

A PANEL DATA APPROACH TO THE BEHAVIOURAL EQUILIBRIUM EXCHANGE RATE OF THE ZAR

By

Andrea Saayman & Marianne Matthee

School of Economics

North-West University, Potchefstroom Campus

Private Bag X6001

Potchefstroom, 2520

Tel: 018 2991443

Fax: 018 2991398

e-mail: Andrea.Saayman@nwu.ac.za & Marianne.Matthee@nwu.ac.za

Abstract:

The question of whether the Rand is currently overvalued is often asked. To determine over- or undervaluation implies the existence of an equilibrium exchange rate (EER). The aim of this research is to determine the long run equilibrium exchange rate of the South African Rand, using the behavioural exchange rate (BEER) methodology. Most studies on the BEER follow a single equation VECM approach. This paper rather utilises a panel of data from South Africa's main trading partners – USA, Europe, UK, Japan. Panel data studies estimate the relationship between the equilibrium exchange rate and the fundamentals with the aim to obtain some kind of “average” coefficients for a set of countries. These “average” coefficients describe the long-term behaviour of the individual countries' real exchange rates. Substituting the observed fundamental time series into the estimated equation derives the equilibrium exchange rate for each country and over- and undervaluation can thus be determined.

1. INTRODUCTION

The South African rand has experienced tremendous fluctuations in its value over the past decade. Moving from a level of R6=US\$1 to more than R10=\$1 and again back to R5 and R6 against the dollar. This brings to the fore the question of whether the Rand is overvalued or undervalued at certain stages. To determine over- or undervaluation implies the existence of an equilibrium exchange rate (EER). The aim of this research is to verify the determinants of the long run equilibrium exchange rate of the South African Rand, using the behavioural exchange rate methodology in a panel data setting.

Initially equilibrium exchange rates were viewed according to the Purchasing Power Parity theory. Yet, Balvers and Bergstrand (1997:345-346) indicate that real exchange rates have departed for great periods of time from its PPP level and to explain these variations, various models of equilibrium exchange rate determination have surfaced. MacDonald (2001:1) indicates that these models are distinguished by a wide variety of acronyms such as FEER, BEER, PEER, DEER and NATREX.

The Fundamental equilibrium exchange rate (FEER) is the exchange rate associated with underlying balance, such as those normally achieved in the long run, where all underlying economic forces has worked themselves out. It is thus the equilibrium exchange rate consistent with both internal and external balance in the economy (Williamson, 1994:179-180). The desired equilibrium exchange rate (DEER) refers to the equilibrium real exchange rate consistent with macroeconomic balance, based upon a set of desired macroeconomic objectives. The exchange rate is therefore not the actual exchange rate, but an estimate of what the exchange rate should be at the desired internal and external macroeconomic balance (Bayoumi et al., 1994:20-21). NATREX is the acronym for natural real exchange rate, which refers to the medium-run, inter-cyclical equilibrium exchange rate as determined by real, fundamental factors. It is a moving equilibrium real exchange rate that responds to continual changes in exogenous and endogenous real fundamentals. Martinez (2003:25) indicates that the NATREX equilibrium is a sequence of medium run equilibriums that evolve into a long run reference rate.

The behavioural equilibrium exchange rate (BEER) is a more statistical approach to exchange rate modelling and splits the normative aspects of exchange rate modelling from the behavioural aspects. Normally this entails a two-stage procedure, where the first stage entails the estimation of the behavioural exchange rate relationship and the second stage entails the construction of an assessment of whether the exchange rate is overvalued or not (MacDonald, 2001:1). This misalignment depends on short-term transitory factors and the departure of the fundamentals from their long-term value. The total misalignment can thus be split into a permanent and transitory component by decomposing the cointegration vector and therefore the permanent equilibrium exchange rate acronym (PEER) (Égert, 2002:6).

Most studies on the behavioural equilibrium exchange rate used to follow a single equation VECM approach. Yet, panel data studies on equilibrium exchange rate determination are becoming more popular. This paper utilises a panel of data from South Africa's main trading partners, namely the USA, Europe, the UK and Japan, in estimating the equilibrium exchange rate. These four currencies are also the main ingredients in the effective exchange rate of South Africa. The weights of the four major currencies since January 2003 are (1999 weights in brackets): Euro 36.38 (35.70), US dollar 15.47 (15.15), British pound 15.37

(14.91), Japanese yen 10.43 (10.26). It is thus evident that these 4 currencies represent more than 75% of South Africa's effective exchange rate.

The paper is structured as follows: Section 2 gives an overview of the different approaches to estimating equilibrium exchange rates. Section 3 described the methodology used in this paper, while the results are discussed in Section 4. This paper concludes in Section 5.

