Economic Issues, Vol. 21, Part 2, 2016

Investigating the oil price-exchange rate nexus: evidence from Africa 1970-2004

Simeon Coleman, Juan C Cuestas and Estefanía Mourelle[1]

ABSTRACT

In this paper, we aim to provide further insights into the importance of the real oil price as a determinant of real exchange rates, for a pool of African countries. While this relationship has been explored extensively for industrialised economies, African countries have received little attention. By means of cointegration techniques and nonlinear dynamics we find that, for some of these countries, shocks in the real price of oil are particularly important in determining the real exchange rates, even in the long run. These results are of interest for policymakers, to help them deal more effectively with exchange rate policy decisions aiming at promoting economic growth in the area.

1. INTRODUCTION

Recent years have seen a resurgence in the debate on the pros and cons of exchange rate policy amendments around the world. For example, the much debated policy implications of China's announcement of a number of changes to its foreign exchange regime on July 21, 2005, vis-à-vis reaction by US and other Asian economies, sparked an increase in the number of empirical studies examining the topic (Makin 2009). In the light of such examples, and the policy implications of exchange rate movements, analyses of exchange rates and their dynamics have become a cornerstone of the decision-making process in international markets. This can be of particular interest for emerging economies and in particular, African countries.

Two additional points are worthy of note. First, following Edwards (1989), the degree of exchange rate misalignment has been associated with the extent of over- or under-valuation of currencies and is typically used as a yardstick for economic integration in the real markets of countries (see also Coulibaly and Gnimassoun, 2013, and Kenan Lopcu *et al* 2013, for more recent contributions). Second, rigorous examination of the real exchange rate (hereafter RER) has become even more important in view of the crucial role

that misalignment has assumed in explaining economic underdevelopment (see Rodrik 1994; Yotopoulos 1996; and more recently Ibrahim *et al* 2012; Grekou 2015; and Tang 2015). In this vein, the RER may affect long run growth via sectoral allocation of resources and also influence export performance, hence the trade balance (see Hinkle and Montiel 1999). This is a crucial feature of RERs, which may serve as a means of promoting (or undermining) economic growth, a particularly important fact for developing economies (Razin and Collins 1999; and Faria and Leon-Ledesma 2003).

Surveys of exchange rate models point out that monetary models for RER determination are unsatisfactory, in particular in the post Bretton-Woods period (Backus 1984; Meese 1990; Mussa 1990; among others). The consensus is that a random walk model outperforms traditional models of the exchange rate. Although several studies have confirmed the important role of oil prices on the RER, the literature has focussed mainly on the US and other developed economies (see Chen and Chen 2007; Babajide 2014; Turhan *et al* 2014, and the references therein). While African countries form the bulk of developing economies, not much attention has been paid to the role of real oil prices on the RER of African countries. Individually, African economies are not among the highest consumers of oil, but collectively their imports and consumption of oil become significant.[2] The discussion of the potential effects of oil price shocks is not new. The 1970s 'oil crisis' stimulated substantial interest in this question and generated extensive research into how oil price shocks affect the economy (see Jiménez-Rodríguez and Sánchez 2005; Nugent and Switek 2013; Narayan *et al* 2014, among others).

Contributions to the literature on developing economies highlight how they are severely affected by external influences. Given that they are usually oil importing economies, oil price fluctuations become an important factor to consider. First, real oil prices might be a proxy for exogenous changes of the terms of trade, and arguably the most important exchange rate long run determinant (Amano and van Norden 1998). Second, movements in oil prices may be linked to wealth transfers among oil-importing and oil-exporting countries, i.e. to the balance of payments and international portfolio choices (Golub 1983; Ozturk *et al* 2008). Therefore, the effects of movements in oil prices may pass through different transmission channels.

This paper seeks to contribute to the empirical literature in this field and, on this basis, we propose the use of the real price of oil as the main long run determinant of RERs for a group of developing, specifically, African countries. We then investigate the evidence of a long run relationship between the countries' RERs and real oil prices. The remainder of the paper is organised as follows. The next section provides a brief overview of the literature and background. Section 3 describes the econometric methodology we employ. Section 4 presents the empirical evidence and preliminary analysis. Section 5 offers some relevant policy implications. Section 6 summarises the main findings and concludes.

2 Background and brief literature review

Typically, the two main sources of fluctuations in the RER are the financial markets and the real economy views. According to the former (*à la* Dornbusch's 1976 'disequilibrium approach') shocks in money markets lead to volatility in exchange rate markets as an equilibrating mechanism, particularly when prices are slow to adjust (Frankel and Rose 1996; Chen 2004). The second approach, the real economy view (*à la* Stockman 1980), attributes fluctuations in the RER to shocks in factors influencing output, such as government expenditure, labour supply or productivity (Zhou 1995; Bjornland 2004).

From an empirical point of view, Clarida and Galí (1994) use the Blanchard-Quah identification strategy to estimate the share of exchange rate variability that is attributable to different shocks, by using quarterly US/Canada, US/Germany, US/Japan, and US/UK real exchange rate data from 1974:Q3 to 1992:Q4. They find that real shocks can account for more than 50 per cent of the variance of real exchange rate changes over all time horizons. Similar results are obtained by Lastrapes (1992), who also uses the Blanchard-Quah approach but in a structural Vector Autoregression (VAR) framework.

Evans and Lothian (1993) and Rogoff (1996) claim that RER misalignment from fundamental equilibrium may be due to real shocks, among which supply shocks may be behind the empirical failure of the purchasing power parity (PPP) theory (Edwards 1987). This is corroborated by Gruen and Wilkinson (1994), who find that the RER of Australia can be explained by shocks to goods and services and real interest rate differentials. Moreover, Chen and Rogoff (2003), Cashin *et al* (2004) and Camarero *et al* (2008) find evidence of long run dependence of the RER on prices of primary products for some developing countries, which explains RER misalignment from the supply side. Among the different sources of real disturbances, such as oil prices, fiscal policy, and productivity shocks, it has been shown that oil price fluctuations play a major role in explaining real exchange rate movements (see Amano and van Norden 1998, amongst many others).

From the theoretical point of view, Neary (1988) and Blundell-Wignall and Gregory (1990) justify the role of real shocks, proxied by terms of trade, on long run RER behaviour. In the same spirit, Cashin *et al* (2004) find that the effect of commodity terms of trade is similar to the Balassa-Samuelson effect on the RER. To sum up, the key point lies in identifying the long run driver of the RER. By doing so, insights into the determinants of exchange rates will be gained, which will lead to a better understanding of the variable, as well as serve to help foreign exchange policy design.

There are a number of more recent studies which analyse the relationship between oil prices and exchange rates. For instance, Zhang *et al* (2008) use VAR, ARCH models and Granger causality to uncover the spillover effects of oil price movements on exchange rates for the US. In a similar vein, but for

a larger number of currencies, Reboredo (2012) finds evidence of a co-movement between exchange rates and oil prices, especially in the aftermath of the Global Financial Crisis, using correlation measures. See also Reboredo and Rivera-Castro (2013), Reboredo *et al* (2014) and Wu *et al* (2012) for related articles.

For oil producers distributed world wide Ahmad and Moran Hernández (2013), using nonlinear techniques, find mixed results on the long run relationship between oil prices and exchange rates.

For the case of African economies Salisu and Mobolaji (2013) analyse the transmission between oil prices and the nominal bilateral US-Nigeria exchange rate. These authors find the existence of breaks at the time of the start of the financial crisis and the Nigerian crisis, and the use of oil to hedge risk in Nigerian financial portfolios.

Against this background, we employ a simple model which allows us to study the relationship between real exchange rates and the oil price, for African economies.

3. Econometric methodology

3.1 Cointegration analysis

In order to explain the long run determinants of African RERs, we apply the Johansen cointegration approach (Johansen 1988; and Johansen and Juselius 1990). In addition, we test for the stability of the parameters by applying the Hansen and Johansen (1999) test for the long run parameters and loadings.

Although cointegration techniques might indeed reveal a long run relationship between African RERs and real oil prices, it will be characterised as a linear one. Given this fact, the following question immediately arises: do short-run deviations of exchange rates from their equilibrium state exhibit linear or nonlinear behaviour? The key point is that exchange rates might readjust to equilibrium in different ways, depending on the evolution of certain variable(s), so nonlinearities may affect the response of exchange rates to such deviations. In fact, detecting nonlinearities, i.e. investigating data-generating processes of inherently asymmetric realisations, has long been of interest to applied economists. More recently, a number of empirical works have found evidence of nonlinear evolution in observed economic series (for example van Dijk and Franses 1999; Öcal and Osborn 2000; Sensier *et al* 2002; Skalin and Teräsvirta 2002). In this vein, this is the focus of the next stage of the current investigation.

