Real exchange rate misalignment and economic performance in Sudan

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Abstract

This article investigates the behavior of equilibrium exchange rate and real exchange rate misalignment in Sudan over the period 1979–2009. In addition, the impact of real exchange rate misalignment on economic performance is examined. The empirical results show that the equilibrium exchange rate is significantly influenced by economic policy variables such as trade openness, government expenditure and taxes. The results also reveal that the Sudanese economy has exhibited an exchange rate overvaluation over the period under consideration. Consistent with our expectations for the period that related to oil exploitation, the real exchange rate has shown a low volatility owing to huge inflows of foreign exchange. Moreover, the results demonstrate that exchange rate misalignment has a deleterious impact on Sudanese export performance.

Keywords: Cointegration, economic performance, error correction model, exchange rate misalignment, Sudan

1 Introduction

In the past few decades, the issue of managing real exchange rate (RER) has attracted considerable attention from academics and policy makers in both developed and developing countries. Indeed, a stable RER is a key factor in improving the trade sector, and in enhancing overall economic performance. On the other hand, RER misalignment has been considered as the main cause of economic instability and the dismal economic performance of numerous countries and regions. In the literature, an exchange rate is described as overvalued or undervalued when it appreciates over or depreciates under its equilibrium level – both situations refer to a misalignment. Exchange rate overvaluation can damage the potential economic growth of a country through foreign currency shortage, large current account deficits and frequent macroeconomic cycles (Rodrik, 2008). Exchange rate devaluation, on the other hand, distorts price signals and negatively affects the aggregate demand by raising the cost of imported goods and deterring both domestic and foreign investment (Bruno, 1979; Branson, 1986; Bahmani-Oskooee & Miteza, 2003).

Like other developing countries that aim to enhance their external balance and achieve economic stability, Sudan has adopted a number of different exchange rate regimes in the last five decades. These include the fixed, floating and dual exchange rate regimes. The change in exchange rate policy during such period resulted in remarkable exchange rate fluctuations, accompanied by dismal performance in the

exports sector and the flow of foreign private capital into Sudan. Numerous factors have been identified as causing Sudan's unfavourable economic performance, yet the impact of real exchange rate misalignment has not received adequate attention in the Sudanese literature. Moreover, the condition of the Sudanese economy after the secession of South Sudan and the loss of most of its oil resources, has rendered exchange rate stability an urgent strategy when it comes to enhancing export performance.[1] Therefore, investigating exchange rate misalignment would be vital in the formulation of an appropriate exchange rate policy that fosters growth and export performance in Sudan.

Based on the above, many questions could be raised in this study, including: What are the determinants of the equilibrium real exchange rate in Sudan? Has Sudan's economy suffered from exchange rate misalignment during the period under consideration? If so, what it is impact on the country's economic performance? Thus, the main objective of this study is twofold: 1) to investigate the presence of exchange rate misalignment in Sudan over the period 1979–2009; 2) to examine the impact of RER misalignment on economic growth and export performance.

The importance and contribution of this article is to fill a gap in the Sudanese literature by identifying the short and long-run determinants of equilibrium exchange rate. The study also contributes to the empirical literature on the impact of RER misalignment on economic performance in Sudan, since there is a dearth of empirical studies on this issue. Most previous studies (e.g., Abdallah, 2009) focus only on measuring exchange rate misalignment and do not examine its impact on economic growth and export performance. The study by Elbadawi *et al*. (2012) does examine the effect of RER misalignment using Sudanese data in a cross-country framework, but this study uses single-country data.

The remainder of this article is organised as follows: The next section discusses exchange rate policies in Sudan. Section three reviews the empirical literature on the relationship between RER misalignment and economic performance. While section four outlines the research methodology, section five presents the empirical results. Finally, section six ends with a conclusion and policy recommendations.

2 Exchange rate policy in Sudan: Some stylised facts

During the past five decades, Sudan has adopted numerous exchange rate policies, including fixed, floating and dual exchange rate regimes. For instance, from 1956–1979, the exchange rate was pegged at a fixed rate of approximately one Sudanese pound to 2.85 US dollars. In September 1979, the government shifted from the fixed regime to a floating exchange rate system, with the support of the International

1 Based on the Comprehensive Peace Agreement (CPA) of 2005, southern Sudanese were given the right of self- determination through a referendum, which took place as scheduled in January 2011, where about 98 per cent of southern people voted in favour of independence. This event led Sudan to lose most of its oil resources, as South Sudan was the source of about 75 per cent of oil production.

Monetary Fund and the World Bank's structural adjustment programme (Ebaidalla, 2014). As a result, the Sudanese pound underwent a significant devaluation, to the rate of one US dollar to 0.35 Sudanese pounds. The main goal of this policy was to reduce external imbalances by increasing the volume of exports and attracting private international capital, such as the remittances of Sudanese nationals working abroad (SNWA).[2]

Throughout the 1980s, the exchange rate in Sudan experienced a series of devaluations, owing to economic and political instability. Notably, during the 1980s the country was subject to many factors affecting its economic performance, such as drought and famine (1984–1985) and the eruption of the second civil war (1983). The country therefore suffered from a severe lack of foreign reserves and relied mainly on foreign aid to finance development projects. As such, in 1985 the exchange rate was devalued by 48 per cent, with the official rate set at LS2.5/US$ and the parallel at LS3.3/US$. By the end of 1980s the black market was active, and speculation on foreign currency and non-tradable goods were the dominant activities, thereby causing the black market exchange rate to be set at more than LS20/US$ in late 1989 (Central Bank of Sudan, 2009).

In the early 1990s, the economy witnessed several transformations, notably the transition from the state-controlled policies that characterised the 1970s and 1980s, to free market polices (Ebaidalla, 2014). During this time, the exchange rate received great attention from government, because it was believed to be a core factor affecting economic instability. At the start of the economic recovery programme of 1990, the black market exchange was prohibited and was considered an illegal practice; the government imposed strict punishments on illegitimate exchange dealers. Thus, all foreign exchange transactions were confined to licenced commercial banks. Yet despite these measures, the exchange rate was higher in the early 1990s than in the 1980s. As a part of the economic liberalisation policies, in 1992 the government unified the exchange rate market. Nevertheless, due to the drastic depreciation of the local currency and the subsequent increase in the inflation rate, the floating system was abandoned in October 1993 and replaced by the dual exchange system. The formal rate was set at LS215/US$, while the parallel was set at LS300/US$. Thereafter, the exchange rate underwent continuous devaluations as set by the Bank of Sudan at LS300/$ and LS430/$ in 1994 and 1995, respectively.

In the latter 1990s, the exchange stabilised owing to the flow of foreign direct investment (FDI) and the commercial exploitation of oil in 1999. Notably, the flow of oil revenues brought to the economy a huge amount of foreign reserves. As a result, the exchange rate underwent substantial stability with a limit rate at LS 2650–2600 per dollar during 2000–2003. It is worth mentioning that oil exports in the early 2000s became the major source of foreign exchange and accounted for around 85 per

2 In the early 1970s Sudan was considered a major labour-exporting country in the Arab region, with SNWA's remittances accounting for more than three times the foreign exchange earnings from exports (Elbadawi, 1994).

cent of the total value of exports. Accordingly, during this period the Central Bank of Sudan adopted a managed floating exchange regime.