2. ESTIMATING EQUILIBRIUM EXCHANGE RATES

Wren-Lewis (2003) divides the estimation approaches to computing and equilibrium exchange rate into four categories, namely:

- o Complete macroeconomic model – where the EER is the outcome from a complete macroeconomic model.
- o Partial equilibrium model – estimates a model for aggregate trade flows, but uses existing estimates for medium-term capital flows and key variables.
- o Reduced form regression equation – the estimation of a single equation for the exchange rate as a function of medium-term determinants.
- o Direct estimates of purchasing power parity (PPP) – measuring prices of similar baskets of goods across countries.

In the complete macroeconomic model approach, the real exchange rate is included as one variable in a complete system of equations (Wren-Lewis, 2003). This approach has already been implemented by researchers such as Barrell et al. (1991), Church (1992), Bayoumi et al. (1994) and Piscitelli and Westaway (2004). One of the shortcomings of this approach is that macroeconomic models are not restricted to the medium term, and it may be difficult to split the medium run from the short run.

The partial equilibrium approach estimates only part of the economic system and treats the other variables as exogenous input, based on judgement. The key exogenous inputs are medium-term capital flows and the cyclically-adjusted level of output. Medium-term trade flows are modelled and the equilibrium exchange rate is the rate that produces a current account that matches the assumptions about medium-term capital flows (Wren-Lewis, 2003). This approach was used by, amongst others, Williamson (1994). The main advantage of this approach is its simplicity and clarity – it provides a direct relationship between the equilibrium exchange rate and the fundamentals of the economy (Piscitelli & Westaway, 2004).

The reduced form regression approach estimates the equilibrium exchange rate by using a single equation and a number of key explanatory variables. Wren-Lewis (2003) indicates that if all the explanatory variables in the regression were equivalent to the exogenous variables in the structural model, the regression can be viewed as a reduced form of the complete model. This single equation approach was used by Clark and MacDonald (1999) in estimating the BEER and also by Baffes et al. (1997). Wren-Lewis (2003) concludes that there seem to be no compelling reason to prefer one approach above the others, although he indicates that the partial equilibrium approach is more meticulous to EER estimation and its advantages and disadvantages can be appreciated by comparing it to the complete model approach.

Besides the different approaches and theories available to estimate the equilibrium exchange rate, different econometric techniques can also be employed. Égert (2002) divides these techniques broadly into time series techniques and panel data techniques.

Recent time series studies, using the BEER approach, include those of MacDonald (2001) for the New Zealand dollar, Baffes et al. (1997) for the Ivory Coast and Burkino Faso, Ricci & MacDonald (2003) for the South African Rand. The use of panel data in recent BEER studies includes Maeso-Fernandez et al. (2004), Candelon et al. (2007), Kim & Korhonen (2005). None of these studies include estimations of the South African Rand.

3. METHODOLOGY

The underlying methodology of this research lies in the behavioural equilibrium exchange rate approach. The behavioural exchange rate (BEER) is determined by an appropriate set of explanatory variables and is not derived from macroeconomic balance. The real exchange rate is calculated using the fundamental determinants of the actual real exchange rate and not the exchange rate that is consistent with internal and external balance. Therefore the actual real exchange rate is in equilibrium in a behavioural sense when its movements reflect changes in these fundamentals (Zhang, 2001:83).

Égert (2002:7) explains the difference between time series analysis and panel data in this approach as follows: Panel data studies estimate the relationship between the equilibrium exchange rate and its fundamentals with the aim to obtain some kind of “average” coefficients for a set of countries. These “average” coefficients describe the long-term behaviour of the individual countries’ real exchange rates, since, in the long run, the real exchange rate is supposed to react similar to changes in fundamentals in each country. Substituting the observed fundamental time series into the estimated equation derives the equilibrium exchange rate for each country.

The advantage of using panel data is that it adds a time dimension to cross-sectional analysis, which increases the information set, but simultaneously also complicates the analysis (Maeso-Fernandez et al., 2004:15-16). In many ways, the procedure followed to estimate the behavioural equilibrium exchange rate in a panel is largely similar to that of estimating a time-series modelling, as will be explained subsequently.

3.1 Estimating technique

Most economic time-series are non-stationary, and the first step in the estimation is to determine the presence of a unit root. Various tests are currently available to test for unit roots in panel data, starting with the test suggested by Levin and Lin in 1992/3, Im, Pesaran and Shin in 1995 and 1997 (referred to as the IPS t-test), and Hadri in 2000 (Harris & Sollis, 2003:191). The IPS test is based on N augmented Dickey-Fuller regressions, where N is the cross section dimension. The null hypothesis is that the individual time series in the panel are jointly non-stationary. The Hadri-test is a residual-based Lagrange Multiplier (LM) test, where the null hypothesis is that the time series for each cross section member are stationary around a deterministic trend (Maeso-Fernandez et al., 2004:116 and Harris & Sollis, 2003:197).

