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Impact of Exchange Rate Volatility on Macroeconomic Performance in Sudan

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Abstract

This paper investigates the impact of exchange rate volatility on macroeconomic performance in Sudan, focusing on three key indicators namely, economic growth, foreign direct investment (FDI) and trade balance, during the period (1979-2009). The study measures the volatility of real effective exchange rate (REER) using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. The results reveal that REER volatility has negative and significant impact on the flow of FDI into Sudan, in the short and long-run. This implies that volatility of REER has played a crucial role in fluctuations of FDI inflows during the last decades. The results also point out that volatility of exchange rate has no significant impact on economic growth and current account balance. Moreover, the results of the robustness checks of variance decomposition and impulse response function analysis confirm the findings of cointegration and error correction model. Finally, the paper recommended that systematic currency devaluations should be avoided to mitigate the unfavorable impact on REER volatility. Thus, policymakers need to adopt inflation targeting strategy in addition to the autonomy of the monetary policy. Further, diversification of the economy should be considered as top priority within the development agenda.

أثر تقلبات سعر الصرف على أداء الاقتصاد الكلي في السودان

عبيدالله محجوب

ملخص

تهدف هذه الورقة الى دراسة تأثير تقلبات سعر الصرف على أداء الاقتصاد الكلي فى السودان، بالتركيز على ثلاثة مؤشرات رئيسية وهي النمو الاقتصادي والاستثمار الأجنبي المباشر والميزان التجارى، وذلك خلال الفترة (1979–2009). تقيس الدراسة تقلب سعر الصرف الفعلي الحقيقي بإستخدام نموذج الإنحدار الذاتي المشروط بعدم التجانسح (ARCH). وقد كشفت نتائج الدراسة أن تقلب سعر الصرف الفعلي الحقيقي له تأثير سلبى ومعنوى على تدفقات الإستثمار الأجنبى المباشر إلى السودان. وهذه النتيجة تعني أن تقلب سعر الصرف الفعلي الحقيقي قد لعب دوراً مهماً في تقلبات تدفقات الاستثمار الأجنبي خلال العقود الماضية. وتشير النتائج أيضاً إلى أن تقلب سعر الصرف ليس له تأثير معنوى على نمو الناتج القومى و الميزان التجارى. بالاضافة الى ذلك، فإن نتائج إختبارات متانة التحليل بإستخدام دوال الاستجابة للصدمات ونموذج مكونات التباين تؤيد نتائج التكامل المشترك ونموذج تصحيح الخطأ. أوصت الورقة بضرورة تقليل التخفيض المستمر للعملة الوطنية وذلك لتخفيف الاثر السالب لتقلبات سعر الصرف. عليه، يجب تبنى استراتيجية لاستهداف التضخم بالاضافة الى تطبيق استقلالية السياسة النقدية. أيضاً، أوصت الورقة بضرورة تنويع الاقتصاد باعتباره استراتيجية مهمة لاستقرار سعر الصرف وتحقيق الاهداف التنموية.

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1. Introduction

The impact of exchange rate volatility on macroeconomic variables has become a subject of increasing debate in recent decades, in both developing and advanced countries. Advocates of fixed exchange rate argue that exchange rate stability enhances exports and provides attractive environment for the flows of international capital like foreign direct investment (FDI), and eventually stimulates economic growth. In their view, volatile and unpredictable exchange rate may lead to many harmful macroeconomic consequences such as, volatility of prices and output, deterioration of total exports, as well as worsening the external competitiveness (Gylfason (2000), Rose (2000), Frankel and Rose (2002) and De Grauwe and Schnabl (2004)). On the other hand, proponents of floating exchange rate regime believed that exchange rate flexibility helps balance of payment adjustment in response to external shocks and positively influence the trade volume and economic growth (Friedman (1953), Fischer (2001), Edwards and Levy-Yeyati (2003)).

Like other developing countries that face the challenge of improving balance of payments and stimulating economic growth, Sudan has adopted a number of different exchange rate regimes over the last five decades. These systems included the fixed, floating and dual exchange rate regimes. For example, following independence in 1956, and up to early 1979, Sudan had adopted fixed exchange rate. Thereafter, in September 1979, the government shifted from fixed to flexible exchange rate system, with the support of IMF and World Bank' structural adjustment programs. Since then, the exchange rate has witnessed continuous devaluations and interventions. However, these changes in exchange rate have been accompanied by considerable fluctuations in the macroeconomic indicators, such as, economic growth, foreign trade and foreign direct investment (FDI).

Based on the above, the main question of this study is: What is the impact of real effective exchange rate volatility on the main macroeconomic indicators such as, economic growth, FDI and foreign trade? To answer this question, the study used annual data over the period 1979–2009, employing cointegration and Error Correction Model (ECM) in addition to Variance Decomposition (VD) and Impulse Response Function (IRF).

The contribution of this paper is to fill a gap in literature on the impact of exchange rate volatility, as most of empirical studies on exchange rate in Sudan have focused on identifying the determinants of equilibrium exchange rate and the extent

of its misalignment (e.g. Abdallh (2009). In addition, many factors have been blamed as major variables that responsible for disappointing economic performance in Sudan; nevertheless, the effect of exchange rate volatility has not been adequately studied. Moreover, Sudan' economy is now experiencing a sharp decrease in foreign exchange reserves due to the loss of most of the oil resources as a result of the secession of South Sudan(1). Therefore, understanding the impact of exchange rate volatility would help in guiding appropriate exchange policies that foster exports' competitiveness, and attract foreign financial sources such as, FDI and migrants' remittances.

The remainder of this paper will be organized as follows: section two reviews exchange rate policies in Sudan. Section three outlines the theoretical and empirical literature on the relationship between exchange rate fluctuations and macroeconomic indicators. Section four discusses data and research methodology and section five presents the empirical results. Section six ends with conclusion, policy recommendations and suggestions for further research.