3.2 Nonlinear framework

3.2.1 The specification

The long run relationship between African exchange rates and real oil prices, revealed by cointegration techniques, are based upon a linear specification of

the dynamics. In practice, this restriction may be misplaced, and (non)linearity modelling may be more appropriate. The intuition is simple: assuming that the parameters on the relationship between real exchange rates and oil prices have not changed for these countries may be too strong. With the type of nonlinear models described below, we allow for the parameters to change depending on a shock, which is defined on an ad hoc basis. The analysis, then provides us with more flexibility when analysing the dynamics of exchange rates and oil prices. See for example Cuestas and Mourelle (2011), who estimated nonlinear models for African real exchange rates.

Amongst the most common nonlinear specifications, we have the Smooth Transition (ST) model, which is the framework we apply in this paper. STs belong to the family of state-dependent models where the data-generating process is a linear one that switches between a certain number of regimes according to some rule. This parameterisation has several advantages, including being flexible enough to capture different types of nonlinearity; standard nonlinear estimation techniques can be used; and there exists a well-defined modelling cycle in the literature (Granger and Teräsvirta 1993; Teräsvirta 1994, 1998; and van Dijk *et al* 2002, among others, describe STs in detail).

In this paper we resort to the widest generalisation of the ST model, the Smooth Transition Regression (hereafter, STR). This specification contains an endogenous structure, as well as exogenous variables. Let y_t be a stationary, ergodic process, and, without loss of generality, only one exogenous variable x_t. The STR model is defined as

$$y_t = w_t'\pi + (w_t'\theta)F(s_t;\gamma,c) + u_t \tag{1}$$

where $w_t = (1, y_{t-1},..., y_{t-p_1}; x_t, x_{t-1},..., x_{t-p_2})'$ is a vector of regressors, $\pi = (\pi_0, \pi_1,...,\pi_p)'$ and $\theta = (\theta_0, \theta_1,...,\theta_p)'$ are parameter vectors $p = (p_1 + p_2 + 1)$, and u_t is an error process, $u_t \sim Niid(0,\sigma^2)$. The transition variable, s_t, can be a lagged endogenous variable, an exogenous variable or just another variable. The function $F(s_t; \gamma, c)$ is the transition function, customarily bounded between 0 and 1, making the STR coefficients vary between π_j and $\pi_j + \theta_j$ (j=0,…,p) respectively. The transition function contains the slope parameter γ and the location parameter, c. The former points out how rapid the transition between the extreme regimes is, whilst the latter indicates the threshold between these regimes. The transition variable and the associated value of $F(s_t)$ determine the regime at each t.

The usual formulations for F are the logistic and the exponential function. A proper selection of F is a key issue in nonlinear analyses, since Logistic STR (LSTR) and Exponential STR (ESTR) models describe quite different types of behaviour. The logistic function implies extreme regimes associated with s_t values far above or below c, where dynamics may be different. In the expo-

nential case, the extreme regimes are related to low and high absolute values of s_t, with rather similar dynamics, which can be different in the transition period.

Accordingly, the exponential model appears to be the most suitable for describing the evolution of the exchange rates. The reason is that this specification permits incorporation of the location parameter into the equilibrium RER value, and the dynamics of the variable would vary depending on the distance from the equilibrium state. In the latter case, there would not be differences between largely overvalued or largely undervalued exchange rates.

Thus, two points arise. On the one hand, according to the debate in the introduction, we consider two main forces to be driving nonlinear behaviour in exchange rates, idiosyncratic components specific to international trade, and oil prices. On the other hand, for the purposes of this research, linear and STR Error Correction Models (ECM) will be set out, as they reflect short run and long run effects on the data.

4 Empirical Evidence

4.1 The data

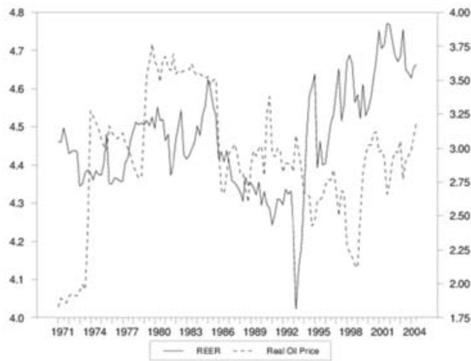
In this paper, we consider a sample of thirteen African countries: Burkina Faso, Cameroon, Ivory Coast, Kenya, Madagascar, Mauritius, Morocco, Nigeria, Rwanda, Senegal, Seychelles, South Africa and Togo. Data for real effective exchange rates (REER) are obtained from Bahmani-Oskooee and Gelan (2007), who construct the RER *vis-à-vis* the main trading partners, defined as the price of local currency in foreign currency, for each country, weighted by trade volumes.[3] By way of construction, a decrease in the REER reflects a real depreciation of the home country's currency. Real oil prices have been obtained by dividing the nominal oil price previously transformed into national currency ($P(oil)\, i$) by the corresponding Consumer Price Index (*CPI*) for each country($CPIi$), both series having been obtained from the International Monetary Fund's International Financial Statistics (IFS) database, for 1970Q1-2004Q4. The analysis has been carried out using the natural logs of both variables.

For the sake of brevity, the logs of the REER and real oil prices for only a sub-sample of the countries in our sample are presented in Figure 1. A cursory look at these figures suggests a degree of co-movement between the two variables, indicating a possible long-run relationship, which we later test empirically.

4.2 Long-run analysis

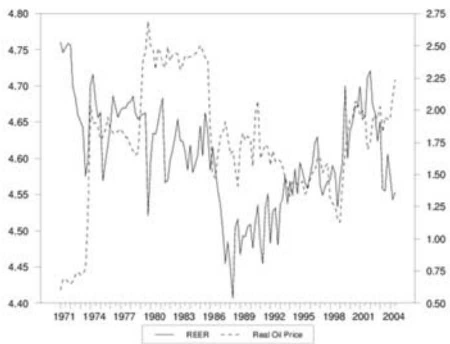
To proceed with the cointegration analysis, we specify the unrestricted VAR models in terms of lag length and statistical properties of the residuals. The bivariate model is based on the log of the REER (q_t) and the log of the real oil price (oil_t). The primary aim here is to analyse whether oilt explains the long run path of q_t. Also, it has been necessary to include some dummy variables,

Figure 1: Real Effective Exchange Rates (left axis) and Real Oil Prices (right axis), in logs



(a) Kenya

(b) Madagascar



(c) Mauritius

(d) Morocco

(e) Seychelles

(f) South Africa

and a shift restricted to the cointegration space given that some shocks did not cancel out in the cointegrating space.[4] The lag length for each VAR has been chosen by means of a goodness of residual tests specification. The baseline models were tested for misspecification using a variety of diagnostic statistics, which are summarised in Tables 1 and 2. We find that some normality and heteroskedasticity problems persist even after inclusion of the dummy variables. However, following Gonzalo (1994), the Johansen maximum likelihood estimation procedure is robust to normality and heteroskedasticity problems.

Table 1: Univariate misspecification tests

Country/ VAR(p)	*Variable*	*ARCH*	*Normality*	*Skewness*	*Kurtosis*
Burkina Faso	Δq_t	19.021 [0.000]	11.461 [0.003]	0.758	4.253
VAR(2)	Δoil_t	4.955 [0.175]	42.922 [0.000]	0.809	7.692
Cameroon	Δq_t	4.685 [0.096	28.053 [0.000]	0.615	6.118
VAR(2)	Δoil_t	8.663 [0.013]	51.806 [0.000]	1.040	9.193
Ivory Coast	Δq_t	0.007 [0.996]	43.292 [0.000]	1.562	7.247
VAR(2)	Δoil_t	8.463 [0.015]	56.753 [0.000]	0.930	9.041
Kenya	Δq_t	0.285 [0.594]	24.631 [0.000]	-1.226	6.716
VAR(1)	Δoil_t	2.293 [0.130]	53.706 [0.000]	1.035	9.284
Madagascar	Δq_t	0.571 [0.966]	73.895 [0.000]	-2.726	18.614
VAR(2)	Δoil_t	1.775 [0.777]	30.339 [0.000]	0.993	7.340
Mauritius	Δq_t	1.050 [0.902]	5.933 [0.051]	-0.421	3.851
VAR(2)	Δoil_t	4.332 [0.363]	37.176 [0.000]	0.768	7.179
Morocco	Δq_t	10.278 [0.113]	121.629 [0.000]	-0.082	10.473
VAR(6)	Δoil_t	5.048 [0.538]	29.503 [0.000]	1.190	7.899
Nigeria	Δq_t	8.596 [0.014]	6.683 [0.035]	0.226	3.942
VAR(2)	Δoil_t	0.094 [0.954]	146.256 [0.000]	2.811	15.585
Rwanda	Δq_t	4.838 [0.304]	15.897 [0.000]	0.904	4.481
VAR(4)	Δoil_t	5.724 [0.221]	46.379 [0.000]	0.968	8.531
Senegal	Δq_t	4.053 [0.542]	13.186 [0.001]	0.796	3.994
VAR(5)	Δoil_t	5.566 [0.351]	44.040 [0.000]	1.048	8.706
Seychelles	Δq_t	3.530 [0.832]	16.963 [0.000]	0.073	4.770
VAR(7)	Δoil_t	8.169 [0.318]	15.873 [0.000]	0.621	5.158
South Africa	Δq_t	18.094 [0.001]	127.674 [0.000]	-0.305	10.938
VAR(4)	Δoil_t	0.774 [0.942]	62.747 [0.000]	0.564	8.170
Togo	Δq_t	21.571 [0.001]	22.033 [0.000]	0.344	5.293
VAR(6)	Δoil_t	3.653 [0.724]	34.238 [0.000]	1.076	8.013

Note: P-values are reported in brackets.