Following the tests for unit roots is the test for cointegration. In an economic sense, two or more series are cointegrated when there exists a long-run equilibrium to which they converge over time, and the white noise error can be interpreted as the disequilibrium error. Thus, if series x_i and y_i are both stationary in first differences (I(1)) and the error term u_i is stationary in levels (I(0)), then the two series would be integrated of order CI(1,1) (Harris & Sollis, 2003:34). For standard time-series modelling, the Johansen cointegration test is often used. Yet, for panel data modelling, the cross-sectional element should also be considered. Three cointegration tests are commonly employed in panel data studies, namely that of Pedroni (1999), Kao (1999) and McCoskey and Kao (1998). In 2001, Larsson, Lyhagen & Lothgren constructed a panel data cointegration test based on the Johansen framework.

The test by Kao (1999) is based on the Engel-Granger two step procedure, and impose homogeneity on the members in the panel. The null hypothesis of no cointegration is tested using an ADF-type test. The test by McCoskey & Kao test the null-hypothesis of cointegration and is similar to the Hadri LM test for unit roots (Harris & Sollis, 2003:201, 204). The seven residual-based cointegration tests by Pedroni are based on the null hypothesis of no cointegration and it allows for heterogeneous variances across countries in the panel. Four of the tests are based on the within-dimension of the panel and three on the average along the between-dimension (Maeso-Fernandez et al., 2006:506). The starting point in the Pedroni cointegration test is a group-by-group estimation of the proposed long-run relationship:

$$y_{it} = \alpha_i + \gamma_i t + \theta_i + \beta_1 x_{1it} + \dots + \beta_K x_{Kit} + \varepsilon_{it} \quad (1)$$

where K = number of regressors, β_K = elasticities, a and γ = deterministic elements and θ_i = time effects. Maeso-Fernandez et al. (2004:17) note that this formulation makes requirements for exogeneity of the regressors unnecessary, since the dynamics are jointly for y_i and all x_{ki} .

There are various methods to estimating the cointegration vector using panel data. Harris & Sollis (2003:207-211) focuses on the fully modified OLS (FMOLS) and dynamic OLS (DOLS) estimators. FMOLS is a non-parametric approach to dealing with corrections for serial correlation – it therefore takes into account the possible correlation between the error term and the first differences of the regressors as well as the presence of a constant term (Maeso-Fernandez et al., 2006:507). The FMOLS long run coefficient estimators can be defined as:

$$\hat{\beta}_i = \left(\sum_{t=1}^T x'_{it} x_{it} \right)^{-1} \sum_{t=1}^T \left(x'_{it} y_{it}^* - T \hat{\lambda}_i \right) \quad (2)$$

where y_{it}^* are the regressands adjusted for covariance between the error term and the first differences of the regressors (Δx_i); $T \hat{\lambda}_i$ = adjustment for a constant term. The mean-group FMOLS long-run coefficient is the average of the group estimate

over N , namely $\hat{\beta}_{MG}^{FMOLS} = N^{-1} \sum_{i=1}^N \hat{\beta}_i$ and the corresponding t-statistic converges to a standard normal distribution (Maeso-Fernandez et al., 2004:19).

DOLS is a parametric approach where the lagged first-difference terms are explicitly estimated (Harris & Sollis, 2003:207). With DOLS, the errors are augmented with leads, lags and contemporaneous values of the regressors. The relationship between the residuals and the first differences of the leads, lags and contemporaneous values of the regressors can be expressed as follows:

$$\varepsilon_{it} = \sum_{j=-q}^q c_{ij} \Delta x_{it-j} + \varepsilon_{it}^* \quad (3)$$

If this is substituted into equation (1), the following is obtained:

$$y_{it} = \alpha_i + \gamma_i t + \theta_i + \beta_1 x_{1it} + \dots + \beta_K x_{Kit} + \sum_{j=-q}^q c_{ij} \Delta x_{it-j} + \varepsilon_{it}^* \quad (4)$$

Using simple OLS with the above specification delivers consistent estimates of the long-run parameters (Maeso-Fernandez et al., 2004:20). One of the disadvantages of using DOLS, is that degrees of freedom (Maeso-Fernandez et al., 2006:507). Maeso-Fernandez et al. (2004:20) also note that FMOLS require fewer assumptions than DOLS and therefore it tends to deliver more robust results.

