ denotes the macro component of the model and $g(X,I,Z)$ 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 micro determinants, denoted by Z. Lyons (2001) notes that $f(i,m,o)$ and $g(X,I,Z)$ depends on 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 Deutschemark and the US dollar and more than 40 percent of the daily variations of the log of the exchange rate between the 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 running 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 appear on the right hand side of an exchange rate model, if nothing else.

[2] For details see Rossi (2005).

3 Hybrid regression models

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

Our basic test regression takes the following form:

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

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 stand point 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 its depreciation caused by the uncovered interest parity. The coefficient a_2 is also expected to have a negative sign, indicating that net purchases of the 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,[3] whereas in Evans and Lyons study order flow is based on the net quantity of foreign exchange transactions. The reason we adopted the transactions monetary flow instead of the number of transactions is simply 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.

3.1 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 their 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.

This above analysis suggests the following test regression:

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

where com stands for the Economist commodity price index.

3.2 Country-risk-augmented exchange rate model

The traditional exchange rate models assume risk-neutrality. As a result, non-fundamental risk-related variables end up being excluded in those models. If indeed investors are risk averse, as it is usually the

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

case, it becomes necessary to take into account the premium that compensates investors for the risk of holding assets in foreign currency.[4] 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:

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

4 Econometric issues and data analysis

The study utilises the autoregressive distributed lag model (ARDL) of Persaran, Shin and Smith (2001) and as explained in 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:

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

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 $\mathbf{z_t}$ is a vector of exogenous variables with fixed lags and/or deterministic variables such as the time trends and an intercept term.

The error correction representation takes the following form:

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

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's Bayesian Information Criterion (SBC) or the Lagrange Multiplier (LM) test. The author prefers the Schwarz Bayesian Criterion 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).

[4] See also Medeiros (2005).

- If the calculated F-statistic *falls above* the upper bound, 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 bounds, 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 roots techniques.

The dependent variable is the log-level of the ZAR/USD 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 SARB Quarterly Bulletin's 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 Global Emerging Market Bond Index, which is used as a measure of country risk.
$TIME =$	Time trend
$ITN =$	Intercept term.

The following are the Error Correction Model results using *Microfit*:

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 dDRAND and in cases where the error correction model is highly restricted, these measures could become negative.

5 Conclusions

The inference is based on the results appearing in Table 2. The most consistent results are the one based on the Schwarz Bayesian Criterion. In this context, a long-run relationship is confirmed at 10 per cent significance level. The results, based on the Schwarz Bayesian Criterion and ten percent significance level, show that the there is a long-un relationship between the rand-dollar exchange rate and the interest differential and the proxy for order flow, which is proxied by the dollar-denominated daily net turnover on the South African markets. Short-term dynamics as represented by the coefficient of ECM variable shows speedy convergence toward equilibrium. This is confirmed by the additional results appearing in Appendix A.

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
No intercept and no 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
No intercept and no time trend	2.96	2.17	3.19

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APPENDIX A

Bayesian Swartz 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 Swartz 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]

****

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 Swartz Criterion
No 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)	.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
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)	.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
No Trend no 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

****

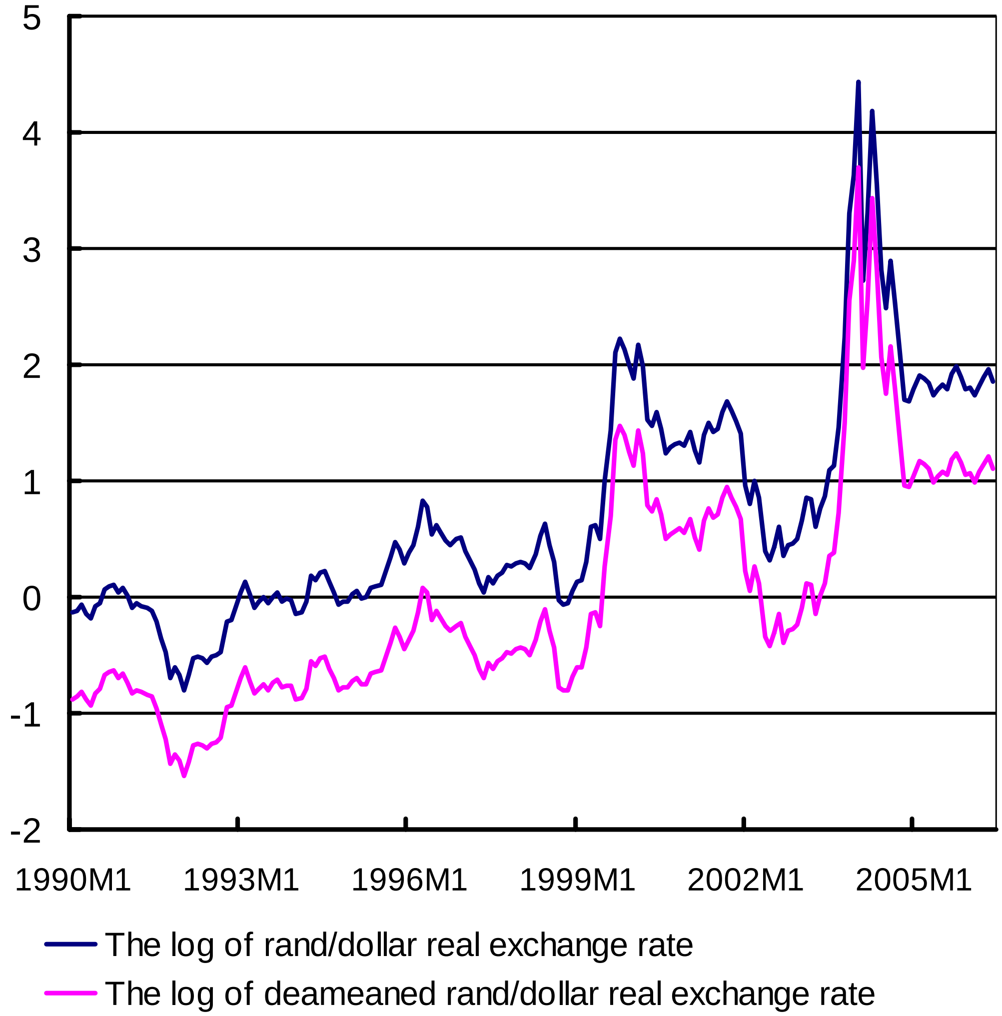
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DRAND(-1)	.22513	.089648	2.5113[.013]
DTURN	.0069401	.019872	.34924[.728]
DTURN(-1)	.047524	.020604	2.3066[.023]
DTURN(-2)	.046383	.020330	2.2815[.024]
DTURN(-3)	.028500	.020293	1.4044[.163]
DUSSA	-.0092490	.0050404	-1.8350[.069]
COMM	.2292E-4	.2586E-3	.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

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