2. Exchange Rate Policy in Sudan: An Overview

Since long, the exchange rate market in Sudan has undergone numerous policy interventions. Throughout the period 1956–1979, the exchange rate has been pegged at a fixed rate, approximately with a proportion of: one Sudanese pound to 2.85 US dollar. In 1979, the government shifted to floating exchange rate system aiming at recovering the economy, as the country during seventies' decade has witnessed many economic problems including, fiscal deficit, external disequilibrium, high inflation rates and mounting external debts (Ali, 1985). Thus, the government has launched the first version of the stabilization and liberalization programs, which focused on the exchange rate devaluation as a key policy tool for economic recovery. Therefore, the exchange rate has been devalued to the rate of one US dollar equivalent to 0.35 Sudanese pounds. The main goal of this policy was to reduce the external imbalances through encouraging the volume of exports, and attracting private international capital, such as, remittances of Sudanese nationals working abroad (SNWA)(2)(Elbadawi, 1994).

Throughout the 1980s, the exchange rate in Sudan experienced a series of devaluations, owing to the economic and political instabilities. Notably, the country during 1980s had experienced many factors affecting economic performance, such as, drought and famines in 1984–1985 and the eruption of the second civil war in 1983.

The country, therefore, has suffered from a severe lack of foreign reserves and relied mainly on foreign aid in financing development projects. As such, the exchange rate was devalued in 1985 by 48 percent, with the official rate set at LS2.5/US$ and the parallel at LS3.3/US$. By the end of 1980s the black market was active, and the speculation of foreign currency and nontradable goods were the dominant activities; thereby causing the black market exchange rate to be set at more than LS20/$ in the late 1989.

In the early 1990s, the economy had seen several transformations, notably the transition from the state control policies that characterized the period of 1970s and 1980s to the free market polices. The Salvation Revolution government of 1989 has launched many economic recovery programs, which aimed at encouraging the export through stabilizing the exchange rates. The Comprehensive National Strategy 〈CNS〉 of 1992–2002 was an ambitious one. The CNS had focused on liberalization of trade and exchange rate, liberalization of the financial sector, removing of agricultural subsidies, reducing trade tariffs and privatization of inefficient public enterprises. Accordingly, the exchange rate policy has received considerable attentions from the government, because it was believed to be a core factor affecting the economic instability. Thus, at the beginning of the economic recovery program of 1990, the black market exchange was prohibited as an illegal practice and the government implemented strict punishment to the illegitimate exchange dealers; thus, all foreign exchange transactions were confined to the licensed commercial banks. Despite these measures, the exchange rate reported higher rates in the early 1990s compared to the period of 1980s.

In the second half of 1990s, the exchange rate witnessed a remarkable stability owing to the flow of FDI and the commercial exploitation of oil in 1999. Notably, the flow of oil revenues has brought to the economy a huge amount of foreign reserves. As a result, the exchange rate saw substantial stability with a limit rate at LS2650–2600 per US dollar during 2000–2003. It is worth mentioning that, oil exports in the early 2000–2007 became the major source of foreign exchange and accounted for around 85% of the total value of exports. Accordingly, during such period the Central Bank of Sudan has adopted managed floating exchange regime. Moreover, during the period that was accompanied by oil exportation, the economy witnessed a favorable economic performance. For example, the country reported a positive and high economic growth rate, leading Sudan to be one of the fastest growing countries in the region 〈World Bank, 2008〉. The rate of inflation also declined to one digit in such period. Nevertheless, other sectors of the economy, like agriculture have deteriorated severely, and they might be influenced by the windfall of oil, which appreciated the exchange rate and hence, reduced its competitiveness. This

appreciation of the exchange rate in that period has been suspected as symptoms of the Dutch disease (Abdallh, 2009). In fact, the share of the agricultural sector in GDP and total exports has declined sharply after oil exploitation.

During the period 2008–2010, the exchange rate has seen many fluctuations owing to the reduction in oil prices due to global economic crisis. As a result of declining in the flow of foreign currencies, numerous exchange markets have been emerged in such period, including official and black market. Recently, in the aftermath of the secession of South Sudan in July 2011, Sudan has suffered from many economic challenges owing to the sudden stop of oil revenues. Therefore, the exchange rate has depreciated rapidly, leading to increase in the black market premium. In response to such situation, in last June 2012 the authorities have adopted a new exchange rate measure, which devalued the currency to the rate of SDG4.42/US$(3).

Overall, it was observed that the exchange rate in Sudan has seen a continuous devaluation since 1979, particularly in the period which preceded the oil exploitation. Annex (IV), reveals that the nominal exchange rate reported positive trend with a slight increase during the period 1979–1991, with a rate which did not exceed LS500/US$. After the economic liberalization policies of 1992 and up to 1996, the exchange rate has depreciated dramatically reaching about LS2000/US$ in 1997. However, during the period of managed floating exchange rate regime and oil exploitation (i.e., 1997–2007), the exchange rate was stable at the rate of 2.5SDG/US$ on average and then decreased subsequently to about SDG2/US$ in 2008 (see, Annex (IV)).

3. Literature Review

Since the Breakdown of Breton Woods system of pegged exchange rates and the switch to floating exchange rates in the early 1970s, the effect of exchange rate volatility on economic performance has become a subject of interest for both policy makers and researchers. Therefore, a huge body of empirical studies has grown in recent decades on the effect exchange rate variability on macroeconomic indicators, such as economic growth, trade and FDI. Despite the extensive and diversified literature on this issue, the existing evidence is far from any consensus. This disagreement is attributed to the difference in models specification, sample period, methods of measuring exchange rate volatility and macroeconomic indicators considered. In this section, we briefly review the theoretical and empirical arguments on the impact of exchange rate volatility on three main macroeconomic variables namely, economic growth, trade and foreign direct investment.

First, the relationship between exchange rate volatility and economic growth has received a relatively little attention from both theoretical and empirical perspectives. This is because, the exchange rate is considered as nominal variable and not related to the long-term real growth performance (Levy-Yeyati and Sturzenegger (2002) and Bayoumi and Eichengreen (1994)). However, the general consensus between economists is that the impact of exchange rate volatility on economic growth depends on the type of the exchange rate regime which the economy adopts. Economists who are in favor of fixed exchange rate regime (e.g. McKinnon (1963), Mundell (1973), Rose (2000) and Frankel and Rose (2002)) argue that exchange rate stability is conducive to economic growth through its positive impact on trade and investment. In their view, a stable exchange rate reduces price uncertainty and real interest rates volatility and improves the efficiency of price mechanisms at international level; hence, contributing significantly to economic stability and growth (De Grauwe, 2005; Schnabl, 2008). By contrast, the supporters of flexible exchange rate (e.g. Meade (1951), Friedman (1953), Fischer (2001) and Levy-Yeyati and Sturzenegger (2002)) argued that the volatility of exchange rate reduce the negative impact of real asymmetric shocks on local and external disequilibrium. That is, in a case of real asymmetric shocks, if prices and wages adjust slowly, flexible exchange rates can adjust relative international prices to compensate for output losses (Mundell, 1961 and Arratibel 2011). Moreover, Ghosh et al. (1996) show that a pegged exchange rate may distort price signals in the economy by creating misalignment of the real exchange rate, and in turn leads to inefficient allocation of resources across sectors.