Maeso-Fernandez (2006) adds the mean-group estimators (MGE) and pooled mean-group estimators (PMGE) to the list. The mean group estimators use a maximum likelihood method, rather than a modified OLS. The PMGE constrains the long-run coefficients to be identical across groups in an error correction framework, but allows differences in short-run coefficients and error variances. The following autoregressive distributed lag model of order (p, q) is thus estimated:

$$\Delta y_{it} = \phi y_{it-1} + \beta_i' x_{it} + \sum_{j=1}^{p_i-1} \lambda_{ij} \Delta y_{it-j} + \sum_{j=0}^{q_i-1} \delta_{ij}' \Delta x_{it-j} + \alpha_i + \gamma_i t + \varepsilon_{it} \quad (5)$$

where x_{it} is a $m \times 1$ -vector of independent variables, α_i = country-specific intercept, γ_i = time trend parameters, λ_{ij} and δ_{ij} = country-specific coefficients of the short-term dynamics, ε_{it} = error term. Note that β is the long-run coefficient, which is assumed to be same across countries (Maeso-Fernandez et al., 2004:18). It should be noted that Kim & Korhonen (2005:158) found similar results using both PMGE and FMOLS.

3.2 Data

The real exchange rate can be defined as the nominal exchange rate adjusted for price differences between countries. Various price indices can be used to adjust the nominal exchange rate, including the consumer price index, the price of tradeables versus non-tradeables and unit labour cost indices (see Saayman, 2006). In this research we compute the real exchange rate as follows:

$$E_t = \frac{P_t^*}{e_t P_t} \quad (6)$$

where E_t = the real exchange rate; e_t = nominal exchange rate and P_t and P_t^* = the price index in the home country and foreign country respectively. Chou and Shih

(1998:167) applies the wholesale price index (or producer price index) of the foreign country (WPI*) as a proxy for the price of foreign tradables, and the domestic consumer price index (CPI) as a proxy for local non-tradables. This is also the approach followed in this research, since it would be comparable to the real effective exchange rate of the South African Rand and thus to previous studies.

Three previous research articles have estimated the real equilibrium exchange rate for South Africa, using a single equation approach – Aron, Elbadawi & Kahn (1998), Ricci & MacDonald (2003) and Saayman (2005). Typical variables included in their single equation estimates were the real interest rate, real GDP per capita, real commodity prices or the gold price, openness, the fiscal balance or government expenditure relative to GDP, net foreign assets relative to GDP, the terms of trade, capital flows, foreign reserves and total domestic credit extension (see Saayman, 2007).

Égert (2002) summarises the variables used in panel data studies completed until 2002 as follows:

- Coudhert (1999) used the productivity differential (defined as the relative price of non-tradeables and the GDP per capita) and the foreign indebtedness ratio.
- Halpern & Wyplosz (1997) used GDP per capita (as proxy for productivity differences), school enrolment, and agricultural production as percentage of GDP, and government consumption.
- Begg, Halpern and Wyplosz (1999) added the dependency ratio, openness ratio, net foreign assets of the banking sector and private credit extension to the above-mentioned list.
- Krajnyák & Zettelmeyer (1997) included GDP per capita, school enrolment, the share of agriculture in GDP, and variables that describe institutions in the country, such as the fiscal regime, property rights and economic freedom.
- Maurin (2001) considered the productivity differential, public consumption expenditure, the real domestic interest rate and external debt as independent variables.
- De Broek & Sløk (2001) uses the productivity growth differential between the open and sheltered sector and the export-weighted average productivity growth differential, as well as openness and government balances.

In addition to the above-mentioned list, recent studies by Kim and Korhonen (2005), Candelon et al. (2007) and Maeso-Fernandez et al. (2004) were also considered. Popular independent variables included in their panel estimates are:

- Productivity differences proxies, including relative GDP per capita, the ratio between industry production and industry employment.
- International economic environment and integration proxies, including openness as measured by the sum of exports and imports relative to GDP, and the real interest rate differential and terms of trade.

- Demand pressure proxies, including government spending, consumption expenditure and total expenditure relative to GDP.
- Foreign indebtedness, as measured by net foreign assets.

Based on the above-mentioned, all four categories of variables are included in the estimates for the South African Rand. The proxies that are used, as well as the relevant data sources are indicated in Table 1:

Table 1: Variables and sources

Variable	Description	Source
RER	Real exchange rate, calculate as in equation (6), but denominated in units of foreign currency for South African Rand	IFS and SARB
GDP	Relative GDP per capita in constant 2000 US\$ terms, expressed as GDP_{pc}^*/GDP_{pc}	IFS and WDI
OPEN	Exports plus imports as percentage of GDP, expressed as a ratio of foreign openness to openness of SA	IFS
GOV	Government consumption as percentage of GDP, expressed as a ratio GOV^*/GOV	IFS
RES	Gross reserves as a percentage of GDP, expressed as a ratio of foreign to local	IFS

Quarterly data from 1990 to end 2005 is used in the analysis. The data is available for all the countries, except the European Union, for which the data is only available since 1999. This led to an unbalanced panel that is used in the analysis. Figure 1 illustrates the variables according to each country (note 1=USA, 2=UK, 3=Japan and 4=European Union).