Table 2: Multivariate misspecification tests

Country	Test	Statistic	Value
Burkina Faso	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(120)=160.523[0.008]$
		LM(1):	$\chi^2(4)=2.754[0.600]$
		LM(2):	$\chi^2(4)=6.113[0.191]$
	Test for Normality:		$\chi^2(4)=58.543[0.000]$
	Test for ARCH:	LM(1):	$\chi^2(9)=30.050[0.000]$
		LM(2):	$\chi^2(18)=37.417[0.005]$
Cameroon	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(124)=131.923[0.296]$
		LM(1):	$\chi^2(4)=3.217[0.522]$
		LM(2):	$\chi^2(4)=4.846[0.303]$
	Test for Normality:		$\chi^2(4)=86.902[0.000]$
	Test for ARCH:	LM(1):	$\chi^2(9)=21.501[0.011]$
		LM(2):	$\chi^2(18)=23.394[0.176]$
Ivory Coast	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(124)=141.357[0.136]$
		LM(1):	$\chi^2(4)=4.617[0.329]$
		LM(2):	$\chi^2(4)=3.924[0.416]$
	Test for Normality:		$\chi^2(4)=113.144[0.000]$
	Test for ARCH:	LM(1):	$\chi^2(9)=15.648[0.075]$
		LM(2):	$\chi^2(18)=20.230[0.320]$
Kenya	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(128)=142.164[0.185]$
		LM(1):	$\chi^2(4)=9.537[0.049]$
		LM(2):	$\chi^2(4)=3.994[0.407]$
	Test for Normality:		$\chi^2(4)=83.606[0.000]$
	Test for ARCH:	LM(1):	$\chi^2(9)=3.171[0.957]$
		LM(2):	$\chi^2(18)=6.668[0.993]$
Madagascar	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(112)=134.564[0.072]$
		LM(1):	$\chi^2(4)=2.356[0.671]$
		LM(2):	$\chi^2(4)=0.776[0.942]$
	Test for Normality:		$\chi^2(4)=102.320[0.000]$
	Test for ARCH:	LM(1):	$\chi^2(9)=1.184[0.999]$
		LM(2):	$\chi^2(18)=0.052[1.000]$
Mauritius	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(112)=124.982[0.189]$
		LM(1):	$\chi^2(4)=6.583[0.160]$
		LM(2):	$\chi^2(4)=4.985[0.289]$
	Test for Normality:		$\chi^2(4)=40.218[0.000]$
	Test for ARCH:	LM(1):	$\chi^2(9)=11.450[0.246]$
		LM(2):	$\chi^2(18)=17.819[0.468]$

...cont

Morocco	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(104)$=100.457[0.580]
		LM(1):	$\chi^2(4)$=3.011[0.556]
		LM(2):	$\chi^2(4)$=4.445[0.349]
	Test for Normality:		$\chi^2(4)$=153.533[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=31.400[0.000]
		LM(2):	$\chi^2(18)$=34.567[0.011]
Nigeria	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(124)$=137.499[0.192]
		LM(1):	$\chi^2(4)$=3.758[0.440]
		LM(2):	$\chi^2(4)$=1.040[0.904]
	Test for Normality:		$\chi^2(4)$=148.843[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=7.164[0.620]
		LM(2):	$\chi^2(18)$=10.300[0.922]
Rwanda	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(112)$=115.871[0.382]
		LM(1):	$\chi^2(4)$=4.984[0.289]
		LM(2):	$\chi^2(4)$=10.660[0.031]
	Test for Normality:		$\chi^2(4)$=63.852[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=9.556[0.388]
		LM(2):	$\chi^2(18)$=19.791[0.345]
Senegal	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(108)$=112.555[0.363]
		LM(1):	$\chi^2(4)$=2.146[0.709]
		LM(2):	$\chi^2(4)$=14.088[0.007]
	Test for Normality:		$\chi^2(4)$=58.762[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=5.043[0.831]
		LM(2):	$\chi^2(18)$=12.840[0.801]
Seychelles	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(100)$=82.320[0.901]
		LM(1):	$\chi^2(4)$=3.584[0.465]
		LM(2):	$\chi^2(4)$=3.165[0.531]
	Test for Normality:		$\chi^2(4)$=33.227[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=24.539[0.004]
		LM(2):	$\chi^2(18)$=25.503[0.112]
South Africa	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(112)$=109.188[0.558]
		LM(1):	$\chi^2(4)$=2.100[0.717]
		LM(2):	$\chi^2(4)$=23.155[0.000]
	Test for Normality:		$\chi^2(4)$=192.494[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=44.143[0.000]
		LM(2):	$\chi^2(18)$=48.366[0.000]
Togo	Tests for Autocorrelation:	Ljung-Box(33):	$\chi^2(104)$=112.483[0.268]
		LM(1):	$\chi^2(4)$=9.658[0.047]
		LM(2):	$\chi^2(4)$=4.034[0.401]
	Test for Normality:		$\chi^2(4)$=65.254[0.000]
	Test for ARCH:	LM(1):	$\chi^2(9)$=21.067[0.012]
		LM(2):	$\chi^2(18)$=33.575[0.014]

Note: P-values are reported in brackets.

Given that we have two variables, there can be a maximum of one cointegrating vector.[5] Table 3 reports the results of the Johansen stationarity tests and suggest that for Ivory Coast, it is not possible to reject the null of stationarity for at least one of the variables, the real price of oil. Therefore, for this country, we conclude that there is no long run relationship between REER and real oil prices.

Testing for the existence of a cointegrating relationship, Table 4 reports results of Johansen's Trace test. The results imply that, in most cases, the null of a unique cointegrating relationship is rejectedthe exceptions being Kenya, Madagascar, Mauritius, Morocco, Seychelles and South Africa.[6] Hence, hereafter the analysis focuses on these six countries, given that a stable relationship between oil prices and the REER cannot be found for the other countries.

Next, we test for weak exogeneity of the REER and real price of oil, we find that in most cases the hypothesis that the real price of oil is weakly exogenous cannot be rejected at conventional significance levels.[7] The only exception is Seychelles, where the hypothesis that real oil prices are weakly exogenous is rejected. One interpretation may be that, for Seychelles, the extent to which the real price of oil in national currency depends on the real exchange rate is high enough to make the real oil prices endogenous. We note that while Kenya, Madagascar and Mauritius are not oil-producers, Morocco and South Africa produce some oil. Nonetheless, with the exception of Mauritius, all these countries export some oil and petroleum products.[8] However, Seychelles is somewhat different, in that the re-export of petroleum products feature heavily in its exports. The relative importance of the real exchange rate in this process, therefore, may explain why we do not find evidence of (weak) exogeneity in the real price of oil.

The cointegrating relationships are reported in Table 5. On the one hand, for Morocco and South Africa, the sign on the parameter for the oil price (oilt) is negative, which implies that a rise in oil prices leads to a depreciation in their currency, in real terms. On the other hand, for Kenya, Madagascar, Mauritius and Seychelles the picture is different, where an increase in oil prices appreciates the national currency in real terms. Based on the relative oil-production status of these countries, these results appear counter to the expected effect. However, this 'reverse' effect is neither unusual nor counter-intuitive, as noted by authors including Amano and van Norden (1995, 1998) who suggest possible reasons for similar findings for Canada and the US respectively.

We suggest here that while an increase in the price of oil is more likely to lead to higher wealth transfer from the relative oil importers i.e. Kenya, Madagascar, Mauritius and Seychelles, it may also be argued that an increase in oil prices leads to an adverse shift in the aggregate supply curve which in turn raises aggregate prices and reduces output. This 'Dutch disease' situation has been reported as a stylised fact within the literature, whereby a depreciation of the currency in real terms may affect the export sector, sinceproducts exported by the country will be more expensive in foreign currency.

Table 3: Tests for stationarity

Country	q_t	oil_t
Burkina Faso	[0.018] 5.632	[0.023] 5.162
Cameroon	[0.023] 5.195	[0.002] 9.170
Ivory Coast	[0.068] 3.331	[0.146] 2.117
Kenya	[0.021] 5.350	[0.000]22.060
Madagascar	[0.072] 3.245	[0.000]12.668
Mauritius	[0.039] 4.267	[0.070] 3.274
Morocco	[0.009] 6.858	[0.051] 3.820
Nigeria	[0.005] 7.849	[0.018] 5.606
Rwanda	[0.084] 2.987	[0.019] 5.535
Senegal	[0.047] 3.962	[0.009] 6.766
Seychelles	[0.000]14.654	[0.063] 3.463
South Africa	[0.035] 4.448	[0.057] 3.623
Togo	[0.004] 8.465	[0.017] 5.669

Note: P-values are reported in brackets.