Empirical evidence on the other hand, also offers mixed findings regarding the impact of exchange rate volatility on growth. For example, Ghosh et al. (1997) studied the growth performance under alternative regimes in 145 IMF-member countries and found that there are no significant differences in output growth across exchange regimes. They argued that pegged regimes increases investment and volatility of growth and employment but reduce productivity growth and inflation. McKinnon and Schnabl (2004) examined the impact of exchange rate volatility for East Asian countries. They argued that before the Asian crisis of 1997/98 the exchange-rate stability contributed significantly to low inflation, sound fiscal position, high investment and boosted long-term growth. Schnabl (2007) examined the impact of exchange rate volatility on growth for a sample of 41 countries. He found that exchange rate fluctuation works against the adjustment of asset and labour market and in turn reducing economic growth. By contrast, studies by Edwards and Levy-Yeyati (2003) and Levy-Yeyati and Sturzenegger (2002) found that floating exchange rate fosters economic growth.

Second, as for the link between exchange rate volatility and trade volume, the literature has provided extensive evidence since the collapse of Breton–woods system of fixed exchange rate. This is because fluctuations in exchange rate may negatively affect the competitiveness of the tradable goods and in turn, reduce the volume of trade and worsens the balance of payments. On the theoretical front, the literature provides a lot of models explained the association between the exchange rate and the volume of trade. For instance, the earlier model of Clark (1973) and Hooper and Kohlhagen (1978) argued that exchange rate volatility increases the risk–averse traders and then squeezes the volume of trade. Their view based on the fact that if exporter agrees on production contract without knowing the actual situation of exchange rates and cannot hedge this source of risk predicted, hence, an increase in exchange rate volatility negatively affect a risk–averse exporter (Clark (1973)). Moreover, another group of theoretical models showed that exchange rate volatility has ambiguous impact on trade, either positive or negative (e.g. Franke (1991) and Sercu and Vanhulle (1992) and De Grauwe (1988)). De Grauwe (1988) showed that an increase in risk has both a substitution and an income effect. Thus, the dominance of income effects over substitution effects may lead to positive association between trade volume and exchange rate volatility. De Grauwe concluded that if exporters are sufficiently risk averse, an increase in exchange–rate volatility raises the expected marginal utility of export revenue and therefore induces them to increase their exports activities. On the other hand, if producers are not risk averse, higher exchange rate volatility reduces the expected marginal utility of exports revenues, and in turn leads them to produce less for exports.

On the empirical front, the evidence on the impact of exchange rate volatility on trade also failed to reach a consensus. A survey of previous literature on this issue yields negative and positive impacts as well as inconclusive results. Some studies have found that exchange rate volatility exert negative impact on trade volume (e.g. Akhtar and Hilton (1984), Peree and Steinherr (1989), Chowdhury (1993) and Lee and Saucier (2005)). On the other hand, empirical studies by others have found that exchange rate volatility has positive effect on trade volume, Klein (1990), Franke (1991), McKenzie and Brooks (1997) and Kasman and Kasman (2005), among others. Moreover, another group did not find any significant association between exchange rate volatility and trade (e.g. McKenzie (1998) and Hooper and Kohlhagen (1978)).

Finally, the link between exchange rate volatility and FDI is regarded as the one of scant areas in literature. Most of empirical studies have focused on the level of exchange rate (i.e. appreciation and depreciation) as a main determinant of FDI flow to the host

countries. However, a few group of these studies stressed the impact of volatility in attracting FDI (e.g. Dixit and Pindyck (1994) and Markusen (1995)). Theoretically, the models which link between exchange rate volatility and FDI depends on two arguments: production flexibility argument and risk aversion argument. According to production flexibility argument, exchange rate volatility fosters foreign direct investment, since foreign producers are assumed to be able to adjust the use of one of their variable factors following the realization of a stochastic input into profits (Goldberg and Kolstad (1995)). On the other hand, according to the risk aversion theory, FDI decreases as exchange rate volatility increases. The risk aversion theory claims that higher fluctuations in exchange rate lower the certainty equivalent expected exchange rate, which in turn reduces FDI. The literature; however, stated that using production flexibility approaches versus risk aversion approaches needs to distinguish between short-term exchange rate volatility and long-term misalignments (Goldberg and Kolstad (1995)). That is, risk-aversion argument is more appropriate under short-run exchange rate volatility because firms are unlikely to be capable of adjusting factors in the short-run. In the short-run, factors of production are usually fixed; hence, firms will only be risk-averse to volatility in their future profits. Whereas, the production flexibility argument appears to be more appropriate under the long-term horizon because firms are now able to adjust their use of variable factors.

Likewise, empirical evidence on the impact of exchange rate volatility on FDI flow is mixed. For example, Cushman (1988), Stokman et al (1996) and Foad (2005) argued that exchange rate volatility exerts positive impact on FDI flow to the host countries. These findings based on the argument that FDI is export substitution. That is, an increase in exchange rate volatility in the host country induces a multinational firm to serve the host country via a local production facility rather than exports, thereby insulating against currency risk. On the other hand, another group of empirical studies stated that exchange rate volatility negatively affects the flow of foreign direct investment (e.g. Darby et al (1999) and Dixit and Pindyck (1994)). They claimed that a country with a high degree of exchange rate volatility will have a high degree of currency risk, which converts the flow of FDI to countries with more stable exchange rates.

Overall, the above discussion has revealed that the literature on the impacts of exchange rate volatility on the real macroeconomic indicators is extensive and diversified. However, there is a dearth of studies on such issue in Arab countries in general and Sudan in particular. This study; therefore, would contribute to empirical literature on this issue.