What is expected from these variables? For the productivity proxy, relative GDP per capita, a negative sign is expected, since higher per capita income is normally associated with an appreciation in the real exchange rate. The effect of demand pressure variables may be ambiguous, since the extent of crowding out influences the sign of the variable (especially where government consumption is considered). The effect of openness is also ambiguous, since more trade should enhance economic performance, but also leads to less protection that can cause a depreciation of the exchange rate (Maeso-Fernandez et al., 2004:22-25). Using net foreign assets as a proxy for international indebtedness has its difficulties. Firstly, the foreign assets and liabilities that should be included or not (i.e. monetary sector, banking sector, other financial sector) is always a contentious issue. Secondly, net foreign assets are sometimes negative, causing problems with interpreting the results of the analysis since it is again expressed as a ratio. To overcome these problems, the variable “gross reserves (excluding gold) as a percentage of GDP” is rather used in the analysis. Theoretically, the stock of foreign exchange reserves is expected to have a positive effect on the real exchange rate. This is consistent with the role of the foreign exchange reserves as a relatively liquid indicator of the stock of national wealth (Aron et al., 1997).

4. PRELIMINARY RESULTS

All the analyses were completed using the programme, EViews 6. The natural logarithm of all the variables was taken to standardise the data (therefore the “L”-prefix to the variables). Firstly the unit root tests were performed. EViews allows various unit root tests to be performed and the results of the Im, Pesaran and Shin (IPS) individual unit root tests as well as the Hadri test and Levin, Lin and Chu (LLC) common unit root tests are indicated in Table 2.

Table 2: Unit root test results

Variable	LLC	LLC	LLC	IPS	IPS	Hadri [#]	Hadri [#]
	Individual intercept	Individual intercept & trend	None	Individual intercept	Individual intercept & trend	Individual intercept	Individual intercept & trend
LGDP	-1.76096 (0.0391)*	1.97073 (0.9756)	0.82450 (0.7952)	0.83258 (0.7975)	3.92302 (1.0000)	8.14125 (0.0000)	6.93227 (0.0000)
D(LGDP)	-5.53162 (0.0000)**	-6.93690 (0.0000)**	-7.39446 (0.0000)**	-5.25910 (0.0000)**	-6.99181 (0.0000)**	6.41854 (0.0000)	2.45669 (0.0070)
LGOV	-0.26241 (0.3965)	1.58639 (0.9437)	-1.71080 (0.0436)*	0.43477 (0.6681)	1.52916 (0.9369)	9.06422 (0.0000)	5.28176 (0.0000)
D(LGOV)	-2.59418 (0.0047)**	-1.47846 (0.0696)	-8.74117 (0.0000)**	-6.48214 (0.0000)**	-5.51109 (0.0000)**	-0.51997 (0.6985)**	0.39247 (0.3474)**
LOPEN	0.49999 (0.6915)	1.02527 (0.8474)	-0.79891 (0.2122)	-0.25986 (0.3975)	0.43657 (0.6688)	4.46038 (0.0000)	3.33302 (0.0004)
D(LOPEN)	-8.91614 (0.0000)**	-9.42898 (0.0000)**	-11.9599 (0.0000)**	-9.70103 (0.0000)**	-9.04183 (0.0000)**	-0.06188 (0.5247)**	1.64443 (0.0500)*
LRES	0.47472 (0.6825)	-0.26666 (0.3949)	-1.60085 (0.0547)	1.03163 (0.8489)	-0.60553 (0.2724)	9.60973 (0.0000)	2.47840 (0.0066)
D(LRES)	-10.0935 (0.0000)**	-9.96150 (0.0000)**	-10.5605 (0.0000)**	-8.67398 (0.0000)**	-7.97203 (0.0000)**	-1.07878 (0.8597)**	0.06468 (0.4742)**
LRER	-0.18986 (0.4247)	0.74884 (0.7730)	0.09804 (0.5390)	-0.21055 (0.4166)	1.02156 (0.8465)	4.63314 (0.0000)	2.31921 (0.0102)
D(LRER)	-6.46232 (0.0000)**	-5.98780 (0.0000)**	-9.56106 (0.0000)**	-7.03881 (0.0000)**	-6.12148 (0.0000)**	-0.36044 (0.6407)**	1.49370 (0.0676)*

Null hypothesis for Hadri test is no cointegration

* = significant at a 5% level; ** = significant at a 1% level

From Table 2 it can be seen that, according to the IPS-test, all the individual series are stationary in first differences – thus all the series are I(1). The common unit root tests, Levin, Lin and Chu (LLC) as well as the Hadri-test, reveal mixed results. The LLC test shows that the hypothesis of a unit root can for almost all variables (according to almost all assumptions) be rejected. Yet, the first difference of the variables are all stationary – I(1). The Hadri-test indicates that the hypothesis of no unit root for the first differenced variables, capital to GDP and GDP per capita, cannot be rejected. Yet, from the strong evidence provided by the IPS and LLC tests, it can be deduced that all the variables are stationary in first differences.