Table 4: Trace test for the cointegration rank

Country	p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
Burkina Faso	2	0	0.122	23.664	23.019	27.134	0.122	0.142
	1	1	0.046	6.328	6.141	13.020	0.409	0.429
Cameroon	2	0	0.120	22.847	22.234	27.134	0.147	0.169
	1	1	0.043	5.832	5.618	13.020	0.464	0.489
Ivory Coast	2	0	0.089	18.537	118.025	27.134	0.356	0.389
	1	1	0.045	6.104	5.667	13.020	0.433	0.483
Kenya	2	0	0.209	38.362	38.129	26.953	0.001	0.001
	1	1	0.050	6.869	6.856	12.965	0.365	0.366
Madagascar	2	0	0.177	35.575	34.050	26.415	0.003	0.004
	1	1	0.074	10.084	9.883	12.840	0.142	0.152
Mauritius	2	0	0.097	18.675	17.851	20.164	0.081	0.104
	1	1	0.040	5.300	5.066	9.142	0.261	0.286
Morocco	2	0	0.134	30.142	30.142	26.391	0.016	0.016
	1	1	0.086	11.567	11.567	12.830	0.082	0.082
Nigeria	2	0	0.089	16.635	16.217	27.134	0.486	0.516
	1	1	0.031	4.191	3.978	13.020	0.669	0.696
Rwanda	2	0	0.104	21.952	20.894	27.214	0.183	0.229
	1	1	0.056	7.510	7.227	13.046	0.294	0.318
Senegal	2	0	0.104	20.010	20.010	27.258	0.275	0.275
	1	1	0.044	5.787	5.787	13.060	0.460	0.460
Seychelles	2	0	0.156	27.906	27.906	26.387	0.032	0.032
	1	1	0.048	6.249	6.249	12.827	0.471	0.471
South Africa	2	0	0.119	26.812	26.812	26.395	0.044	0.044
	1	1	0.077	10.373	10.373	12.832	0.128	0.128
Togo	2	0	0.107	18.937	18.937	27.304	0.337	0.337
	1	1	0.033	4.332	4.332	13.076	0.636	0.636

Note: The symbol * represents bartlett corrections.

Table 5: Identified cointegrated vectors

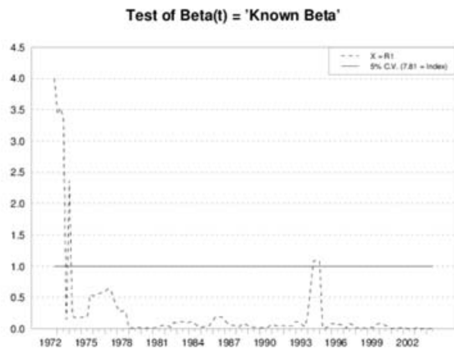
Kenya	q_t=4.176+0.258ds932+0.076oil_t
Madagascar	q_t=4.874-0.642ds862+0.037oil_t
Mauritius	q_t=4.501+0.044oil_t
Morocco	q_t=4.997-0.289ds852-0.205oil_t
Seychelles	q_t=3.582+0.899ds851+0.682oil_t
South Africa	q_t=4.806-0.164ds853-0.051oil_t

Darby (1982) argues that with an increase in inflation, the domestic interest rate is likely to be increased as a policy response. There is likely to be an inflow of foreign capital in response to a rise in the domestic interest rate, leading to an appreciation of the domestic currency. Moreover, with the higher inflow of wealth into the oil exporting nations, the resulting impact on the trade balance is ambiguous. A resulting higher level of imports from and spending on these oil importing countries would lead to an improved trade balance and an appreciation in the domestic currency.

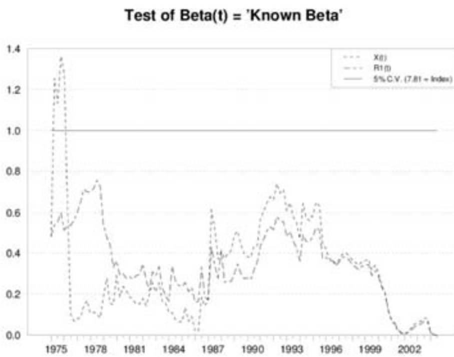
The dummy variables appear to capture adequately any significant incidents in the countries. For example, Morocco's policy actions in 1985 to tackle their heavy debt burden, including a series of devaluations of the Dirham, is captured. The negative relationship captured by the cointegrating vector for Morocco also points to the effort put in by the Moroccan authorities to minimise the appreciation of the currency i.e. aiming to minimise the 'Dutch disease' effect on their exports.[9] As shown is Figure 1 (d), there is a general trend towards the depreciation of the currency during the period analysed, which is particularly strong during the first half of the sample period. Similarly, South Africa's major financial crisis in 1985, following the imposition of a state of emergency, and the resulting loss of confidence on the international front, leading to the worst devaluation of the Rand, is also captured. Similarly, the Central Bank of Kenya's depreciation of the shilling by 85 per cent and policy moves towards liberalisation in 1993, and Madagascar's 20 per cent devaluation of the Malagasy Ariary in 1986, also appear to be adequately captured.

Figure 2 provides a graphical representation of the recursive Hansen and Johansen (1999) stability tests for the cointegration relationship. Bearing in mind that the graphical representations of the tests are, during most of the sample period, below the critical level of 1, we can conclude that the relationships identified in Table 5 are globally stable. In the case of Mauritius and Morocco some minor instability is evident, therefore we should consider these elasticities as average figures for the whole sample.[10]

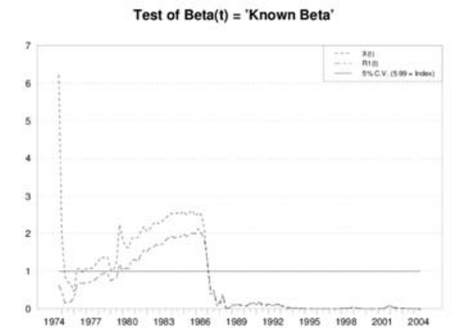
Figure 2: Structural stability tests



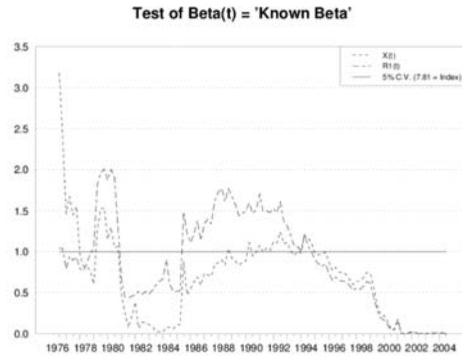
(a) Kenya



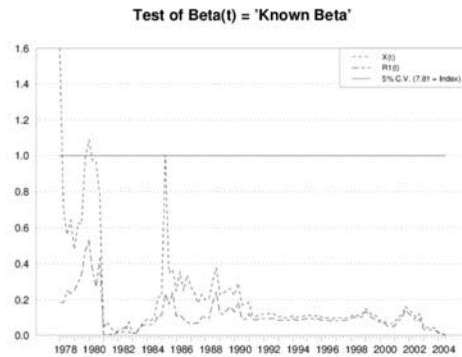
(b) Madagascar



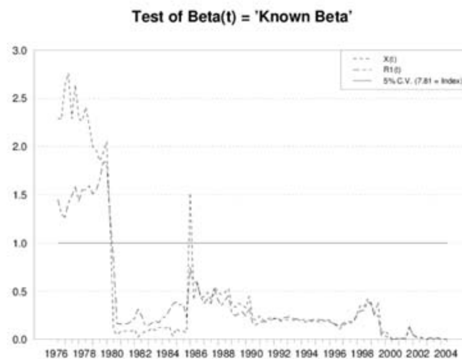
(c) Mauritius



(d) Morocco



(e) Seychelles



(f) South Africa

4.3 Nonlinear dynamics

4.3.1 Detecting nonlinearities

The modelling procedure begins with the linear specification that describes the behaviour of the exchange rates for those countries where a cointegration relationship is found. Two equations, one for the exchange rate and the other for the oil price, are estimated in the only case where none of these variables are exogenous. The maximum lag order (*p*) of the variables is the one considered in the cointegration analysis (i.e. 1 in Kenya; 2 in Madagascar and Mauritius; 4 in South Africa; 6 in Morocco; 7 in Seychelles). In addition to the first difference of (the logarithm of) REERs and real oil prices, we introduce variation in the dummy variable and the error correction term at *t*-1. The constant term is also included in the cointegration relationship.

Linear models are estimated by OLS with all parameters introduced initially, but then we successively exclude those with the lowest t-values (the limit is 1.6). For Seychelles we find that neither the REERs nor real oil prices are exogenous. We thus estimate equations for both variables. The exogeneity of real oil prices in Kenya, Madagascar, Mauritius, Morocco and South Africa leads to only one model for the exchange rates.[11] Upon obtaining the linear models, we then test whether there is evidence of the type of nonlinear behaviour generated by STRs.