4. Model Specification, Data and Methodology

4.1. Measuring Exchange Rate Volatility

Measuring exchange rate volatility is one of the controversial issues in the recent economic literature. Therefore, the ambiguous findings on the impact of exchange rate volatility are attributed to the absence of a unique method of measuring volatility (Siregar and Rajan, 2004). In the literature, there are several methods have been used for computing exchange rate volatility, including standard deviations and Autoregressive Conditional Heteroscedasticity (ARCH) techniques. However, methods based on standard deviation suffer from many shortcomings. First, the standard deviation measures of exchange rate volatility ignore relevant information on the random process that generates the exchange rate (Jansen, 1989). Second, this method is arbitrary in choosing the order of the moving average and noted for underestimating the effects of volatility on decisions (Pagan and Ullah, 1988). Finally, standard deviation measure of volatility is characterized by skewed distribution.

To overcome the methodological deficiencies of standard deviation methods, the study uses ARCH technique introduced by Engle (1982) and later developed by Bollerslev (1986) as the Generalized Autoregressive Conditional Heteroscedasticity (GARCH). The advantage of the ARCH and GARCH methods over the standard deviation measures is their ability to discriminate between predictable and unpredictable elements in the exchange rate formation process, and therefore, they serve as accurate measures of volatility (Arize, et al., 2000; and Darrat and Hakim 2000).

Therefore, the conditional variance of GARCH model could be specified as follows:

$$h_t = \alpha + \beta e^2_{t-1} \gamma h_{t-1} + \mu_t \qquad (1)$$

This equation means that the conditional variance is a function of three terms: the mean, α; information about volatility from the previous period, measured as the lag of the squared residual from the mean equation, e^2_{t-1} (the ARCH term) and the variance of previous period's forecast error, h_t (the GARCH term). Accordingly, we will estimate GARCH model on annually real effective exchange rate (REER), over the period 1979–2009(4).

4.2. Model Specification

To investigate the impact of the exchange rate volatility on macroeconomic performance, the study focuses on the effect of exchange rate volatility on three key macroeconomic indicators, namely, Real GDP growth, FDI flows and current account balance. These variables are assumed to reflect the macroeconomic performance. Each macroeconomic variable under investigation will be considered as a dependent variable to be explained by REER volatility beside other relevant control variables, which are supported by theoretical and empirical literature.

First, the impact of exchange rate volatility on real output growth will be examined through estimation of the following model:

$$y_t = \beta X_t + \delta EV_t + \varepsilon_\tau \quad (2)$$

Where y is the real GDP growth, X is the vector of control variables, EV is the volatility of real effective exchange rate and ε is the error term. The control variables include inflation rate, trade openness, domestic investment and government expenditure. The model also involves two dummy variables, one to capture the announcement of full floating exchange rate in 1992 and the other to indicate the adoption of managed floating exchange rate after oil exploitation in 1999[5]. The first dummy variable takes the value of one for 1992 and zero otherwise, while the second dummy takes the value of one during 1999–2009. All variables will be expressed in logarithm form, except real GDP growth which bears negative signs in some years. These variables also are selected based on previous studies on the effect of exchange rate volatility on growth (e.g. Arratibel et al. (2011) and Schnabel (1997))[6].

According to theoretical and empirical literature, inflation rate may have negative or positive impact on economic growth. The trade openness also has mixed effect on growth depending on trade policy. The domestic investment is considered as an important factor for stimulating growth; hence its impact is expected to be positive. The government spending is assumed to have positive impact on economic growth. The impact of exchange rate volatility can be either positive or negative as literature provided mixed findings.

Second, regarding the effect of exchange rate volatility on foreign direct investment, we estimate the following equation:

$$FDI_t = \beta X_t + \delta EV_t + \varepsilon_t \quad \langle 3 \rangle$$

Where FDI is the ratio of stock of inward FDI to GDP, X is a vector of control variables, EV is the REER volatility and ε is the stochastic error term. In literature a huge set of explanatory variables have been predicted as significant variables that attracts FDI flow into the host country. However, for the purpose of this study we focus on the most important macro-determinants of FDI due to availability of data and their relevant to the case of Sudan. Therefore, the control variables include real per capita GDP as proxy for the market size, level of infrastructure, inflation rate and trade openness. We examine the impact of structural breaks in exchange rate systems by using two dummy variables one for the adoption of full floating and unification of exchange rate in 1992 and the second for managed floating system during 1999-2009. All variables will be expressed in logarithm form.

The market size measured by real GDP is supposed to increase the flow of FDI, since foreign investors are interested where there is a large market for their product. The levels of infrastructure would be positive as foreign investors prefer the country with well infrastructure. Trade openness is assumed to have positive impact on FDI flow. The impact of oil would be positive as oil exploitation attracted a huge amount of FDI in last decade. Finally, the sign of exchange rate volatility is inconclusive as most of empirical studies offered ambiguous results.

Finally, with respect to the impact of exchange rate volatility on trade, the analysis will follow Arratibel et al. 〈2011〉 model. Therefore, the estimable current account equation is specified as follows:

$$CA_t = BX_t + \delta EV_t + \varepsilon_t \quad \langle 4 \rangle$$

Where CA_t is the current account balance; X is a vector of control variables which include real per capita growth, trade openness, inflation rate and FDI; EV is REER volatility and ε_t is the error term. We also use two structural break dummies to reflect the adoption of dual exchange rate system during 1979-1984 and the second to capture the announcement of full floating exchange rate in 1992.

According to economic theory, GDP growth is expected to have negative impact on current account balance, as an increase in the level of income raises the import

expenditure, which tends to worsen the current account. Trade openness via low trade restriction will improve the current account balance. An increase in inflation will reduce productivity and export competitiveness and then worsens the current account balance. Foreign direct investment will increase the capacity of the economy to produce and export more; hence FDI is expected to have positive impact on the current account. The volatility of exchange rate would be either negative or positive as there is disagreement in the literature regarding the impact of exchange rate volatility on current account.

4.3. Data and Methodology

The study utilizes the annual time series data covering the period 1979–2009. This period is selected because since 1979 the exchange rate has seen many policy interventions. In addition, by the end of 1970s, the country has started to suffer from unfavorable economic situations. Moreover, this period ensures the availability of data on the variables under investigation. The definitions and sources of the data that will be used in the study are presented in Annex 〈I〉. The statistical description of the variables is also depicted in Annex 〈II〉.