From 2008–2010 the exchange rate saw many fluctuations, owing to the reduction in oil prices due to the global economic crisis. The decline in the inflow of foreign currency that followed led to another split in the exchange markets, into official and black. Recently, in the aftermath of the secession of South Sudan in July 2011, Sudan has suffered numerous economic challenges due to the sudden lack of oil revenues. As a result, the exchange rate depreciated rapidly, leading to increase in the black market premium. In response, in June 2012 the government adopted a new exchange rate measure which devalued the currency to the rate of SDG4.42/US$[3] (Ebaidalla, 2014). Overall, the exchange rate in Sudan has seen a continuous devaluation since 1979, particularly in the period preceding the exploitation of oil reserves. Figure 1 reveals that the nominal exchange rate reported a positive trend with a slight increase during 1979–1991, but did not exceed LS500/US$. With the economic liberalisation policies of 1992–1996, the exchange rate depreciated dramatically to about LS2000/US$ in 1997. However, during the period of the managed floating exchange rate regime and oil exploitation (1997–2007), the exchange rate was stable at the rate of 2.5SDG/US$ on average, before subsequently decreasing to about SDG2/US$ in 2008.

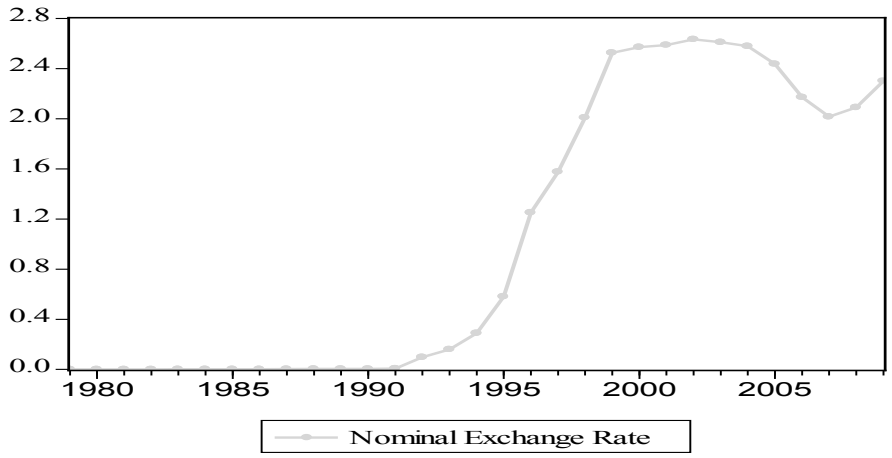

Figure 1: The trends of nominal exchange rate in Sudan (1979-2009)

Source: Adapted from the Central Bank of Sudan (COBS) Annual Report – various issues

3 In 1999 the legal tender (the Pound, LS) was replaced with a new currency, the Dinar (SDD), with an exchange proportion of 1 SDD = 10 LS. The Dinar operated up to 2007, when it was replaced by the new Pound (SDG), with 1 SDG = 100 SDD, or 1000 old Pounds, i.e., 1 SDG = 1000 LS.

3 Literature review

Motivated by the negative impact of exchange rate misalignment on economic outcomes in recent decades, a huge body of literature has sought to examine the relationship between RER misalignment and economic performance. Most empirical studies suggest that misaligned RER has had an adverse effect on economic indicators, such as economic growth and export performance (e.g., Cottani *et al*., 1990; Ghura & Grennes, 1993; Razin & Collins, 1997; Domaç & Shabsigh, 1999).

Ghura and Grennes (1993) are amongst those who employed the PPP model to study the relationship between RER and economic performance for a sample of 33 countries in sub-Saharan Africa. Using three measures of RER misalignment (PPP-based, black market-based and endogenous growth model-based), the authors found a negative relationship between RER misalignment and economic performance. They argue that the chronic RER misalignment was the main source of slow growth in Africa.

In their influential paper, Razin and Collins (1997) analysed the relationship between exchange rate misalignment and economic growth for a sample of 93 countries over the period 1975–1992. Their main contribution is that they developed and adopted an RER misalignment indicator based on an IS-LM model of an open economy. Razin and Collins found that exchange rate misalignment is negatively associated with economic growth, and concluded that very high overvaluation has a negative and significant impact on economic growth, while undervaluation has no significant effect.

In the same vein, Aguirre and Calderon (2006) examined the growth effects of RER misalignment in 60 countries during 1965–2003. Using a single equation model estimated by dynamic panel data techniques, the authors point out that RER misalignment has an adverse impact on economic growth. Moreover, they examined the growth impact of undervaluation and overvaluation, and found that both large over- and undervaluation negatively affect growth in developing countries, while a moderate level of undervaluation in the exchange rate boosts economic growth

Rodrik (2008) examined the impact of RER misalignment on growth for a sample of 184 countries using annual data for 1950–2004. He developed an index to measure the level of RER undervaluation based on the Balassa-Samuelson model using real per capita gross domestic product (GDP) data. Rodrik found that countries with more undervalued RERs achieved higher growth rates than those with overvaluation growth rates, implying that an overvalued RER negatively affects growth, while an undervalued exchange rate stimulates growth. Rodrik also noted that the magnitude and statistical significance of the estimated coefficient for RER undervaluation is higher for developing countries, because they are often characterised by institutional fragility and market failure.

Berg and Miao (2010) used a fundamental equilibrium exchange rate model (FEER) to compare Rodrik' (2008) results with what they call the Washington Consensus (WC) view. Their findings suggested that WC and Rodrick's views are observationally equivalent for main growth regressions, but there are some

identification problems since the determinants of RER misalignments are also likely to be independent variables in the growth regression model. However, their empirical findings support the view of Rodrik (2008), in the sense that undervaluation promotes long-run growth while overvaluation has the opposite effect – a result that it is not consistent with the WC viewpoint.

Recently, Elbadawi *et al*. (2012) evaluated the relationship between RER misalignment and economic performance measures, focusing on economic growth, export diversification and sophistication for a sample of 83 countries. They found that countries that have experienced some growth associated with a measure of export diversification were also likely to have avoided disequilibrium RER overvaluation. They also point out that not only is overvaluation bad for growth and export diversification, but undervaluation is good for both. Interestingly, their findings indicate that Sudan is among the group of SSA countries that has seen some increasing overvaluation in the latter 1990s and early 2000s.

The above discussion has revealed that exchange rate misalignment has a negative impact on economic performance. Yet despite extensive literature on the effect of exchange rate misalignment, there is a dearth of studies on the issue in African countries in general, and Sudan in particular. In addition, most existing studies employ cross-country data, while this study concentrates on single-country data. This study therefore contributes to the empirical literature on the issue.