It is worth pointing out at this point that the linearity test process consists of completing a sequence of auxiliary regressions. Owing to the fact that we have an adequate number of observations, we use the so-called *unconditional* approach. This is based on the notion that for each transition variable candidate, the transition lag *d* is unknown. The transition variable is assumed to be the linear combination $\sum_{i=0,1}^{p} \upsilon_i s_{t-i}$, where $\upsilon' = (0...1...0)'$ is a selection vector with the only unit element corresponding to the transition lag.[12] The transition variables taken into account are the differences of (the logarithm of) REERs and real oil prices, and the error correction term. The transition lag *d* goes from 0 or 1 to the maximum *p* contemplated in each country. For increased flexibility, we permit the transition function to be either logistic or exponential, even in the case of exchange rates (although the exponential function is deemed to be the most appropriate for this variable).

Table 6 presents the p-values of the linearity tests for the exchange rates in all countries and the oil prices in Seychelles. Rejection of linearity is stronger when dealing with oil prices, for both types of transition function. As can be appreciated, the evidence of nonlinear behaviour in the two variables under study is not overwhelming, but it is considerable at a 0.10 significance level. As the results are not conclusive for all countries, we follow the aforementioned strategy of an extensive search of STR models for the REERs and, where necessary, the real oil prices.

Table 6: Linearity tests against smooth transition regression (p-values)

	Transition variables					
	Δq_t		Δoil_t		ec_{t-1}	
	LSTR	ESTR	LSTR	ESTR	LSTR	ESTR
Kenya - q_t	0.0017	0.0009	0.2837	0.5313	0.9527	0.8138
Madagascar - q_t	0.6558	0.0303	0.0019	0.0001	0.9963	0.9788
Mauritius - q_t	0.4986	0.3295	0.3263	0.0634	0.7714	0.1439
Morocco - q_t	0.1487	0.1939	0.4589	0.6508	0.2916	0.2938
Seychelles - q_t	0.0750	0.2996	0.0362	0.0047	0.1324	0.2662
Seychelles - oil_t	0.0729	0.1349	0.0343	0.0591	0.0809	0.1300
South Africa - q_t	0.0100	0.0002	0.0001	0.0013	0.0214	0.0003

4.3.2 Nonlinear modelling

Given the linear long run relationship exchange rates and oil prices, the empirical evidence suggests nonlinear behaviour in the short-run deviations of both variables from equilibrium. We achieve valid STR-ECMs for the exchange rates in all six countries; and for the oil prices in only Seychelles. The estimated models are reported in Table 7, together with descriptive statistics and misspecification tests. The descriptive statistics presented are the residual standard error(s) and the variance ratio of the residuals from the nonlinear model and the linear specification (s^2/s_L^2). With regard to the misspecification tests, those employed are the test of no Autoregressive Conditional Heteroskedasticity (ARCH) with four lags and the three specific tests proposed by Eitrheim and Teräsvirta (1996).[13]

Table 7: Estimated STR models

KENYA

$$\Delta q_t = \underset{(0.06)}{0.17}\,\Delta oil_t - \underset{(0.02)}{0.09}\,ec_{t-1} - \underset{(0.05)}{0.22}\,\Delta ds9302 + \left(\underset{(0.12)}{-0.49}\,\Delta oil_t - \underset{(0.02)}{0.09}\,ec_{t-1}\right)\times$$
$$\left[1 - exp\left\{-\underset{(0.38)}{0.64}\times 303.12\left(\Delta q_{t-1} + \underset{(0.01)}{0.04}\right)^2\right\}\right] + u_t$$

s=0.04; s^2/s_L^2 = 0.83 ; ARCH=0.74 (0.56); AUTO=1.40 (0.24); NL=1.40 (0.16); PC=0.60 (0.96)

MADAGASCAR

$$\Delta q_t = \underset{(0.20)}{1.15}\Delta oil_t - \underset{(0.02)}{0.13}ec_{t-1} + \left(\underset{(0.20)}{1.15}\Delta oil_t - \underset{(0.02)}{0.13}ec_{t-1}\right)\times$$
$$\left[1 - exp\left\{-\underset{(12.61)}{29.53}\times 31.43\left(\Delta oil_{t-2} + \underset{(0.01)}{0.13}\right)^2\right\}\right] + u_t$$

s=0.08; s^2/s_L^2 = 0.78 ; ARCH=0.11 (0.98); AUTO=1.60 (0.18); NL=1.63 (0.06); PC=1.05 (0.42)

...cont

MAURITIUS

$$\Delta q_t = \underset{(0.04)}{0.11}\Delta q_t + \underset{(0.05)}{0.12}\Delta oil_t + \underset{(0.08)}{0.22}\Delta oil_{t-1} - \underset{0.02}{0.06}ec_{t-1} - \underset{(0.03)}{0.13}\Delta ds7904 +$$

$$\left(-\underset{(0.04)}{0.11}\Delta q_{t-1} - \underset{(0.08)}{0.22}\Delta q_{t-2} - \underset{(0.05)}{0.13}\Delta oil_t - \underset{(0.08)}{0.20}\Delta oil_{t-1} - \underset{(0.02)}{0.06}ec_{t-1}\right) \times \left[1 - exp\left\{-\underset{(20.31)}{29.08} \times 168.35\left(ec_{t-1} - \underset{(0.003)}{0.03}\right)^2\right\}\right] + u_t$$

s=0.03; s^2/s_L^2 = 0.86; ARCH=0.32 (0.86); AUTO=0.54 (0.71); NL=1.27 (0.21); PC=0.47 (0.99)

MOROCCO

$$\Delta q_t = \underset{(0.20)}{0.36}\Delta q_{t-1} + \underset{(0.18)}{0.52}\Delta oil_{t-6} - \underset{0.02}{0.05}ec_{t-1} - \underset{(0.03)}{0.09}\Delta ds8502 +$$

$$\left(-\underset{(0.23)}{0.81}\Delta q_{t-1} - \underset{(0.28)}{0.73}\Delta q_{t-6} - \underset{(0.02)}{0.05}ec_{t-1}\right) \times \left[1 - exp\left\{-\underset{(1.32)}{2.21} \times 40.92\left(\Delta oil_{t-2} - \underset{(0.01)}{0.06}\right)^2\right\}\right] + u_t$$

s=0.03; s^2/s_L^2 = 0.86; ARCH=0.23 (0.92); AUTO=1.42 (0.23); NL=1.43 (0.09); PC=1.63 (0.09)

SEYCHELLES

$$\Delta q_t = \underset{(0.06)}{0.11}ec_{t-1} + \underset{(0.05)}{0.22}\Delta ds8501 + \left(-\underset{(0.04)}{0.09}\Delta oil_{t-7} - \underset{(0.07)}{0.17}ec_{t-1}\right) \times$$

$$\left[1 - exp\left\{-\underset{(6.27)}{6.96} \times 4.43\left(\Delta oil_{t-2} - \underset{(0.02)}{0.07}\right)^2\right\}\right] + u_t$$

s=0.05; s^2/s_L^2 = 0.92; ARCH=0.52 (0.72); AUTO=0.72 (0.58); NL=1.50 (0.06); PC=0.50 (0.98)

$$\Delta oil_t = -\underset{(0.07)}{0.19}\Delta oil_{t-5} + \underset{(0.08)}{0.17}\Delta oil_{t-6} - \underset{(0.23)}{0.41}\Delta q_{t-1} + \underset{0.03}{0.13}ec_{t-1} - \underset{(0.13)}{0.20}\Delta ds8501 +$$

$$\left(\underset{(0.14)}{0.72}\Delta oil_{t-1} - \underset{(0.36)}{0.92}\Delta q_{t-4} + \underset{0.03}{0.13}ec_{t-1}\right) \times \left[1 - exp\left\{-\underset{(15.80)}{13.70} \times 347.70\left(\Delta q_{t-6} - \underset{(0.01)}{0.01}\right)\right\}\right]^{-1} + u_t$$

s=0.13; s^2/s_L^2 = 0.86; ARCH=1.95 (0.11); AUTO=2.99 (0.02); NL=1.43 (0.09); PC=1.12 (0.43)

SOUTH AFRICA

$$\Delta q_t = \underset{(0.04)}{0.07}\Delta oil_{t-1} - \underset{(0.08)}{0.29}\Delta ds8503_{t-6} + \left(-\underset{0.12}{0.22}\Delta oil_{t-2} - \underset{0.31}{0.71}ec_{t-1}\right) \times$$

$$\left[1 - exp\left\{-\underset{(0.81)}{1.05} \times 38.56\left(\Delta oil_{t-4} - \underset{(0.02)}{0.02}\right)^2\right\}\right] + u_t$$

s=0.08; s^2/s_L^2 = 0.92; ARCH=1.10 (0.36); AUTO=0.36 (0.83); NL=1.38 (0.12); PC=1.31 (0.15)

Notes: Δq_t stands for the REER in first differences; Δoil_t for the oil price in first differences; ec_t for the error correction term; Δdx for the variation of the step dummy variable at time *x*. Values under regression coefficients are standard errors of the estimates; *s* is the residual standard error; s^2/s_L^2 is the variance ratio of the residuals from the nonlinear model and the best linear regression; ARCH is the statistic of no ARCH based on four lags; AUTO is the test for residual autocorrelation of order 4; NL is the test for no remaining nonlinearity; PC is a parameter constancy test. Numbers in parentheses after values of ARCH, AUTO, NL and PC are *p*-values.