The descriptive statistics of all variables used in the analysis are presented in Annex II. The results of descriptive statistics show that most of the variables have small standard deviation, except the inflation. This result confirms the fact that Sudan economy suffered from the problem of prices instability during last decades. Interestingly, REER volatility registered the lowest standard deviation 〈0.07〉 among the other variables; which may exerts a little impact on the other variables understudy.

To investigate the impact of exchange rate volatility on macroeconomic indicators, the study uses the cointegration and error correction model 〈ECM〉. The first is used to identify the long–run effects, while the second approach captures the short–run effects.

As is common in time series analysis, prior to estimating regression models, all series require to be tested for the unit root to avoid the spurious regression. Therefore, the analysis starts with identifying the order of integration of the variables, using Augmented Dickey–Fuller 〈ADF〉 and Philips–Perron 〈PP〉 tests for unit root. Since the unit root tests are sensitive to the lag length, the study uses the Akaike Information Criterion 〈AIC〉 to select the optimal lag length.

After determination the order of integration of the variables, the next step is to test whether the long-run relationship between the variables exists, using the cointegration test. In addition, the cointegration analysis allows the identification of the long-run effect of REER volatility; hence, the study employed the Johansen-Juselius multivariate cointegration test. Before undertaking the cointegration tests, the relevant order of the vector autoregressive (VAR) model is specified. Since the sample size is relatively small, we have selected lag 1 for the order of the VAR as suggested by Pesaran and Pesaran (1997).

For further inference, the study will examine the relationship between exchange rate volatility and macroeconomic variables using Variance Decompositions (VDs) and Impulse Response Function (IRF) analysis, based on Vector Autoregression (VAR) model. The Variance Decompositions (VDs) and Impulse Response Function (IRF) analysis will be used to examine the dynamic relationship between exchange rate volatility and macroeconomic variables. The VDs approach identifies the proportion of the movements in the variable under study that are due to their own' shocks and shocks to the other variables. On the other hand, IRFs traces out the effect of a one standard deviation shock to the orthogonalized residuals of equation on current and future values of the endogenous variables. Thus, impulse responses measure the responsiveness of the dependent variables in the VAR to shocks to each of the variables. The analysis will be conducted using unrestricted VAR model with four variables, including economic growth, FDI, current account and exchange rate volatility.

It is worth mentioning that, the forecast error variance decompositions (VDCs) and the impulse-response functions (IRFs) are derived from the vector autoregression model (VAR). Precisely, VDCs and RIFs are the transformation of VAR model into its moving average (MA) representation (Sims, 1980). However, the main challenge facing employing VDCs and IRFs analysis is the selection of order of the variables in the VAR system. This is because orthogonalisation involves the assignment of contemporaneous correlation only to specific series. In other words, the first variable in the ordering is not contemporaneously affected by shocks to the other variables, but shocks to the first one do affect the other variables in the system; the second variable affects contemporaneously the other variables (except the first one), but it is not contemporaneously affected by them; and so on. Therefore, we follow Sims (1980) work which suggested starting with the most exogenous variable in the system and ending with the most endogenous one.

5. Empirical Results and Discussions

Prior to investigating the effect of exchange rate volatility, the analysis proceeds via testing the properties of time series variables using unit root and cointegration tests. First, the order of integration of all variables have been identified, using Augmented Dickey–Fuller ⟨ADF⟩ and Philips–Perron ⟨PP⟩ tests. The results of the unit root test for each variable with and without trend are reported in Table 1 in Appendix ⟨III⟩. The results show that most of the series are nonstationary at level. When taking the variables in their first difference, the results show that all variables are stationary, i.e. integrated of order one I⟨1⟩ at 5% significant level, by both ADF and PP test. Therefore, we can conclude that all the series are integrated of order one.

Second, we applied Johansen–Juselius multivariate cointegration test to determine whether the long run relationship between the variables exists for each model understudy. The results of trace and maximum eigenvalue statistics obtained from the Johansen–Juselius ⟨JJ⟩ method using the assumption of linear deterministic trend in the data are presented through table 2 to 4 in Appendix ⟨III⟩.

The results of conitegration for the economic growth model show that trace statistics indicates three cointegration relations while maximum eigenvalue statistic simultaneously indicates two cointegration relations. For the FDI model the JJ multivariate test indicates one cointegration relation by both trace statistics and eigenvalue. Finally, the cointegration test for the current account model show that trace statistic indicate three relations while maximum eigenvalue indicates one cointegration relation. Therefore, we conclude that there is a cointegration relationship between the variables of each model under investigation. This finding justifies the use of error correction model to investigate the short–run impact of REER volatility on macroeconomic indicators, since according to Engle–Granger representation ⟨1987⟩ theorem a cointegration relationship implies an existence of dynamic error–correction representation.

5.1. Estimating REER volatility

The series of exchange rate volatility that used in the three equations under consideration will be generated using GARCH model as specified in equation 1. First we estimated the model based on GARCH ⟨1,1⟩ and found that the GARCH coefficient is not significant. When estimated the model using ARCH ⟨1⟩ specification, the coefficient

is significant. The results of ARCH and GARCH models are presented in Table 1 below:

Table (1): Results of GARCH Model

GARCH (1,1) Model			
Regressor	Coefficient	z-statistics	Probability
α	0.016	1.136	0.2556
β	1.260*	2.176	0.0295
γ	-0.049	-0.256	0.7978
ARCH (1) Model			
α	0.015	1.535	0.1246
β	1.160*	2.250	0.0244

Note: *: indicates significance at the 10% level.

The result in Table 1 indicates that the ARCH is better than GARCH specification, since it has a significant impact. Therefore, ARCH specification is applied in generating the volatility of REER. The trend of REER volatility measured by the ARCH equation is presented in Annex (V).

5.2. Exchange Rate Volatility and Economic growth

The impact of REER volatility on economic growth is investigated through the estimation of equation (2) using cointegration and error correction model. First the results of normalized cointegrating coefficients of growth equation are presented in Table 2.