Following the unit root test, the variables were tested for cointegration. The cointegration tests were performed for each variable and the real exchange rate separately, as well as a joint test. EViews 6 allows the use of the Pedroni, and the Kao cointegration tests. The results of these tests are indicated in Table 3. Note that the additional variables were included one-by-one and the test results are reported correspondingly.

Table 3: Results of the Pedroni and Kao cointegration tests[#]

Variables	Trend	Within dimension (Panel stats)			Between dimension (Group stats)		
		None	Deterministic intercept & trend	Intercept, no trend	None	Deterministic intercept & trend	Intercept, no trend
LRER, LGDP	rho	0.019227 (0.3989)	1.866413 (0.0699)	0.740531 (0.3033)	1.365157 (0.1571)	2.218089 (0.0341)*	1.631617 (0.1054)
	Phillips Peron	-1.015083 (0.2383)	-0.014746 (0.3989)	-0.728882 (0.3059)	-0.708894 (0.3103)	0.417227 (0.3657)	-0.056272 (0.3983)
	Adapted DF	-1.316620 (0.1677)	-0.275337 (0.3841)	-1.199607 (0.1943)	-1.229158 (0.1874)	-0.001327 (0.3989)	-0.748573 (0.3015)
	Kao (ADF)	-2.401366 (0.0082)**					
LRER, LGDP, LGOV	rho	0.856001 (0.2766)	1.758188 (0.0850)	0.993098 (0.2436)	2.005411 (0.0534)	2.063938 (0.0474)*	2.058425 (0.0480)*
	Phillips Peron	0.052014 (0.3984)	-0.600194 (0.3332)	-0.823070 (0.2843)	0.811114 (0.2871)	-0.458541 (0.3591)	0.038751 (0.3986)
	Adapted DF	-0.100240 (0.3969)	-0.052945 (0.3984)	-0.620008 (0.3292)	0.439476 (0.3622)	0.258221 (0.3859)	0.083365 (0.3976)
	Kao (ADF)	-2.610311 (0.0045)**					
LRER, LGDP, LGOV, LOPEN	rho	0.447134 (0.3560)	1.036941 (0.2330)	0.563205 (0.3404)	0.463028 (0.3584)	1.171950 (0.2008)	0.607460 (0.3317)
	Phillips Peron	-1.84816 (0.0723)	-3.254413 (0.0020)**	-2.612224 (0.0132)*	-3.015708 (0.0042)**	-4.572341 (0.0000)**	-3.822796 (0.0003)**
	Adapted DF	-0.71696 (0.3085)	-0.325184 (0.3784)	-0.446703 (0.3611)	-0.924198 (0.2603)	-1.317865 (0.1674)	-0.829449 (0.2828)
	Kao (ADF)	-2.670071 (0.0038)**					
LRER, LGDP, LGOV, LOPEN, LRES	rho	0.877230 (0.2715)	1.466165 (0.1362)	1.317929 (0.1674)	0.912129 (0.2632)	1.920367 (0.0631)	1.409987 (0.1476)
	Phillips Peron	-2.172998 (0.0376)*	-3.162574 (0.0027)**	-1.852907 (0.0717)	-3.355359 (0.0014)**	-5.286121 (0.0000)**	-2.636977 (0.0123)
	Adapted DF	-0.928515 (0.2592)	-0.708635 (0.3104)	0.036280 (0.3987)	-1.822172 (0.0758)	-1.786634 (0.0809)	-0.654645 (0.3220)
	Kao (ADF)	-2.914168 (0.0018)**					

Notes: p-value in brackets (); # Null hypothesis: no cointegration; * significant at 5% level; ** significant at a 1% level

From the above Table it can be seen that the null hypothesis of no cointegration is in almost all the cases rejected. Only the Phillips Peron statistic show no cointegration when the openness ratio is added, while the *rho* statistic indicates that group cointegration is present in some cases. According to Maeso-Fernandez et al. (2006:506), the panel *rho* statistic is more reliable for larger sample sizes in terms of the time dimension ($T=100$), while the parametric t-statistic (thus the ADF statistic) is more reliable for smaller sample sizes. Taking this into account, as well as the limited number of variables available for Europe, the ADF-statistic points, in all cases of the Pedroni test, to cointegration. The Kao test results, on the other hand, shows towards no cointegration. Yet, since the Kao test do not allow for heterogeneity between groups, which could contribute towards the weak test results. All in all there seems to be enough support for cointegration between the variables.