First, focusing on the modelling of the exchange rates, variations depend on their own recent history only in some countries (Mauritius and Morocco) and on the changes in oil prices in almost all cases (the exception is Morocco). Remarkably, movements in the exchange rates appear to react to deviations from the long run state in all 6 countries. The dynamics of the dummy variables are also present in the models.

We find that the transition between regimes is an exponential one in the case of the exchange rates, which fits with the findings in the literature (see Michael *et al* 1997; Taylor and Peel 2000). The variations of the oil prices determine the nonlinear behaviour of the exchange rates in 4 out of 6 countries; the own past values of the exchange rate growth and their deviations from the equilibrium path are the source of nonlinearities in Kenya and Mauritius, respectively.

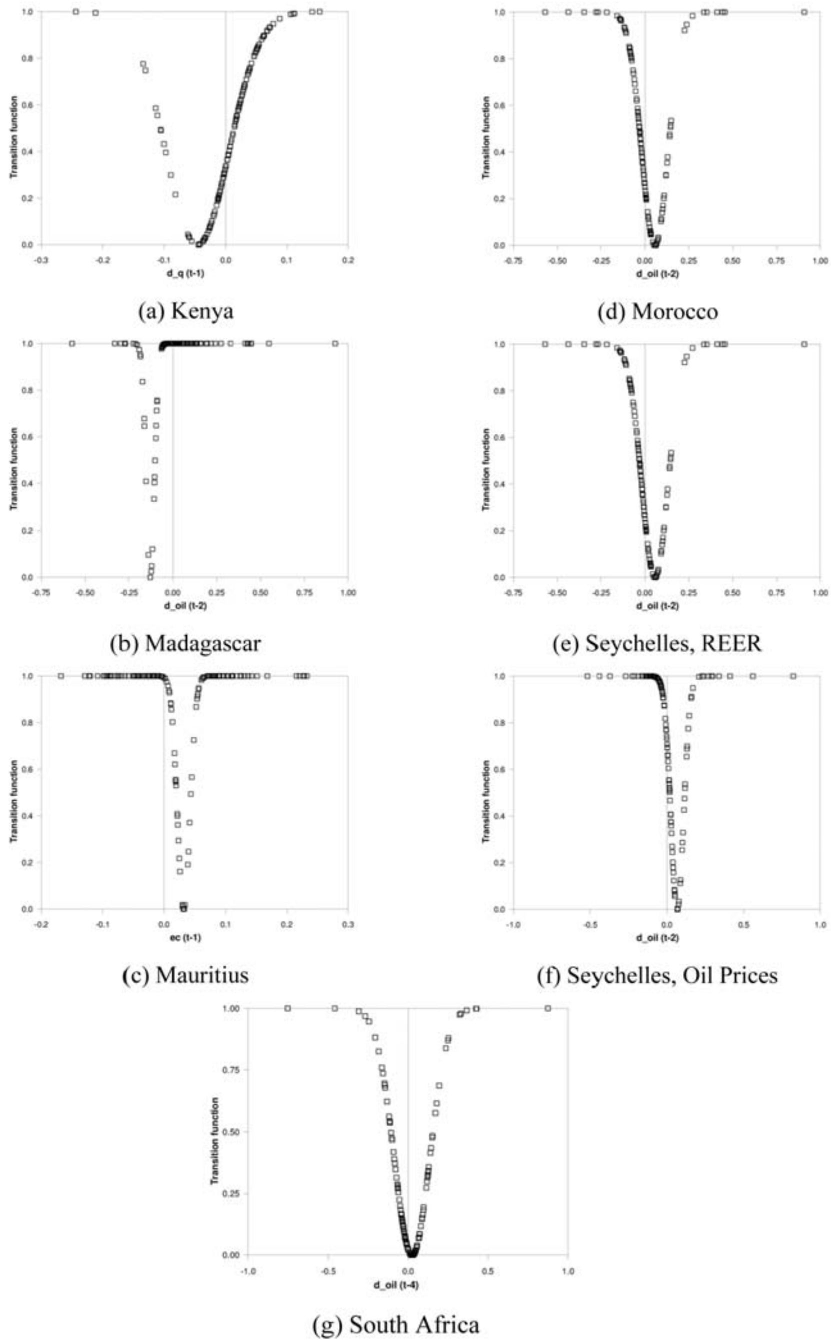
Figure 3 presents the estimated transition functions. Madagascar, Morocco, Seychelles and South Africa show two extreme regimes associated with the changes in the prices of oil, the inner regime for an (approximately) null growth and the outer regime for (larger) positive and negative values. In Kenya the extreme regimes are related to (approximately) null and large (positive and negative) variations in the exchange rates; most observations lie to the right of the location parameter, so that the function mimics a logistic one in this country. Mauritius presents an inner regime for values of the error correction term reasonably close to zero and an outer regime covering the remaining (positive and negative) values. The asymmetric evolution is clearly observable in all countries; the higher the absolute deviations from the corresponding threshold, the more pronounced the reaction of the exchange rates.

The exchange rates appear to evolve more rapidly from one extreme regime to the other in Madagascar, Mauritius and Seychelles than in Kenya, Morocco and South Africa. That is, the exchange rates seem to be more sensitive to shocks in the first set of countries than in the second, as they react in a more immediate way. This is unsurprising, given that the first set of countries are, within the sample, most dependent on imported oil, and with low nominal GDPs (see World Economic Outlook Databases), are therefore likely to be more susceptible to oil price shocks.

In fact, the abrupt regime changes we observe suggest the need for threshold specifications, strengthening the importance of employing STR models. According to the validation tests, there is no evidence of misspecification in the proposed ESTR models for the exchange rates, so one may conclude that they are adequate. A fact to emphasise is the high explanatory power of the nonlinear models compared with the linear regressions. Further, the variance ratios indicate that the estimated STRs explain 8 to 22 per cent of the residual variance of the linear specifications in all six countries.

Focusing now on oil prices in the case of Seychelles, their growth displays dependence on their own past values and on the evolution of the exchange rate; the deviations from the equilibrium path also influence the

Figure 3: Estimated STAR functions



(a) Kenya (d) Morocco

(b) Madagascar (e) Seychelles, REER

(c) Mauritius (f) Seychelles, Oil Prices

(g) South Africa

behaviour of these prices, as well as the dynamics of a dummy variable for the first quarter of 1985.

The transition function is logistic and is determined by variations in the exchange rate; oil price growth shows different dynamics for negative (lower regime) and positive (upper regime) exchange rate variations. As shown in Figure 3, the observations display a broadly equal distribution, giving rise to a clear representation of a logistic function. Following the validation stage, there are no indications of misspecification in the nonlinear model. Moreover, according to the variance ratio, the STR model explains 14 per cent of the residual variance of the linear regression. The key finding is the nonlinear nature of the exchange rate dynamics in all our countries, and of oil prices in the only case where this variable is not exogenous. The underlying factors in the asymmetric evolution of the exchange rates in most countries are the movements in the price of oil; the dependence of these economies on this product contributes to a large extent to this.

In the framework of our analysis, a shock in the oil price has two basic implications: an immediate variation in the price of oil, and an alteration in the long run relationship with exchange rates. These two effects must be taken into account as their relevance, or weight, would differ across countries. Interestingly, the relationship "exchange rates-oil prices" is not only mirrored in the dynamic structure of the exchange rates in the 6 countries (and the oil prices in Seychelles), but also in the transition variable (Mauritius). With regard to oil prices in Seychelles, the exchange rate dynamics appear to cause nonlinear effects in their behaviour.

5 Policy implications

The importance of oil price movements in informing policy formulation is underscored by the scope of literature on the topic. Assessment has been from various perspectives, including the impact on inflation (for example, Kilian and Lewis 2011); management of financial risk (for example, Zhang *et al* 2008); and the real economy. In this section, based on our analyses, we contribute to the literature by identifying and presenting some policy implications of real oil price movements for REERs in the 13 African countries in our sample. We highlight a few noteworthy issues below.