Table (2): The Results of Long-run Analysis
(Normalized Cointegrating Coefficients)[7]

Variable	Coefficient	t-statistics	Prob
Constant	7.704***	8.903	0.0001
INF	- 0.018	- 0.160	0.8742
OPN	0.516*	1.820	0.0813
INV	5.390***	7.012	0.0001
GOV	7.691***	8.093	0.0001
EV	-11.806	-0.450	0.6567

Note: ***'*': indicates significance at the 1% and 10% level, respectively.

The results of long-run analysis point out that all the estimated coefficients carry their expected signs. All the variables also are statistically significant, except inflation and

REER volatility. The result indicates that the economic growth in Sudan in the long-run is positively influenced by trade openness, domestic investment and government expenditure. On the other hand inflation and REER volatility have insignificant impact on economic growth.

Having identified the long-run relationships between real economic growth and its main determinants, the next step is to use the ECM model to identify the short-run impact of REER volatility. The results of the estimation of the ECM model are presented in Table 3 below:

Table (3): Estimates of the Error Correction Model: Economic Growth

The Dependant variable is GDP growth			
Variable	Coefficient	t-statistics	Prob
constant	-2.836	-1.253	0.1908
GDD(-1)	0.498**	2.416	0.0115
INF(-1)	0.053	1.453	0.1382
OPN(-1)	0.462**	1.895	0.0422
INV(-1)	0.604	1.503	0.1208
GOV(-1)	-1.406*	-1.735	0.0652
EV(-1)	-6.364	-0.570	0.5571
Dummy-1992	2.150	0.711	0.4327
Dummy-1999-09	6.631*	1.845	0.0555
constant	-2.836	-1.253	0.1908
ECT(-1)	-0.253***	-3.512	0.0004
R-squared	0.65		
F test	3.651 (0.0063)		

Note: ***'**'*: indicates significance at the 1%, 5% and 10% level, respectively.

The results of short-run analysis show that the model has good explanatory power as indicated by high R-squared. Most of the variables carry their expected sings except inflation and government spending. The results also show that the lagged dependent variable, inflation trade openness, domestic investment have positive signs, as suggested by previous studies on economic growth.

The real effective exchange rate volatility has no significant impact on economic growth. This finding could be explained by low volatility (standard deviation) of REER exchange rate compared with the other variables as outlined in the results of descriptive statistics (See. Annex II).

The structural break dummies have positive signs, indicating an increase in output growth during the adoption of dual exchange rate regime (1992-1998) and over the period of managed exchange rate regime (1999-2009). Particularly, the sign of the second dummy is significant suggesting that the adoption of managed floating exchange rate in 1999 has played a significant role in stimulating output growth in Sudan.

Finally, the error correction term is found to be negative and statistically significant confirming the long-run findings. This implies that the long-run disequilibrium in GDP growth can be corrected each year by a proportion of about 25%, indicating that the adjustment of growth towards long-run equilibrium needs about 0.25 year.

5.3. Exchange Rate Volatility and FDI

The impact of exchange rate volatility on the flow of foreign direct investment is examined through the estimation of equation (3) via both cointegration and ECM. The results of long and short run analysis are presented in Table 4 and 5, respectively.

Table (4): The Results of Long-run Analysis
(Normalized Cointegrating Coefficients)

Variable	Coefficient	t-statistics	Prob
Constant	-0.694***	7.564	0.0001
GDP	-0.002	-0.679	0.5036
OPN	0.005***	3.426	0.0022
INF	- 0.004***	-6.962	0.0001
INRA	0.249***	6.932	0.0001
EV	-2.332***	-9.757	0.0001

Note: ***: indicates significance at the 1% level.

The results of long-run analysis indicate that most of the variables bear their expected signs except GDP growth. The impact of trade openness and infrastructure are

found to be positive and significant on FDI flow into Sudan. The coefficient of inflation is negative and significant. Interestingly, the results show that volatility of REER has negative and significant influence on the flow of FDI. This finding implies that REER volatility exerts negative and significant effect on FDI flow in the long-run. The higher value of its coefficient and t test indicates that REER volatility is the most important factor influencing the flow of FDI into Sudan.

Table (5): Estimates of the Error Correction Model: FDI Model

The Dependant variable is FDI			
Variable	Coefficient	t-statistics	Prob
constant	-0.002	-0.407	0.6879
FDI(-1)	0.993***	4.357	0.0003
GDP(-1)	-0.001	-0.562	0.5798
OPN(-1)	0.009*	1.760	0.0923
INF(-1)	-3.880	-0.491	0.6283
INRA(-1)	0.008	1.41	0.1725
EV(-1)	-0.052**	-2.311	0.0306
Dummy-1992	0.005	0.726	0.4755
Dummy-1999-09	0.01**	2.324	0.0298
ECT(-1)	0.015	0.858	0.4001
R-squared	0.76		
F test	6.351 (0.0002)		

Note: ***'**'*: indicates significance at the 1%, 5% and 10% level, respectively.

The results in Table 5 show that the model has a good explanatory power, as indicated by squared R and the significant F statistic. Similar to the results of long-run analysis, most of the variables have the expected signs, except GDP growth. The results indicate that the lagged dependent variable, trade openness and level of infrastructure have positive effects on FDI flows, as suggested by previous empirical studies of FDI. On other hand, market size measured by real per capita growth exerts negative influence on FDI flow but is not significant. This finding contrasting most of empirical studies; albeit could be explained by the fact that the FDI flow into Sudan is not a market seeking and most of it directed toward natural resources sectors such as, oil and mining.

Similar to results of long run analysis, the sing of exchange rate volatility is negative and significant, indicating that exchange rate volatility discourages the flow of FDI. This result confirms the actual situation in Sudan, since during the period of stable exchange rate (i.e., 2000–2007), the country has received a huge amount of FDI compared to the period of 1980s and early 1990s, which were characterized by exchange rate fluctuations. This finding also supports most of the previous studies on the link between FDI and exchange rate volatility (e.g. Dixit and Pindyck (1994) and Darby et al (1999)).

Moreover, the results reveal that the two dummy variables have positive signs, suggesting an increase in FDI flow in 1992 and during 1999–2009. Particularly, the coefficient of the second dummy (managed floating system) is significant, implying that the adoption of managed floating has encouraged the flow of FDI into Sudan.

5.4. Exchange Rate Volatility and Current Account

Regarding the impact of exchange rate volatility on current account balance, the results of long and short run analysis are presented in Table 6 and 7, respectively.