4 Methodology

To investigate the impact of RER misalignment on economic performance in Sudan, the analysis proceeds in two steps: 1) we measure the exchange rate misalignment, and then 2) assess its impact on economic growth and export performance. Therefore, this section is organised into two sub-sections: the first section outlines the measurement of the exchange rate misalignment, while the second discusses the data and methodology.

4.1 Measuring RER misalignment

RER misalignment refers to a deviation of the actual RER from its long-run sustainable equilibrium path. Measuring RER misalignment has become a controversial issue in recent economic-related literature. However, two common methods have been widely used to measure exchange rate misalignment: purchasing power parity (PPP) estimates and the single equation-reduced form model.

According to the PPP method, RER misalignment refers to a deviation of the RER with respect to parity in some determined level of equilibrium exchange. The PPP approach basically relies on the Law of One Price (LOP), which states that when measured in a common currency, freely traded commodities should cost the same everywhere under perfectly competitive market conditions (i.e., zero transaction costs, no tax, homogeneous goods and complete certainty). In the literature, a large number of studies interrogate the PPP approach (see, e.g., Edwards, 1988; Taylor, 1988; Cottani *et al*. 1990; Chinn, 2006).

Despite the simplicity of the PPP approach, the main shortcoming of the method is that it chooses a single equilibrium rate for all periods and only accounts for the monetary sources of exchange rate fluctuations, without capturing the exchange rate fluctuations attributed to real factors (Aguirre & Calderon, 2006). Accordingly, over the past two decades, most empirical works on this issue have used single equation models which are a reduced form of the equilibrium RER, derived from a wide variety of theoretical models usually relating the RER to a group of variables known as fundamentals. These fundamentals include variables such as productivity differentials, net foreign assets, terms of trade, trade openness, government consumption and trade policy. Thus, misalignments occur when RER deviates from its equilibrium path, which interprets the misalignments as being the result of inadequate macroeconomic, trade and exchange rate policies. The advantage of the single equation model is it uses time series techniques to estimate the equilibrium RER equation from the fundamentals. Moreover, the single equation approach requires fewer time series and allows for changes in the equilibrium exchange rate over time. Therefore, this study uses the single equation approach to measure RER misalignment and examine its impact on economic performance in Sudan.

4.2 Estimation methodology and data

To compute the RER misalignment, the study follows the single equation approach, employing the modified version of Baffes *et al*. (1997) and Elbadawi *et al*. (2012). Since RER misalignment is a deviation of the actual RER from its equilibrium level of RER, we compute equilibrium RER by estimating empirically a long-run RER equation. The single equation model that links RER to a set of fundamentals could be specified as follows:

$$\log RER_t = \beta_1 + \beta_2 \log TOT_t + \beta_3 \log OPN_t + \beta_4 \log PROD_t + \beta_5 \log GOV_t + \beta_6 \log TAX_t + \beta_7\ NFI_t + \varepsilon_t \quad (1)$$

This equation states that RER is explained by the terms of trade (TOT); trade openness (OPN); productivity (PROD);[4] government expenditure (GOV); taxes on non-tradable goods (TAX) and the net foreign income (NFI). All the variables are expressed in logarithm form, except for the NFI because it bears negative values in some years. Since the main objective of this article is to identify the short- and long-run determinants of equilibrium RER, the above model will be estimated employing the cointegration and Error Correction Model (ECM). The former is used to examine the long-run equilibrium relationship between the variables, while the latter approach captures the short-run dynamic.

4 The productivity differentials are introduced to capture the Balasa-Samuelson effect.(i.e., the productivity differentials between traded and non-traded goods, measured by the relative price of non-traded to traded goods).

According to economic theory, the above model postulates that the equilibrium RER will be appreciated with higher terms of trade, less trade openness, higher levels of productivity in the tradable goods sector relative to the non-tradable goods sector, more government expenditure, higher taxes on non-tradable goods and larger NFI .

After estimating equation (1) and determining the short- and long-run determinants of RER, the RER misalignment is obtained by subtracting the equilibrium from the actual exchange rate. That is, the equilibrium RER is derived from the multiplication of the long-run estimated coefficients in equation (1) by the permanent values of the RER fundamentals. The actual fundamental variables will not be chosen because they may exhibit a substantial degree of short-term 'noise', whereas the long-run equilibrium RER would not do so (Baffes *et al*., 1997). Therefore, the analysis will use the Hodrick-Prescott (HP) filter to smooth out the estimated equilibrium RER.[5] As such, the HP filter allows us to obtain the 'long-run', 'permanent' or 'sustainable' values of the economic fundamentals by decomposing the time series into a trend and stationary component. Hence, the equilibrium RER equation can be depicted via the following model:

$$Ln\ e_t^* = \hat{\beta} F_t^p \qquad (2)$$

Where e^* is the equilibrium exchange rate, F is the vector of permanent or sustainable values of fundamentals obtained using the HP filter, and $\hat{\beta}$ is the vector of long-run parameters of equation (1). Therefore, the RER misalignment (EMIS series) will be obtained as the percentage difference between the actual RER and equilibrium RERs, as follows:

$$EMIS = \left(\frac{\text{RER}}{ERER}\right) - 1 \qquad (3)$$

After measuring the RER misalignment indicator, we investigate the impact of misaligned RER on economic performance through assessing its effect on economic growth and export performance. First, we examine the relationship between RER misalignment and growth; this is because arguably a sound exchange rate policy is a crucial condition for improving economic growth in a developing country (Easterly, 2005; Rodrik, 2008). Therefore, the constructed EMIS series will be added to the right-hand side of the growth model beside other major factors affecting growth, as expressed in equation (4):

$$GDP_{\text{t}} = \alpha_1 + \alpha_2 \log GDP_{t-1} + \alpha_3 \log GOV_t + \alpha_4 \log OPN_t + \alpha_5 \log \text{INV}_t + \alpha_6 \log EDU_t + \alpha_7 \text{POP}_t + \alpha_8 \log \text{EMIS}_t + \varepsilon_t \qquad (4)$$

5 Moving average employed to remove short-run fluctuation in the data requires a longer time series. But this approach is not possible in a country like Sudan, where all data are non-stationary and span a short period.

where GDP is the real per capita GDP growth at time t. The explanatory variables are chosen based on the new classical growth model type proposed by Barro and Lee (1994), in which regressors include indicators for the initial conditions, the external environment and the macroeconomic policy. Accordingly, the explanatory variables are as follows: Government consumption (*GOV*); trade openness (*OPN*); domestic investment (INV); education attainment (*EDU*) to capture human capital investment; population growth (POP); and finally RER misalignment (EMIS) is included to capture the effect of exchange rate policy on economic growth performance. The growth model will be estimated using cointegration and the error correction model over the period 1979–2009. The model will also be tested for endogeneity problems using the Durbin-Wu-Hausman test, since endogeneity reduces the efficiency of OLS estimators.[6] Endogeneity might arise due to the appearance of possible endogenous variables in the right-hand side of the equation, e.g., investment and government spending.