Table 4: Dynamic OLS estimate results (sample 1990Q1-2005Q4)

	Model 1		Model 2		Model 3		Model 4	
	Non-weighted	Weighted	Non-weighted	Weighted	Non-weighted	Weighted	Non-weighted	Weighted
LGDP	-1.702 (0.206) [-8.23]**	-1.673 (0.206) [-8.12]**	-1.732 (0.211) [-8.20]**	-1.696 (0.205) [-8.25]**	-0.682 (0.153) [-4.43]**	-0.577 (0.126) [-4.54]**	-0.376 (0.159) [-2.363]**	-0.377 (0.124) [-3.030]**
LGOV			-0.558 (0.123) [-4.51]**	-0.545 (0.121) [-4.48]**	-0.215 (0.080) [-2.68]**	-0.186 (0.070) [-2.62]**	-0.203 (0.074) [-2.737]**	-0.202 (0.067) [-2.975]**
LOPEN					1.181 (0.111) [10.57]**	1.219 (0.100) [12.12]**	1.085 (0.118) [9.172]**	1.124 (0.111) [10.116]**
LRES							0.037 (0.010) [3.741]**	0.034 (0.008) [3.850]**
Constant	3.240 (0.455) [7.11]**	3.176 (0.453) [7.00]**	3.254 (0.459) [7.08]**	3.176 (0.446) [7.11]**	1.437 (0.310) [4.636]**	1.220 (0.258) [4.719]**	0.670 (0.337) [1.989]*	0.692 (0.260) [2.651]**
D(LGDP-1)	3.487 (0.935) [3.72]**	3.482 (0.883) [3.94]**	2.222 (0.794) [2.79]**	2.251 (0.763) [2.94]**				
D(LRES-1)							-0.068 (0.022) [-3.052]**	-0.069 (0.022) [-3.056]**
R ²	0.9968	0.9967	0.9972	0.9973	0.9987	0.9988	0.9988	0.9989

Notes: t-values in [] and standard errors in (). *significant at 5% level, ** significant at 1% level

The cointegration test also pointed to the inclusion of 1 lag in all the cases, even when tested separately. Using this information, the dynamic OLS method is used to estimate the relationship between the variables. Starting with only a bivariate model and expanding the model subsequently, the results are indicated in Table 4 (only the significant dynamic results are indicated). Note that to account for country heterogeneity, fixed effects are specified and both cross-section weighted and non-weighted results are presented. To ensure

contemporaneous values for the regressors, the White cross-section method is applied. This method treat the panel regression as a multivariate regression and compute White-type robust standard errors for the system of equations. The estimator is therefore robust to cross-equation (or contemporaneous) correlation and different error variances in each cross section (QMS, 2004).

The preliminary results found using only the dynamic OLS estimators are encouraging. In all the models, the relative GDP per capita is negative and significant, indicating towards a correct Balassa-Sameulson effect. An increase in the GDP thus leads to appreciation of the exchange rate via the Balassa-Sameulson effect. The coefficients found for relative GDP per capita is also in line with the estimates found in single equation models for South Africa (see for example MacDonald & Ricci, 2003 and Saayman, 2007) as well as other panel studies completed in other parts of the world. Government spending also interacts negatively with the exchange rate, indicating towards a more appreciated exchange rate that is associated with increased government spending. The more open the economy relative to South Africa's economy, the more depreciated the exchange rate is. These results are in line with the results of Maeso-Fernandez et al. (2004). The relative level of gross reserves present conflicting results. In the short-run dynamic side of the model, the result is as expected, with an increase in reserves leading to a more appreciated exchange rate. This is, however, not the case in the long-run part of the model. As such, this necessitates further investigation into the feasibility of gross reserves in the panel model for exchange rate determination.

5. CONCLUSION

The aim of this paper was to identify the determinants of the long run equilibrium exchange rate of the South African Rand, using a panel data approach. The panel consisted of the main trading partners of South Africa, namely the European Union, the United Kingdom, the United States and Japan. The currencies of these countries are also the main ingredients in nominal and real effective exchange rate of South Africa.

Using previous literature on exchange rate modelling and panel data techniques, the methodology underlying this paper is the behavioural equilibrium exchange rate approach. The methods employed include panel unit root tests, notably the Im Pesaran and Shin, Hadri as well as Levin, Lin & Chu tests, and the Pedroni and Kao panel cointegration tests. The coefficients were estimated using a dynamic OLS approach. The preliminary results of the estimations are encouraging in a number of ways. Firstly, the signs of almost all the variables included are correct and all the long run relationships are significant. Secondly, the coefficients of the variables are in line with previous time series coefficients found for South Africa, as well as with those of other panel studies conducted in other parts of the world.

Yet, the dynamic OLS method has its drawbacks, especially the degrees of freedom that is given up when more variables and more lags are included, and the robustness of these estimates should be tested further using fully modified OLS as well as pool mean group estimating techniques.