Table (6): The Results of Long-run Analysis
(Normalized Cointegrating Coefficients)

Variable	Coefficient	t-statistics	Prob
Constant	3.843***	5.735	0.0001
GDP	-0.018	-0.281	0.7811
INF	-0.058***	-4.193	0.0003
FDI	1.155***	3.849	0.0008
OPN	0.009	0.254	0.8017
EV	11.234	1.444	0.1617

Note: *** indicates significance at the 1% level.

The results of long-run analysis indicate that most of the variables bear their expected signs except inflation and GDP. The impact of trade openness and foreign direct investment are found to be positive and significant on current account. The coefficient of inflation is negative and significant. Interestingly, the results show that volatility of REER is positive but is not significant. This finding implies that REER volatility has no important impact on current account in the long-run.

Table (7): Estimates of the Error Correction Model: Current Account Model

The Dependant variable is current account			
Variable	Coefficient	t-statistics	Prob
constant	4.718***	5.242	0.0000
CA(-1)	0.102	0.782	0.6462
GDP(-1)	-0.170***	-3.005	0.0045
INF(-1)	-0.075***	-6.032	0.0000
FDI(-1)	0.075	0.205	0.8363
OPN(-1)	-0.207**	-2.116	0.0462
EV(-1)	1.042	0.276	0.8891
Dummy-1979-84	-4.201***	-3.627	0.0012
Dummy- 1992	-10.197***	-5.762	0.0000
ECT(-1)	-0.756***	-5.342	0.0000
R-squared	0.83		
F test	8.944 (0.0001)		

Note: ***'**'*: indicates significance at the 1%, 5% and 10% level, respectively.

The results of error correction model indicate that most of the variables are in line with theory, except trade openness and GDP growth. The results point out that the current account balance is negatively influenced by GDP growth, inflation and trade openness. Unexpectedly, the results reveal that the real effective exchange rate volatility is not significant, confirming the results of long-run analysis.

Moreover, the parameters of structural break suggest a significant deterioration in current account during 1979-1984 (the shift to flexible and dual exchange rate system). In addition, the floating exchange rate policy in 1992 has negative and significant effect on current account balance. This indicates that unification of exchange rate in such period distorted the current account via increasing imports and decreasing exports.

Finally, the error correction term is found to be negative and statistically significant confirming the long-run findings. The value of error correction term is high (75.6%), implying high speed of adjustment to long-run equilibrium. This finding also implies that the long-run disequilibrium in the current account can be corrected each year by a proportion of about 76%.

5.5. Robustness Checks

The previous analysis examined the impact of exchange rate volatility on macroeconomic variables in the context of single equation model, using cointegration and ECM methods. For further inference and check our above results; alternatively, we investigate the effect of exchange rate volatility through multivariate analysis, employing variance decompositions and impulse response function based on unrestricted Vector Autoregression (VAR) model.

The analysis proceeds with cointegration test to examine the long relationship between the variables. The cointegration analysis allows the use of cointegrated VAR model which account for nonstationarity and endogeneity problems as it is designed for nonstationary time series, and requires no endo-exogenous division of variables (i.e., all variables entering equations system are assumed to be endogenous). Therefore, the study uses Johansen-Juselius (1990) multivariate cointegration test.

The results of trace and maximum eigenvalue statistics obtained from the Johansen-Juselius (JJ) method using the assumption of linear deterministic trend in the data are presented in Table (5) in Appendix (III). The results of both trace statistics and maximum eigenvalue indicates two cointegration relations between the variables under consideration. Therefore, we conclude that there is long-run relationship between the real effective exchange rate volatility and the macroeconomic indicators.

The dynamic analysis of variance decomposition and impulse response function starts with identifying the order of the variables in VAR model. Following Sims' (1980) procedure, we choose the following order: EV, CA, FDI and GDP. The result of forecast error variance decompositions and impulse response function are reported in Table 4 and Figure 1, respectively.

Table (8): Variance Decomposition Results

Period	EV	CA	FDI	GDP
Variance Decomposition of CA				
1	0.311336	99.68866	0.000000	0.000000
4	6.199128	92.75648	0.240836	0.803560
8	11.89989	85.49128	1.851393	0.757430
12	14.67786	81.84150	2.745266	0.735378
Variance Decomposition of FDI				
1	0.251501	18.08591	81.66259	0.000000
4	46.66149	11.46156	41.45124	0.425705
8	66.10427	10.10728	23.52190	0.266551
12	65.82682	12.29752	21.58606	0.289605
Variance Decomposition of GDP				
1	4.497369	2.963363	2.419895	90.11937
2	7.158066	25.27795	8.834671	58.72931
3	9.905036	24.60071	9.041440	56.45281
4	12.11026	24.23144	9.355226	54.30308
Cholesky Ordering: EV, CA, FDI, GDP				

The results of variance decomposition analysis in Table 8 reveal that the response of current account to exchange rate volatility is relatively small, particularly in the first years and then increases slowly to about 14.7% in the 12th year. Expectedly, the exchange rate volatility represents the largest source of shock to foreign direct investment, exceeding its own shock. Specifically, in the first year, the volatility of exchange rate has a very little impact on FDI fluctuations, but after that its contribution increased sharply to 66% and 65% in the fourth and twelfth year, respectively. This finding confirms the previous results of the cointegration and error correction estimators, which revealed that exchange volatility has the highest and significant impact. Finally, the result shows that GDP growth has small response to variability of exchange rate compared to FDI. This result could be explained by the fact that FDI is more sensitive to the distortions of home economy, particularly exchange instability.