Second, we examine the impact of RER misalignment on export performance, as exchange rate misalignment has an adverse impact on the volume of exports and export diversification (Elbadawi *et al*., 2012). Indeed, RER misalignment and particularly overvaluation hurt the competitiveness of exported goods. Following Elbadawi *et al*. (2012) and Nabli and Venganzones-Varoudakis (2002), we assess the export performance impact of RER misalignment by estimating using the following model:

$$\log EX_t = \alpha_1 + \alpha_2 \log GDP_t + \alpha_3 \log TOT_t + \alpha_4 \log INV_t + \alpha_5 \log \mathrm{EDU}_t + \alpha_6 \log FDI_t + \alpha_7 \mathrm{Oil}_t + \alpha_8 \log \mathrm{EMIS}_t + \varepsilon_t \quad (5)$$

Where EX_t is the export indicator, measured by the ratio of total exports to the GDP; GDP_t is GDP per capita; *TOT* is terms of trade; *INV* is the domestic investment; EDU is the education attainment; *FDI* is the foreign direct investment; Oil is a dummy variable to capture the impact of oil on export performance, taking the value of 1 after oil exploitation (i.e., 1999) and zero otherwise; and EMIS is the RER misalignment (see Appendix I for definitions and sources of data). The estimation of the export model will also be performed via the cointegration and error correction model.

The study utilises the annual time series data covering the period 1979–2009. This period is selected because in 1979 Sudan's economy saw the start of exchange rate volatility in addition to economic instability. The period also guarantees the availability of data on the variables under study. The data used in the analysis are macroeconomic data obtained from, amongst others, the Central Bank of Sudan, the World Bank Development Indicators and the International Monetary Fund. The definitions and sources of the data used in the study are presented in Appendix I.

The summary statistics and correlation matrix for the variables used in the analysis are presented in Appendices III and IV, respectively. The results of summary

6 If the test indicates a symptom of endogeneity we will estimate the model using 2SLS and instrumental variables.

statistics show that the standard deviation of the RER is 5.41, implying that Sudan's economy suffered from exchange rate volatility during the period under study. The results in Appendix IV indicate high correlations between some variables such as education and population growth; exports and investment; exports and openness; and exports and FDI.

5 Empirical results and discussions

5.1 RER misalignment

Before examining the exchange rate misalignment, we checked the time series properties of the RER and its fundamentals, employing unit root and cointegration tests. First, the order of integration for all variables is identified by applying DF–GLS and Kwiatkowski *et al*'s 1992 KPSS tests for unit roots in the variables.[7] Since unit root tests are sensitive to lag length, we use the Akiake Information Criterion (AIC) to select the optimal lag length. The results of the unit root test for each variable with and without trend are presented in Table 1 (Appendix II). The results show that all the series are non-stationary at level. When taking the variables in their first difference, the results show that all variables are stationary at one per cent significance level, in both the DF–GLS and KPSS tests. Therefore, we can conclude that all the series are integrated of order one (i.e., *I(1)*).

Having identified the order of integration of the variables, the next step is to test whether a long-run relationship exists between the variables, by using the cointegration test. In addition, the cointegration analysis allows for the identification of the long-run determinants of the RER. Hence, the study employs the Johansen-Juselius multivariate cointegration test. Before undertaking these tests, the relevant order of the vector autoregressive (*VAR*) model is specified. Since the sample size is relatively small, we select lag 1 for the order of the *VAR*, as suggested by Pesaran and Pesaran (1997). The results of trace and maximum eigenvalue statistics obtained from the Johansen-Juselius (1990) (*JJ*) method using the assumption of a linear deterministic trend in the data are presented in Table 2 (see Appendix II). The results of the JJ multivariate cointegration tests indicate that under the trace statistics there are seven cointegration relations between the RER and its determinants. On the other hand, the maximum eigenvalue statistic shows five cointegration relationships. For consistency, therefore, we conclude that there is a long-run relationship between the RER and its major fundamentals in Sudanese economy.

After establishing the long-run relationship between the variables, the cointegration equation can be used to identify the long-run coefficients of the RER, hence deriving the equilibrium RER. We normalised on the RER equation since this is where our focus lies. The results of the long-run cointegrating vector coefficients of RER are presented in Table 1.

7 We used the KPSS and DF-GLS tests because they perform better in the case of a short data sample than the conventional unit root tests, such as Dickey Fuller (DF) and Philips Perron (PP).

Table 1: Results of long-run (normalized cointegrating coefficients)

The dependent variable is the RER			
Variable	Coefficient	t-statistics	Prob
Constant	-20.065	0.231	0.8191
Terms of trade	0.144	0.054	0.9575
Trade openness	-1.638***	-5.189	0.0001
Productivity	-1.902***	-4.766	0.0001
Government spending	-4.456***	-10.078	0.0001
Taxes	1.279***	3.593	0.0015
NFI	-6.541**	-2.702	0.0127

Note: ***, ** and * indicate significance at the 1, 5 and 10 per cent levels respectively

The results reveal that all the estimated coefficients carry their expected signs, except that of trade openness and taxes. All the variables are also statistically significant except the terms of trade. The results indicate that in the long run, RER is influenced positively by the terms of trade and taxes. On the other hand, the economy's openness, productivity, government spending and NFI negatively influence the RER in the long run.

The results indicate that the terms of trade (TOT) have a positive impact on the RER, implying that an increase in the relative price of exported goods to imported goods leads to a depreciation of the RER. This finding supports many empirical studies (e.g., Baffes *et al*., 1997; Aguirre & Calderon, 2006; Elbadawi *et al*., 2012). Unexpectedly, the coefficient of trade openness is negative, contradicting the results obtained by Elbadwai *et al*. (2012). This result indicates that trade liberalisation and fewer trade restrictions appreciate the exchange rate in the long run. This result, however, corroborates the findings of some empirical studies, such as that by Nabli and Venganzones-Varoudakis (2002), who found that trade restrictions in the MENA countries depreciate the exchange rate.

The long-run results also show that the impact of government consumption on the RER is negative, confirming the findings of Aguirre and Calderon (2006). This result indicates that an increase in government spending in Sudan depreciates the RER. Interestingly, the coefficients of productivity and NFI are negative, implying that the improvement of productivity and the increase in the net income from abroad have a depreciative effect on the RER in Sudan.

Having identified the long-run determinants of the RER, the next step is to use the Error Correction Model (ECM) to identify the short-run determinants of the RER. The ECM also allows for an examination of how fast the RER adjusts to changes in its underlying equilibrium. The results of the ECM analysis are presented in Table 2.