First, of the 13 countries in our sample, our inability to find a long-run relationship between REER and real oil prices for any of the countries in the *Communauté Financiére Africaine* (CFA) Franc zone is relevant and suggests that, for these countries, other determinants are more important than oil price. Moreover, such findings of asymmetry would have been theoretically difficult to justify, given the provisions of Article 10 of the Constitution for the *Banque des Etats de l'Afrique Centrale* (BEAC), and Article 6 of the *Union Economique et Monétaire Ouest Africaine* (UEMOA) Accord, both of which provide for freedom of capital flows across the zone. Furthermore, with policy

coordination and fixed nominal exchange rates being foundations of the Union, evidence of heterogeneity in long-run behaviour would pose significant difficulties for (monetary) policy formulation if price stability and provisions of the Constitution are paramount. Differences in price effects, *vis-à-vis* the unrestricted flow of capital across the zone, would skew money supply from some countries to the detriment of economic growth in others. In such a case, in order to maintain the peg, there would have been the need for the uniform monetary policy to be augmented with country-specific measures, which may include increasing government intervention in energy regulation, or even planned transfer of funds, as required.[14]

Second, given the well-documented empirical links between REER (misalignments) and economic growth, increased knowledge about oil price movements should better inform policymakers', particularly in developing countries, on projections about macroeconomic aggregates and welfare. More specifically, for the six countries where we find evidence of a long-run relationship, i.e. Kenya, Madagascar, Mauritius, Morocco, the Seychelles and South Africa, an explicit inclusion of world oil price movements is crucial in economic policy formulation. For example, considering the likely impact of oil price shocks on each of these countries' attempts to minimise their central bank's loss function (whether based on inflation, output, or some weighted combination of the two), it is likely that limited knowledge of the potential REER misalignment implications would have important detrimental knock-on effects on welfare and economic growth.

Third, our finding of a long run relationship between REER and real oil prices for South Africa and Morocco, but not for both Cameroon and Nigeria, both of which produce and export some oil, suggest that being an oil producer per se does not imply the existence of a long-run relationship. Interestingly, however, our results from Table 5 suggest that once the long-run relationship exists, then the oil production status becomes relevant. Hence, for these six countries the main oil producers, i.e. Morocco and South Africa, a positive oil price shock will have a negative long-run impact on the REER, whereas in the case of the others, the opposite effect is observed. It will be instructive for policymakers in each of these six countries to recognise the likely impact on their REER, and to tailor macroeconomic policies towards achieving equilibrium. We posit that, for the countries in our sample, an assumption that the status as an oil producer alone should elicit a specific (or common) policy response to an oil price shock may, indeed, be misplaced.

Fourth, for Kenya, the significant role played by the manufacturing sector has been well documented, and the country is widely touted as the regional hub for trade and finance in Eastern Africa.[15] In the light of this, and the fact that Kenya is a net importer of oil, the viewpoint that a positive shock in oil prices increases the possibility of an important shift in supply dynamics is a plausible one. Similarly, for oil importers Madagascar, Mauritius, and the Seychelles, high dependence on imported oil for the domestic economy appear

to drive up domestic prices, relative to their respective trading partners', hence the observed increase in the REER. More rigorous government intervention in the supply dynamics of these economies may be necessary if such REER appreciation is deemed inconsistent with government targets. Estimates reported in Table 2 suggest that the Seychelles appears to have the most responsive appreciation in REER following an oil price shock and policymakers should be prepared to respond and intervene more aggressively in response to such a shock.

Finally, for the six countries where we find evidence of a long run relationship, the nonlinear behaviour we uncover for exchange rates dynamics provides support some policy intervention, if price stability is considered important. Therefore, the effects generated by more pronounced real oil price shocks should elicit a more rapid and tailored corrective response compared to less pronounced shocks. For these economies in particular, governments and policymakers may need to pay attention to the extent of nonlinearity in their respective countries for appropriate and effective policy formulation. In other words, monetary and fiscal policies should be informed by the degree of nonlinearity specific to that country.

6 Summary and conclusions

Aiming to contribute to studies determining the sources of shocks to real exchange rates, we have analysed the role of oil prices as a long run determinant of real exchange rates in a sample of 13 African countries. Whether or not real exchange rates depend, in the long run, on real oil prices has important implications for exchange rate prediction and modeling, since the country-level relationship between real oil prices and exchange rates has implications for central banks aiming to stabilise exchange rates and/or avoid REER misalignments.

If shocks that affect real exchange rates have permanent effects on the variable and there is no evidence of a long run relationship, then effectiveness of policy measures aimed at returning the real exchange rate to its equilibrium will be limited or, at best, temporary. Misalignments in the REER may have to be tackled via alternative means. However, if real exchange rates are indeed driven by oil prices, then countries' competitiveness (albeit, with a time lag) improve or worsen depending on the direction of the shock. To this end, policymakers should be better equipped to stabilise the real value of the currency, given that a measurable relation has been established between the long-run values of both variables. Specifically, in these developing economies, by monitoring real oil prices, it should be possible to predict the existence of real shocks that affect the real exchange rate.

Our major contribution is hence twofold: (1) Using cointegration techniques for data since 1970 and (2) allowing for nonlinear dynamics, we find that real oil prices and real exchange rates are indeed cointegrated in some

African countries, but not in others. A number of conclusions follow from our results. First, we find evidence to suggest that in six countries — Kenya, Madagascar, Mauritius, Morocco, Seychelles and South Africa — where we find evidence of cointegration, the important role the price of oil plays in real exchange rate determination is established; but not in the other seven countries. Similarly, we do not find evidence of such a link across countries, based on their oil production status. Therefore, any a priori assumption of a policy response to an oil price shock, without adequate country-specific knowledge, can be misleading. The effects of oil price shocks on the evolution of the real exchange rates in each of these developing countries is different, highlighting the fact that oil prices appear to be playing a different role for each of them. This may be because of the different economic structures of these economies, and also whether the country produces some oil. Finally, our results also suggest that allowing for a more flexible exchange rate system is likely to allow these developing countries to improve their international competitiveness more should the need arise and to reduce possibility of misalignments.

Accepted for publication: 28 January 2016

Appendix

The following dummy variables have been included in the VAR models in order to capture the presence of significant socio-political events e.g., devaluations, that have affected the variables (Camarero et al 2008).

Burkina Faso, Cameroon, Ivory Coast, Nigeria, Senegal and Togo: *ds*941
Kenya: *ds*932
Madagascar: *ds*862
Mauritius: *ds*794
Morocco: *ds*852
Rwanda: *ds*952
Seychelles: *ds*851
South Africa: *ds*853
where *dsxxy*=1 from 19xx:y to the end of the sample and 0 otherwise. This shift variables are restricted to the cointegration space and appear in the dynamics in first differences.

Endnotes

1. Simeon Coleman (Loughborough University); Juan C. Cuestas (Eesti Pank and Tallinn University of Technology) corresponding author: Estonia pst 13, Tallinn 10141, Estonia. Email juan.carlos.cuestas@eestipank.ee; Estefanía Mourelle (Universidade da Coruña); The authors gratefully acknowledge two anonymous referees and the associate editor Piers Thompson for useful comments. The usual disclaimer applies. Juan C

Cuestas gratefully acknowledges the MINECO (Ministerio de Economía y Competitividad, Spain) research grant ECO2014-58991-C3-2-R and the Generalitat Valenciana project AICO/2016/038.

2. See Country Energy Data and Analysis page of US Energy Information Administration website.

3. By using an effective exchange rate, we are implicitly considering competitiveness of each country with its main trading partners. The selection of these particular countries has been made based on the availability of data, in particular the REER.

4. See Appendix.

5. A full rank would imply that both variables are stationary.

6. Furthermore, the roots of the companion matrix corroborate these results. Although test results are not reported here for the sake of brevity, they are available from the authors upon request.

7. Results available upon request.

8. Oil exported in barrels per day (bbl/day): Kenya (7,270); Madagascar (365); Morocco (17,420); South Africa (128,500). Source: The World Factbook page of http://www.cia.gov.

9. In recent years China, for example, has been accused of manipulating the yuan's true value, in order to keep exports high.

10. We subsequently show that the nonlinear models are globally stable in the remaining four cases.

11. For the sake of brevity, we do not report the final linear estimated models here, but they are available upon request.

12. The reader is referred to Teräsvirta (1994, 1998) and van Dijk *et al* (2002) for a more detailed discussion on the linearity tests procedure employed.

13. These include the test of residual serial independence against a fourth-order process (AUTO), the test of no remaining nonlinearity in the residuals (NL, computed for all the potential transition variables under the alternative, but only the one minimising the p-value is displayed), and the test of parameter constancy that allows for changing parameters under the alternative (PC).

14. Technically, Cameroon is somewhat distinct in this subset of countries, as it is under the jurisdiction of a separate central bank, the BEAC, while the remaining (West African, or UMOA) countries fall under the control of a common central bank, the BCEAO. Moreover, although Cameroon is not a world-level exporter of oil, it is considered one of Africa's main oil producers and exported (imported) 64,670 (32,490) barrels/day at 2009 estimates, while producing 61,580 barrels (2011 estimate). Proved crude oil reserves are 200 million barrels at January 2013 estimates. (Source: CIA *World Factbook*).