REFERENCES

- Aron, J; Elbadawi, I & Kahn, B. 1997. Determinants of the Real Exchange rate in South Africa, *Working Paper Series WPS/97-16*, University of Oxford, UK.
- Baffes, J; Elbadawi, IZ & O'Connell, SA. 1997. *Single-equation estimation of the equilibrium real exchange rate*, World Bank Working Paper No. 08/20/97. Washington DC.
- Balvers, R.J. & Bergstrand, J.H. 1997. Equilibrium real exchange rates: closed –form theoretical solutions and some empirical evidence, *Journal of International Money and Finance*, 16(3):345-366.
- Bayoumi, T., Clark, P., Symansky, S. and Taylor, M. 1994. The Robustness of exchange rate calculations to alternative assumptions and methodologies. In Williamson, J (ed). *Estimating Equilibrium Exchange Rates*. Washington DC: Institute for International Economics (pp. 19-59).
- Begg, D; Halpern, L and Wyplosz, C. 1999. Monetary and exchange rate policies, EMU and central and Eastern Europe, Forum Report on the Economic Policy Initiative No. 5, CEPR: London, EastWest Institute: New York, Prague.
- Candelon, B; Kool, C; Raabe, K & van Veen, T. 2007. Long-run real exchange rate determinants: Evidence from eight new EU member states, 1993-2003, *Journal of Comparative Economics*,
- Church, K.B. 1992. Properties of Fundamental exchange rate models of the UK economy, *National Institute Economic Review*, pp. 62-70. August. Clark & MacDonald 1999
- Clark, P.B. and MacDonald, R. 1998. Exchange rates and economic fundamentals: A Methodological comparison of BEERs and FEERs, *IMF Working Paper WP/98/67*. Washington DC: IMF.
- Coudert, V. 1999. Comment définir un taux de change d'équilibre pour pays émergents? *Economie Internationale*, No. 77, 1er trimestre, pp.45-65.
- De Broek, M & Slok, T. 2001. Interpreting real exchange rate movements in transition economies, IMF Working Paper No.56, May, Washington DC.
- Égert, B. 2002. Equilibrium real exchange rates in central Europe's transition economies: knocking on heaven's door. William Davidson Working Paper No. 480. The William Davidson Institute.
- Halpern, L & Wyplosz, C. 1997. Equilibrium exchange rates in transition countries, IMF Staff Papers, vol.44 (4), Dec., pp.430-461. Washington DC.
- Harris, R & Sollis, R. 2003. Applied time series modelling and forecasting. West Essex: Wiley.
- Kim, B-Y & Korhonen, I. 2005. Equilibrium exchange rates in transition countries: Evidence from dynamic heterogeneous panel models, *Economic Systems*, 29:144-162.
- Krajnyak, K & Zettelmeyer, J. 1998. Competitiveness in Transition economies: What scope for real appreciation? IMF staff papers No.45, June, pp309-362. Washington DC.
- MacDonald, R. 2001. Modelling the long-run real effective exchange rate of the New Zealand dollar, *Reserve Bank of New Zealand Discussion Paper series DP2002/02*, New Zealand.

- MacDonald, R & Ricci, L. 2003. Estimation of the equilibrium real exchange rate for South Africa, *IMF working paper*, IMF.
- Maeso-Fernandez, F; Osbat, C & Schnatz, B. 2004. Towards the estimation of equilibrium exchange rates for CEE acceding countries: Methodological issues and a panel cointegration perspective. Working Paper No. 353. European Central Bank.
- Maeso-Fernandez, F; Osbat, C & Schnatz, B. 2005. Pitfalls in estimating equilibrium exchange rates for transition economies, *Economic systems*, 29:130-143.
- Maeso-Fernandez, F; Osbat, C & Schnatz, B. 2006. Towards the estimation of equilibrium exchange rates for CEE acceding countries: Methodological issues and a panel cointegration perspective, *Journal of Comparative Economics*, 34:499-517.
- Martinez, C.M. 2003. The Structural Approach of a Natrex model on equilibrium exchange rates. Spain.
- Maurin, L. 2001. Fundamental determinants of RER for transition economies
- Piscitelli, L & Westaway, P. 2004. FEER computation: a model based approach. Bank of England: UK.
- Saayman, A. 2005. A FEER in South Africa's cap. Paper presented at the International Atlantic Economic Society conference, New York, USA, 7-9 October.
- Saayman, A. 2007. The real equilibrium Rand/US\$ exchange rate: A comparison of alternative measures. *International Advances in Economic Research*, June.
- Williamson, J. 1994. *Estimating Equilibrium Exchange Rates*. Institute for International Economics, Washington DC.
- Wren-Lewis S. 2003. *Estimates of equilibrium exchange rates for Sterling against the Euro*. HM Treasury. London.
- Zhang, Z. 2001. Real exchange rate misalignment in China: An empirical investigation, *Journal of Comparative Economics*, 29:80-94.

Figure 1: Variables included in the analysis