Table 2: Results of the Error Correction Model

The dependent variable is the RER			
Variable	**Coefficient**	**t-statistics**	**Prob**
Constant	0.029	0.486	0.6316
ΔRER (-1)	0.249	0.878	0.3890
ΔTerms of trade	0.417*	1.878	0.0731
ΔTrade openness	0.037	0.100	0.9212
ΔProductivity	-0.940*	1.782	0.0880
ΔGovernment spending	-0.676**	-2.556	0.0177
ΔTaxes	0.350	0.802	0.4308
ΔNFI	-3.557	-1.616	0.1197
Error term	-0.257***	-2.925	0.0076
Adjusted R-squared	0.56	Durbin-Watson statistic	2.31
F-statistic	2.024- Prob (0.0572)		

Note: ***, ** and * indicate significance at the 1, 5 and 10 per cent levels respectively

Δ indicates the first difference operator

The analysis shows that most of the variables bear the expected signs, and the findings fit well with existing literature on the RER. The coefficient of lagged dependent variable is positive, indicating that the short-run dynamics of the RER is positively influenced by the previous situation of the RER.

Similar to the long-run results, the short-run analysis indicates that the signs of productivity differentials, government expenditure and NFI are negative, as expected. Unlike the long-run analysis, the ECM results show that the coefficient of trade openness is positive, but not significant. This result contradicts the findings of Elbadawi *et al*. (2012) and Baffes *et al*. (1997). Moreover, the ECT is found to be statistically significant, confirming the long-run findings. The coefficient of ECT implies that the long-run disequilibrium in the RER can be corrected each year by a proportion of about 25 per cent.

After identifying the RER determinants, we proceed to compute the RER misalignment using equation (3). The actual RER series are generated through multiplication of the long-run parameters of Table 1 by sustainable values of the

fundamentals obtained via the HP filter. The results of the RER misalignment are divided into three periods: 1979–1991, 1992–1998 and 1999–2009 (see Table 5, Appendix II). The first period reflects the phase of state control policies; the second represents the economic liberalisation policies, and the third reflects the phase of the advent of oil. The results show that the RER was misaligned over the entire period of the study, with an average of 12 per cent, indicating that the Sudanese economy has experienced an overvalued RER for the past three decades. Over the three periods, we observe that the exchange rate overvaluation varies from one period to another, confirming the high standard deviation of the RER in Appendix IV. In the first period the RER misalignment accounted for 11.6 per cent on average, with the highest level of volatility; in the second period the RER reported a high rate of misalignment, reaching 14.7 per cent on average; and, interestingly, during the third period the RER misalignment indicator accounted for 9.4 per cent, with the lowest level of volatility only 0.6 per cent on average. This finding confirms the results of Elbadawi *et al*. (2012) who found that the RER in Sudan exhibited an overvaluation in the latter 1990s and early 2000s. This result mirrors the actual situation in Sudan; where the nominal exchange rate has reported remarkable stability in the last decade, owing to the huge surge of foreign exchange that accompanied the commercial exploitation of oil and the flow of FDI. Therefore, we conclude that during the entire period of the study (1979–2009), the Sudan economy experienced a substantial exchange rate misalignment, particularly as regards overvaluation.

5.2 Exchange rate misalignment and economic performance

To examine the impact of RER misalignment on economic performance, we estimated the models of economic growth and export, as represented in equations (4) and (5). Before estimating these equations, we checked the log-run relationship between the variables for each equation under investigation. The results of cointegration for economic growth and export equations are presented in Tables 3 and 4 (Appendix II). The results of cointegration for the growth model in Table 3 show that the trace statistics indicate seven cointegration relations while the maximum eigenvalue indicates six. The cointegration tests for exports model (Table 4) demonstrate four cointegration relations between the variables and exports by both trace statistics and maximum eigenvalue tests. Therefore, we estimated the model using both cointegration and ECM techniques.[8] The results of the long- and short-run analyses of the impact of exchange rate misalignment on economic growth are presented in Tables 3 and 4, respectively.

8 We checked the problem of endogeneity for both growth and exports models using the Durbin-Wu-Hausman test, but no serious endogeneity was detected. Therefore, the impact analysis will be performed by applying cointegration and the ECM.

Table 3: Results of long-run model: Growth equation

The dependent variable is economic growth			
Variable	Coefficient	t-statistics	Prob
Constant	-25.007***	5.892	0.0001
Government spending	2.698***	9.966	0.0001
Trade openness	0.310	0.681	0.5024
Investment	9.113***	11.133	0.0001
Education	-2.513	-1.597	0.1234
Population	10.616***	6.517	0.0001
RER misalignment	1.784	1.203	0.2407

Note: ***, ** and * indicate significance at the 1, 5 and 10 per cent levels respectively

The results in Table 3 show that most of the variables carry their expected signs and fit with the theory, except for education. All the variables are statistically significant, except trade openness and education. These results indicate that economic growth in the long run is positively and significantly influenced by government spending, investment and population growth. Unexpectedly, the impact of human capital measured by education level is negative, but not significant. Importantly, the impact of exchange rate misalignment on economic growth is positive, but not significant, confirming the study by Aguirre and Calderon (2006) and MacDonald and Vieira (2010). This implies that the diversion of the exchange rate from its equilibrium level does not play an important role in explaining growth in Sudan in the long run. This finding contradicts those of Elbadawi *et al.* (2012), who found that exchange rate misalignment has a negative and significant impact on economic growth in SSA.

Table 4: Results of the ECM: Growth equation

The dependent variable is economic growth			
Variable	Coefficient	t-statistics	Prob
Constant	-0.029	-0.030	0.9759
ΔGDP growth (-1)	0.874***	4.921	0.0000
ΔGovernment spending	0.939*	1.881	0.0620
ΔTrade openness	-0.164	-0.677	0.4992
ΔInvestment	0.091	0.244	0.8071
ΔEducation	8.672***	3.251	0.0014
ΔPopulation	5.004	0.487	0.6265
ΔRER misalignment	1.916	0.775	0.4394
Error term	-0.033**	-2.156	0.0327
Adjusted R-squared	0.62	Durbin-Watson statistic	2.12
F-statistic	4.110- Prob (0.0040)		

Note: ***, ** and * indicate significance at the 1, 5 and 10 per cent levels, respectively.
Δ indicates the first difference operator

The results of the short-run analysis indicate that all the variables carry their expected signs except trade openness. As suggested by the theory, government expenditure, domestic investment and education level positively affect the economic growth in Sudan. Similar to the long-run analysis, the misalignment index has a positive and insignificant effect. Since the exchange rate misalignment index shows signs of overvaluation during the period under study, we conclude that the exchange rate overvaluation has no significant impact on economic growth in Sudan. This result mirrors the actual situation in Sudan, as the economy during the last decade has witnessed a stable and positive growth rate, despite the exchange rate overvaluation, owing mainly to oil exportation. Finally, the error correction term is negative and significant, confirming the long-run findings.

Second, we examine the effect of the exchange rate misalignment on export performance through the estimation of equation (5) using cointegration and the ECM. The results are presented in Tables 5 and 6, respectively.