15. According to Kenya's Export Promotion Council (EPC), the manufacturing sector contributed 10.5 per cent to the country's GDP in 2005, an increase of 0.6 per cent over the previous year. Moreover, petroleum products feature significantly in the country's exports and include materials such as textiles, margarine, cleansing materials, plastics, confectionery & breakfast cereals, stationery, pharmaceuticals, beverages (beer & spirits), edible oils, construction & building materials, body care products, industrial chemicals, engineering products (e.g. metal frames & bus bodies). See http://epckenya.org.

References

Ahmad A H and Moran Hernández R (2013) 'Asymmetric adjustment between oil prices and exchnage rates: Empirical evidence from major oil producers and consumers', *Journal of International Financial Markets, Institutions and Money*, 27, 306-317.

Amano R A and van Norden S (1995) 'Terms of trade and real exchange rates: the Canadian evidence", *Journal of International Money and Finance*, 14, 83-104.

Amano R A and van Norden S (1998) 'Exchange rates and oil prices', *Review of International Economics*, 6, 683–694.

Babajide F (2014) 'Modelling the oil price–exchange rate nexus for South Africa', *International Economics*, 140, 36–48.

Backus D K (1984) 'Empirical models of the exchange rate: Separating the wheat from the chaff', *Canadian Journal of Economics*, 17, 824–846.

Bahmani-Oskooee M and Gelan A (2007) 'Real and nominal effective exchange rates for African countries', *Applied Economics*, 39, 961–979.

Bjornland H C (2004) 'The role of the exchange rate as a shock absorber in a small open economy', *Open Economies Review*, 15, 23–43.

Blundell-Wignall A and Gregory R G (1990) 'Exchange rate policy in advanced commodity exporting countries: the case of Australia', Working Paper 83, OECD Economics and Statistics Department, Paris, France.

Camarero M, Cuestas J C and Ordóñez J (2008) 'The role of commodity terms of trade in the determination of the real exchange rates of the Mediterranean countries', *The Developing Economies*, 46, 188–205.

Cashin P, Céspedes L and Sahay R (2004) 'Commodity currencies and the real exchange rates', *Journal of Development Economics*, 75, 239–268.

Chen S (2004) 'Real exchange rate fluctuations and monetary shocks: a revisit', *International Journal of Finance and Economics*, 9, 25–32.

Chen S-S and Chen H-C (2007) 'Oil prices and real exchange rates', *Energy Economics*, 29, 390–404.

Chen Y-C and Rogoff K (2003) 'Commodity currencies', *Journal of International Economics*, 60, 133–160.

Clarida R and Galí J (1994) 'Sources of real exchange-rate fluctuations: how important are nominal shocks?', *Carnegie-Rochester Conference Series on Public Policy*, 41, 1–56.

Coulibaly I and Gnimassoun B (2013) 'Optimality of a monetary union: new evidence from exchange rate misalignments in West Africa', *Economic Modelling*, 32, 463–482.

Cuestas J C and Mourelle E (2011) 'Nonlinearities in real exchange rate determination: do African exchange rates follow a random walk?', *Applied Economics,* 43, 243-258.

Darby M R (1982) 'The price of oil, world inflation and recession', *American Economic Review*, 72, 738–751.

Dornbusch R (1976) 'Expectations and exchange rate dynamics', *Journal of Political Economy*, 84, 1161–1176.

Edwards S (1987) 'Commodity export prices and the real exchange rate in developing countries: coffee in Colombia', NBER Working Paper 1570, Cambridge MA, USA.

Edwards S (1989) *Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries*, Cambridge MA: MIT Press.

Eitrheim Ø and Teräsvirta T (1996) 'Testing the adequacy of smooth transition autoregressive models', *Journal of Econometrics*, 74, 59–75.

Evans M D D and Lothian J R (1993) 'The response of exchange rates to permanent and transitory shocks under floating exchange rates', *Journal of International Money and Finance*, 12, 563–586.

Faria J R and León-Ledesma M A (2003) 'Testing the Balassa–Samuelson effect: implications for growth and the PPP', *Journal of Macroeconomics*, 25, 241–253.

Frankel J A and Rose K A (1996) 'A panel project on purchasing power parity: mean reversion within and between countries', *Journal of International Economics*, 40, 209–224.

Golub S S (1983) 'Oil prices and exchange rates', *Economic Journal*, 93, 576–593.

Gonzalo J (1994) 'Five alternative methods of estimating long-run equilibrium relationships', *Journal of Econometrics*, 60, 203–233.

Granger C W J and Teräsvirta T (1993) *Modelling Nonlinear Economic Relationships*, Oxford: Oxford U P.

Grekou C (2015) 'Revisiting the nexus between currency misalignments and growth in the CFA Zone', *Economic Modelling*, 45, 142–154.

Gruen D and Wilkinson J (1994) 'Australia's real exchange rate - Is it explained by the terms of trade or by real interest differentials?', *Economic Record*, 70, 204–219.

Hansen H and Johansen S (1999) 'Some tests for parameter constancy in cointegrated VAR-models', *Econometrics Journal*, 2, 306–333.

Hinkle L and Montiel P J (1999) *Exchange Rate Misalignment*, New York NY: Oxford U P.

Ibrahim A, Elbadawi I A, Kaltani L and Soto R (2012) 'Aid, real exchange rate misalignment, and economic growth in Sub-Saharan Africa', *World Development*, 40, 681–700.

Jiménez-Rodríguez R and Sánchez M (2005) 'Oil price shocks and real GDP growth: empirical evidence for some OECD countries', *Applied Economics*, 37, 201–228.

Johansen S (1988) 'Statistical analysis of cointegrated vectors', *Journal of Economic Dynamic and Control*, 12, 231–254.

Johansen S and Juselius K (1990) 'Maximum likelihood estimation and inference on cointegration with application to the demand of money', *Oxford Bulletin of Economics and Statistics*, 52, 169–210.

Kenan Lopcu K, Dulger F and Burgac A (2013) 'Relative productivity increases and the appreciation of the Turkish lira', *Economic Modelling*, 35, 614–621.

Kilian L and Lewis L T (2011) 'Does the fed respond to oil price shocks?', *Economic Journal*, 121, 1047–1072.

Lastrapes W D (1992) 'Sources of fluctuations in real and nominal exchange rates', *Review of Economics and Statistics*, 74, 530–559.

Makin A J (2009) 'Is China's exchange rate policy a form of trade protection?', *Business Economics*, 44, 80–86.

Meese R A (1990) 'Currency fluctuations in the post-Bretton Woods era', *The Journal of Economic Perspectives*, 4, 117–134.

Michael P, Nobay A and Peel D (1997) 'Transaction costs and nonlinear adjustment in real exchange rates: an empirical investigation', *Journal of Political Economy*, 105, 862–879.

Mussa M (1990) 'Exchange rates in theory and in reality', Essays in International Finance, 179, Princeton University Department of Economics and International Finance Section, Princeton NJ, USA.

Narayan P K, Sharma S, Poon W C and Westerlund J (2014) 'Do oil prices predict economic growth? New global evidence', *Energy Economics*, 41, 137–146.

Neary P (1988) 'Determinants of the equilibrium real exchange rate', *The American Economic Review*, 78, 210–215.

Nugent J B and Switek M (2013) 'Oil prices and life satisfaction: asymmetries between oil exporting and oil importing countries', *Applied Economics*, 45, 4603–4628.

Öcal N and Osborn D R (2000) 'Business cycle non-linearities in UK consumption and production', *Journal of Applied Econometrics*, 15, 27–43.

Ozturk I, Feridun M and Kalyoncu H (2008) 'Do oil prices affect the USD/YTL exchange rate: evidence from Turkey', Research Paper 115/2008, Privredna kretanja i ekonomska politika.

Razin O and Collins S (1999) 'Real exchange rate misalignments and growth', in Razin A and Sadka E (eds) *The Economics of Globalization: Public Economics Perspectives*, Cambridge: Cambridge U P.

Reboredo J C (2012) 'Modelling oil price and exchange rate co-movements', *Journal of Policy Modeling,* 34, 419-440.

Reboredo J C and Rivera-Castro M A (2013) 'A wavelet decomposition approach to crude oil price and exchange rate dependence', *Economic Modelling*, 32, 42–57.

Reboredo J C, Rivera-Castro M A and Zebende G F (2014) 'Oil and US dollar exchange rate dependence: a detrended cross-correlation approach', *Energy Economics*, 42, 132-139.

Rodrik D (1994) 'King Kong meets Godzilla: The World Bank and The East Asian Miracle', in Fishlow A, Gwin C, Haggard S, Rodrik D and Wade R (eds) *Miracle or Design? Lessons from the East Asian Experience*, Washington DC: Overseas Development Council.

Rogoff K (1996) 'The purchasing power parity puzzle', *Journal of Economic Literature*, 34, 647–668.

Salisu A A and Mobolaji H (2013) 'Modeling returns and volatility transmission between oil price and US–Nigeria exchange rate', *Energy Economic*, 39, 169-176.

Sensier M, Öcal N and Osborn D R (2002) 'Asymmetric interest rate effects for the UK