Table 5: Results of long-run model: Export equation

The dependent variable is exports			
Variable	Coefficient	t-statistics	Prob
Constant	5.395	0.8311	0.4141
GDP growth	0.011	0.359	0.7227
Investment	0.337***	6.959	0.0001
Terms of trade	1.348***	25.218	0.0001
Education	-1.188***	17.684	0.0001
FDI	0.366***	12.866	0.0001
RER misalignment	-1.941***	-3.867	0.0001

Note: ***, ** and * indicate significance at the 1, 5 and 10 per cent levels respectively

The results of the long-run analysis indicate that exports are affected positively by real GDP, investment, terms of trade and FDI. This implies that the domestic economic environment plays a significant role in encouraging exports in Sudan, in the long run. Unexpectedly, the coefficient of education is negative and significant in the long run. This finding could be explained by the fact that an improvement in education level pushes workers out of export sectors like agriculture, the leading sector in the economy. The impact of exchange rate misalignment on exports is found to be negative and significant, implying that misalignment of the RER discourages exports performances in Sudan. This result confirms many empirical studies on RER misalignment and export performance (e.g., Nabli & Venganzones-Varoudakis, 2002; Elbadawi *et al*., 2012).

Table 6: Results of the ECM: Exports equation

The dependent variable is exports			
Variable	Coefficient	t-statistics	Prob
Constant	-0.202	-0.656	0.5189
ΔExport (-1)	0.790***	2.820	0.0055
ΔGDP growth	0.113	0.410	0.6824
ΔInvestment	-0.313	-1.547	0.1242
ΔTerms of trade	0.488***	2.887	0.0088
ΔEducation	1.407*	1.673	0.0966
ΔFDI	0.321***	3.106	0.0053
ΔRER misalignment	-2.594**	-2.189	0.0400
OIL	0.342*	1.986	0.0602
Error term	0.210	0.947	0.3449
Adjusted R-squared	0.69	Durbin-Watson statistic	1.93
F-statistic	2.211- Prob (0.0645)		

***, ** and * indicate significance at the 1, 5 and 10 per cent levels, respectively
Δ indicates the first difference operator

The results of the ECM in Table 6 reveal that total exports are positively influenced by the GDP growth rate, domestic investment and human capital, as expected. In addition, the dummy variable of the advent of oil is found to be positive and significant, indicating that oil exploitation has had a positive impact on Sudanese exports. Interestingly, the sign of RER misalignment is negative and significant, confirming the long-run analysis. This finding implies that exchange rate misalignment has a detrimental impact on export performance, supporting most previous studies such as that of Elbadawi *et al*. (2012) and Nabli and Venganzones-Varoudakis (2002). This also indicates that the exchange rate overvaluation over the past decades has had negative effects on Sudan's export performance.

6 Conclusion and policy implications

Over the past five decades, Sudan's economy has suffered continuous exchange rate volatility, accompanied by a remarkably disappointing economic performance. Therefore, this study aimed to measure the RER misalignment and to investigate its impact on economic performance during the period 1979–2009. To this end, the

study used the cointegration and ECM to identify the determinants of equilibrium RER and examine the impact of RER misalignment on the economic growth and exports performance.

The empirical results show that the macroeconomic policy variables such as trade openness, taxes and government spending, play significant role in influencing the RER in both the short and the long run. The results also reveal that during the period under study, the Sudanese economy suffered from RER misalignment, particularly overvaluation. Specifically, when the economic liberalisation policy was in force (1992–1999), the exchange rate was highly overvalued with average of 14.7 per cent. In the period following the exploitation of the country's oil reserves, the exchange rate in Sudan experienced limited overvaluation with a low rate of volatility, at approximately 0.6 per cent.

Moreover, the empirical analysis shows that the RER misalignment has had no significant impact on economic growth in Sudan. On the other hand, the RER misalignment has had a negative and significant impact on export performance. Given the overvaluation trend of the RER in Sudan during the period under study, this finding implies that RER overvaluation is one of the factors wholly responsible for the dismal Sudanese export performance.

Based on the above findings, many policy implications can be drawn. First and foremost, policy makers should pay considerable attention to policy factors that misalign the RER in Sudan, such as trade openness, taxes and government expenditure. Thus, tightened fiscal and monetary policies, and adequate tariff policy should be implemented to maintain the exchange rate at a sustainable stable level. Regarding non-policy factors like productivity and terms of trade, they also need further efforts from policy makers through enhancing the growth of GDP along with export performance. Moreover, since the country is abundant with potential agricultural and mineral resources, further efforts should be made in terms of improving the exchange rate, so as to promote the competitiveness of commodities and to create a conducive investment environment which will attract foreign investors.

However, the following two limitations of the present analysis should be kept in mind when interpreting the results of the study: First, the unavailability of data for some variables posed a challenge in terms of the analysis – with information on some variables (e.g., human capital and productivity) not being available the author used proxies in order to avoid omitting them. Second, the specifications of the economic growth model is restricted to addressing the effect of RER misalignment, as was the case with previous studies such as those of Aguirre and Calderon (2006) and Elbadawi *et al*. (2012). Nevertheless, the growth issue is controversial and may be explained by a huge set of variables, hence the evidence generated from the growth model should be interpreted with caution.

Finally, to enrich the evidence on the RER misalignment and its impact on the economic performance of Sudan, the study suggests several avenues for future research. First, it would be important to identify the channels through which RER misalignment affects economic indicators such as growth and export performance.

Second, empirical studies need to be conducted to examine the impact of RER misalignment during the different sample periods had on economic performance. Finally, a study to investigate the impact of RER misalignment on private capital flow like FDI and capital flight would be both interesting and useful.

Biographical note

Ebaidalla Mahjoub Ebaidalla is an Assistant Professor of Economics at University of Khartoum, Sudan. He graduated in Economics at University of Khartoum, and received his PhD in Economics from the same university. His research interests focus on the fields o f macroeconomics, international economics and labour economics. He has participated in many economic conferences concerning the African countries. He has also published several papers in regional and international journals.

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References

Abdallh, M. (2009). 'Measuring the equilibrium exchange rate in Sudan during the period 1980–2009 (in Arabic)', *Almasrefi Journal*, vol. 53, no. 3, pp. 4–15.

Aguirre, A. and Calderon, C. (2006). 'Real exchange rate misalignments and economic performance', Central Bank of Chile Working Paper, no. 315.

Baffes, J., Elbadawi, I. and O'Connell, S. (1997). 'Single-equation estimation of the equilibrium real exchange rate', Policy Research Working Paper, no. 1800, the World Bank, Washington, DC.

Bahmani-Oskooee, M. and Miteza, I. (2003). 'Are devaluations expansionary or contractionary? A survey article', *Economic Issues*, vol. 8, no. 2, pp. 1–28.

Balassa, B. (1964). 'The purchasing power parity doctrine: A reappraisal', *Journal of Political Economy*, vol. 72, no. 6, pp. 584–596.

Barro, R. and Lee, J. (1994). 'Sources of economic growth', *Carnegie-Rochester Conference Series on Public Policy*, vol. 40, no. 3, pp. 1–46.

Barro, R. and Lee, J. (2010). 'A new data set of educational attainment in the world, 1950–2010', NBER Working Paper no. 15902.

Berg, A and Y. Miao (2010). 'The real exchange rate and growth revisited: The Washington Consensus strikes back?' IMF Working Paper no. 58, March.

Brarson, W.H. (1986). 'Stabilization, stagflation, and investment incentives: The case of Kenya, 1979–1980', in Sebastian, E. and Liaquat, A. (eds.). *Economic adjustment and exchange rates in developing countries*, Chicago Press, Chicago, pp. 267–293.

Bruno, M. (1979). 'Stabilization and stagflation in a semi-industrialised economy', in Dornbusch, R. and Frenkel, J.A. (eds.). *International economic policy: Theory and evidence*, Johns Hopkins University Press, Baltimore.

Central Bank of Sudan (CBOS) (2009). 'Documentary study on the exchange rate policies in Sudan (in Arabic)', *Studies and Research Series*, No. 14, Khartoum, Sudan.

Central Bank of Sudan (CBOS). Annual reports, various issues. Khartoum, Sudan.

Chinn, M. (2006). 'A primer on real effective exchange rates: Determinants, overvaluation, trade flows and competitive devaluation', *Open Economic Review*, vol. 17, no. 1, pp. 115–143.

Cottani, J., Cavallo, D. and Khan, S. (1990). 'Real exchange rate behavior and economic performance in LDCs', *Economic Development and Cultural Change*, vol. 39, no. 1, pp. 61–76.

Domac, I. and Shabsigh, G. (1999). 'Real exchange rate behavior and economic growth: Evidence from Egypt, Jordan, Morocco and Tunisia', IMF Working Paper, no. 40.

Easterly, W. (2005). 'Nationals policies and economic growth: A reappraisal', in Aghion, P. and Durlauf, S. (eds.). *Handbook of economic growth*, Elsevier, Amsterdam.

Ebaidalla, E. (2014). 'Impact of exchange rate volatility on macroeconomic performance in Sudan', *Journal of Development and Economic Policies*, vol. 16, no. 1, pp. 73–105.

Edwards, S. (1988). *Exchange rate misalignment in developing countries*, Johns Hopkins University Press, Baltimore, USA.

Elbadawi, I. (1994). 'The expatriate workers' remittances, parallel foreign exchange market and macroeconomic performance in Sudan', *Journal of African Economies*, vol. 3, no. 3, pp. 481–512.

Elbadawi, I., Kaltani, L. and Soto, R. (2012). 'Aid, real exchange rate misalignment and economic performance in sub-Saharan Africa', *World Development*, vol. 40, no. 4, pp. 681–700.

Ghura, D. and Grennes, T. (1993). 'The real exchange rate and macroeconomic performance in sub-Saharan Africa', *Journal of Development Economics*, vol. 42, no. 1, pp. 155–174.

Johansen, S. and Juselius, J. (1990). 'Maximum likelihood estimation and inference on cointegration – with applications to demand for money', *Oxford Bulletin of Economics and Statistics*, vol. 52, no. 2, pp. 169–210.

Kwiatkowski, D., Phillips, P., Schmidt, P. and Shin, Y. (1992). 'Testing the null hypothesis of stationarity against the alternative of a unit root', *Journal of Econometrics*, vol. 54, no. 3, pp. 159–178.

MacDonald, R. and Vieira, F. (2010). 'A panel data investigation of real exchange rate misalignment and growth', CESifo Working Paper Series, no. 3061. Available at SSRN: http://ssrn.com/abstract=1618198 (accessed 13 June 2011).

Nabli, M. and Venganzones-Varoudakis, M. (2002). 'Exchange rate regime and competitiveness of manufactured exports: The case of MENA countries', Middle East and North Africa Working Paper Series, no. 27.

Pesaran, H. and Pesaran, B. (1997). *Working with Microfit 4.0: Interactive econometric analysis*, Oxford University Press, Oxford.

Razin, O. and Collins, C. (1997). 'Real exchange rate misalignments and growth', NBER Working Paper, no. 6174. Available at http://www.nber.org/papers/w6174.pdf?new_window=1 (accessed 3 April 2011).

Rodrik, D. (2008). 'The real exchange and economic growth', *Brookings Papers on Economic Activities*, vol. 39, no. 2, pp. 365–412.

Taylor, M. (1988). 'An empirical examination of long-run purchasing power parity using cointegration techniques', *Applied Economics*, vol. 20, no. 10, pp. 1369–1381.

World Bank (2011). World Development Indicators, 2011, World Bank, Washington, DC. Available at http://www.worldbank.org/data/wdi2010/index.htm (accessed 2 May 2011).

APPENDICES

Appendix I: Definitions and sources of data used in the analysis

Variable	Definition	Source
RER	Real exchange rate, is defined as , where is nominal exchange rate (local currency by US$), is US wholesale price index, and is local price index	Central Bank of Sudan (CBOS)
GDP	Annual growth rate of GDP per capita	Central Bureau of Statistics, Sudan
TOT	Terms of trade, measured as the ratio of the export unit value indexes to the import unit value indexes	World Bank's World Development Indicators (accessed 2011).
OPN	Trade openness, defined as value of exports plus imports divided by GDP	Central Bureau of Statistics, Sudan
PROD	Productivity differentials, measured the ratio of GDP per capita in the domestic country relative to the GDP per capita in the foreign countries[1]	World Bank's World Development Indicators
GOV	General spending, is the government consumption measured as share of GDP (%)	Central Bureau of Statistics, Sudan
TAX	Taxes, proxied by the ratio of total taxes to GDP	CBOS
NFI	Net foreign income, measured by the ratio of income from abroad to GDP	World Bank's World Development Indicators
INV	Domestic investment, measured by fixed capital formation as share of GDP (%)	
POP	Population growth (annual %), measured as the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage	World Bank's World Development Indicators
EDU	Average year of schooling, for population aged 15 and over	Barro and Lee (2010)
FDI	Foreign direct investment, measured as ratio of FDI inflow to GDP	UNCTAD (2008) and CBOS
EX	Total exports, measured by total exports of goods and services as share of GDP (%)	CBOS

Appendix II: Empirical results

Table 1: Unit root tests –variables used in the regression models

Variable	DG-GLS		KPSS	
	Constant	Constant +trend	Constant	Constant +trend
RER	-2.31**	-2.50	0.251***	0.123*
TOT	-1.95*	-3.27**	0.535*	0.141*
OPN	-2.07**	-2.55	0.291***	0.162*
PROD	-1.23	-0.97	0.344*	0.155
GOV	-1.32	-1.43	0.182	0.179
TAX	-1.87	-2.30	0.442*	0.147*
NFI	-2.27**	-3.36**	1.84	1.35
GDP	-0.76	-3.14*	0.56	0.22
INV	-1.84*	-2.32	0.31***	0.16*
POP	-1.85*	-1.37	0.555	0.075
EDU	-0.943	-1.67	0.704*	0.188*
FDI	-1.17	-0.52	1.89	1.45
EX	-1.12	-1.37	0.360**	0.179*
EMIS	-1.20	-1.77	0.323	0.173
ΔRER	-5.76***	-5.97***	0.204***	0.166***
ΔTOT	-5.79***	-6.29***	0.313***	0.243***
ΔOPN	-7.02***	-7.12***	0.212***	0.116***
ΔPROD	-4.42***	-5.13***	0.334***	0.100***
ΔGOV	-4.71***	-4.95***	0.246***	0.078***
ΔTAX	-5.72***	-5.91***	0.195***	0.112***
ΔNFI	-6.64***	-6.70***	0.130***	0.070***
ΔGDP	-7.26***	-7.87***	0.351*	0.242***
ΔINV	-6.64***	-6.74***	0.158***	0.150***
ΔPOP	-4.98***	-6.71***	0.088***	0.054***
ΔEDU	-2.01**	-3.35**	0.340***	0.174**
ΔFDI	--5.86***	-5.61***	0.229***	0.105***
ΔEX	-6.73***	-6.78***	0.195***	0.131**
ΔEMIS	-4.88****	-5.71***	0.289***	0.066***

Note: *, ** and *** indicate significance at 10, 5 and 1 per cent respectively
Δ: denotes the first difference. Lag 4 is maximum lag length used in the test, selected by Akaike Information Criterion (AIC)

Table 2: Results of cointegration test

Null hypothesis	Eigenvalue	Trace statistics	95%	Maximum eigenvalue	95%
None	0.93	201.79*	125.61	66.69*	46.23
At most 1	0.84	135.10*	95.75	43.67*	40.07
At most 2	0.66	91.42*	69.81	38.68*	33.87
At most 3	0.50	62.74*	47.85	32.77*	27.58
At most 4	0.44	36.97*	29.79	19.26	21.13
At most 5	0.17	19.70*	15.49	12.80	14.26
At most 6	0.00	5.89*	3.84	5.89*	3.84

Note: * denotes rejection of null hypothesis at 5 per cent level of significance. These non-standard critical values are taken from Mackinon-Haug-Michelis (1999)

Table 3: Results of cointegration test: Growth model

Null hypothesis	Eigenvalue	Trace statistics	95%	Maximum eigenvalue	95%
None	0.968968	261.1455*	125.6154	100.7090*	46.23142
At most 1	0.843393	160.4365*	95.75366	53.76651*	40.07757
At most 2	0.726451	106.6700*	69.81889	37.59198*	33.87687
At most 3	0.562077	69.07806*	47.85613	23.94569	27.58434
At most 4	0.522373	45.13238*	29.79707	21.42884*	21.13162
At most 5	0.468267	23.70354*	15.49471	18.31679*	14.26460
At most 6	0.169519	5.386749*	3.841466	5.386749*	3.841466

Table 4: Results of cointegration test: Exports model

Null hypothesis	Eigenvalue	Trace statistics	95%	Maximum eigenvalue	95%
None	0.973664	270.2637*	125.6154	105.4673*	46.23142
At most 1	0.869477	164.7964*	95.75366	59.04993*	40.07757
At most 2	0.795603	105.7465*	69.81889	46.04304*	33.87687
At most 3	0.683899	59.70345*	47.85613	33.39914*	27.58434
At most 4	0.373059	26.30432	29.79707	13.54018	21.13162
At most 5	0.341671	12.76414	15.49471	12.12344	14.26460
At most 6	0.021851	0.640692	3.841466	0.640692	3.841466

Table 5: Exchange rate misalignment and volatility

Period	Misalignment (average)	Volatility %
1979–1991	11.6%	8.6%
1992–1998	14.7%	2.7%
1999–2009	9.4%	0.6%

Source: Authors' calculations

Appendix III: Descriptive statistics of the variables used in the analysis

Variable	Mean	Maximum	Minimum	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Probability	Observations
RER	2.41	3.82	0.59	0.70	-0.60	3.38	2.082	0.3533	31
EX	9.81	22.36	3.34	5.41	0.69	2.33	3.01	0.2215	31
POP	2.54	3.36	2.00	0.41	0.74	2.43	3.23	0.1984	31
EDU	2.17	3.07	1.21	0.65	-0.14	1.62	2.58	0.2746	31
TOT	0.51	1.07	0.27	0.22	1.06	3.19	5.90	0.0524	31
GDP	4.65	14.22	-6.28	4.97	-0.72	3.18	2.73	0.2555	31
INV	13.83	26.54	5.54	5.25	1.07	3.27	6.01	0.0495	31
GOV	10.19	18.23	4.84	4.01	0.39	1.92	2.30	0.3172	31
OPN	26.49	46.35	11.09	11.08	0.17	1.76	2.13	0.3450	31
TAX	8.09	18.20	4.90	2.82	1.66	6.39	29.13	0.0000	31
FDI	2.20	9.71	-0.25	2.98	1.06	2.88	5.85	0.0538	31
NFI	0.00	-0.79	-0.02	0.01	-1.53	4.05	13.52	0.0012	31
PROD	0.02	0.04	0.01	0.01	0.37	1.94	2.16	0.3398	31

Appendix IV: Correlation of variables used in the analysis

	RER	EXGDP	POP	EDU	TOT	RGDP	INV	GOV	OPN	TAX	FDI	NFI	PROD
RER	1.00												
EXGDP	-0.01	1.00											
POP	0.007	-0.36	1.00										
EDU	0.16	0.58	-0.83	1.00									
TOT	-0.06	0.51	-0.62	0.63	1.00								
RGDP	0.12	0.27	-0.40	0.52	0.26	1.00							
INV	-0.14	0.79	-0.24	0.47	0.56	0.29	1.00						
GOV	-0.33	0.66	-0.02	0.10	0.35	0.12	0.69	1.00					
OPN	0.01	0.74	-0.15	0.45	0.62	0.25	0.48	0.70	1.00				
TAX	-0.01	-0.07	0.16	-0.63	-0.36	-0.23	0.10	0.20	0.12	1.00			
FDI	0.06	0.79	-0.37	0.59	0.66	0.35	0.37	0.48	0.74	-0.36	1.00		
NFI	-0.63	0.24	0.10	-0.30	0.19	-0.17	0.15	0.53	0.26	0.19	0.09	1.00	
PROD	-0.51	-0.02	0.43	-0.57	-0.11	-0.15	0.12	0.54	0.01	0.51	-0.32	0.63	1.00

Note

1 Productivity differential is usually measured by labour productivity of traded relative to non-traded sectors. However, due to the lack of availability of long data, we use the ratio of output per capita relative to the output per capita in the foreign country. Output per capita is proxied by the GDP per capita, and the output per capita of the foreign country is a trade-weighted average of GDP per capita of the domestic country's trading partners.