Figure (1): Impulse Response Functions Results

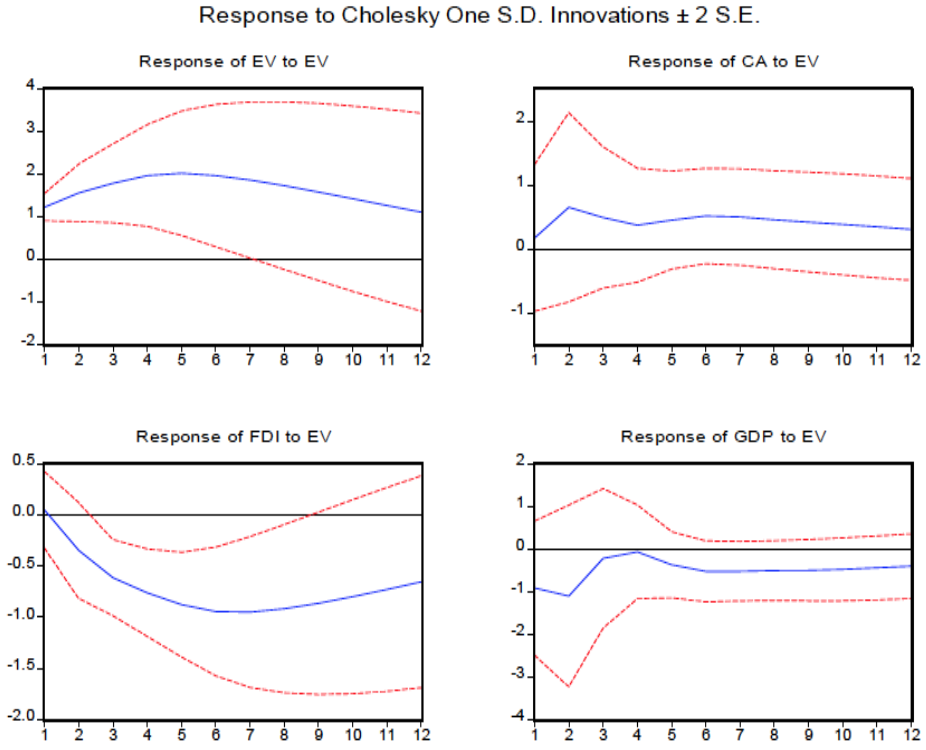

Figure 1 presents the impulse response functions of each macroeconomic variable to one standard deviation in REER volatility over a horizon of 1 to 12 years. The results show that the effect of shocks in exchange rate volatility on the macroeconomic variables supports the results of cointegration and VDC analysis. The response of GDP growth to exchange rate volatility is negative; supporting the previous findings that volatility exerts inverse effect on GDP growth. Regarding to the response of FDI to exchange rate volatility, the result also reveals negative response. Similar to the previous analysis, the IRFs analysis indicates that current account balance responses positively to volatility of real effective exchange rate.

6. Conclusion and Policy Implications

This study aimed at investigating the impact of exchange rate volatility on the macroeconomic performance following the continuous changes in exchange rate policies during the last four decades. The analysis has focused on three key macroeconomic variables namely, economic growth, foreign direct investment and current account balance, during the period 1979–2009.

The empirical results show that real effective exchange rate volatility has negative and significant affects on the flow of foreign direct investment into Sudan. Precisely, the results indicate that REER volatility is the largest and significant source of FDI fluctuations. The results also indicate that real effective exchange rates volatility play unimportant role in explaining economic growth and current account balance. Moreover, the robustness check of Variance Decompositions and Impulse Response Functions analysis supports the findings from cointegration and error correction models.

Based on the findings above, many policy implications can be drawn regarding the relationship between exchange rate volatility and macroeconomic indicators in Sudan. First and foremost, reducing exchange rate volatility is quite crucial to mitigate its negative impact on FDI flow. Factors that stimulate exchange rate fluctuations like high inflation and budget deficit should be paid serious attention. Given the significant impact of REER on FDI flows, many efforts should be exerted to stabilize the exchange rate. Thus, policy makers need to adopt inflation targeting as urgent strategy in addition to the autonomy of the monetary policy. Further, authorities should try to avoid systematic currency devaluation in order to maintain exchange rate volatility at a rate encourage domestic and foreign investment.

Considering the current shortage of foreign exchange after the separation of South Sudan, the economy needs effective exchange rate policy in order to overcome the unfavorable impact of the declining foreign reserves. Therefore, an encouraging exchange rate should be offered for foreign transactions and transfers so as to attract flows of foreign capital such as, FDI and migrants' remittances. In addition, diversification of the economy should be considered as top priority within the development agenda. In this respect, managing a competitive exchange rate would be a crucial tool to enhance productivity of the agricultural and manufacturing sectors. Moreover, trade cooperation with neighboring countries in the region like South Sudan would be helpful in increasing foreign earnings, particularly in the short-run.

Finally, to provide a complete view on the exchange rate volatility and its economic impact, this issue needs further research on four aspects. First, a study to explore the channels through which exchange rate volatility affects economic performance would be useful. Second, it would be important to identify the source of exchange rate volatility as the economy has undergone many transformations in the last decades including the advent of oil and the secession of South Sudan. Third, empirical studies need to be conducted to assess the impact of exchange rate volatility on FDI by sector. Finally, it could be useful to identify the de facto exchange rate regime for Sudan, which would help in an in-depth understanding of impact of the exchange rate policy interventions on macroeconomic performance.

Footnotes

〈1〉 Based on the Comprehensive Peace Agreement 〈CPA〉 of 2005, southern Sudanese were given the right of self determination through referendum, which took place as scheduled in January 2011. The result of the referendum revealed that about 98% of southern people voted in favor of independence. This event rendered Sudan loses most of its oil resources, as South Sudan was the source of about 75% of oil production.
〈2〉 In the early 1970s Sudan was considered a major labour exporting country in the Arab Region, with the remittances sent by Sudanese nationals working abroad 〈SNWA〉 accounting for more than three times the foreign exchange earnings from exports 〈Elbadawi, 1994〉.
〈3〉 In 1999 the legal tender 〈the Pound, LS〉 has been replaced with new currency- the Dinar 〈SDD〉, with exchange proportion of 1 SDD = 10 LS. The Dinar operated up to 2007. In 2007 the Dinar has also been replaced by the new Pound 〈SDG〉, with 1 SDG= 100 SDD, or 1000 of old Pounds, i.e. 1 SDG= 1000 LS.

(4) Most of empirical studies used the nominal or real exchange rate, but this study uses the real effective exchange rate, because it reflects a country's international competitiveness.
(5) During the period under investigation (1979–2009), the exchange rate policy in Sudan has experienced several transformations as stated in section two. Thus, we use dummy variables to capture these structural breaks. In 1979 the country the system of dual exchange; in 1992 the government adopted full floating regime and during 1999–2009 the managed exchange rate system has been followed oil exploitation.
(6) See appendix (I) of definitions and sources of data.
(7) The dummy variables in the equation are entered as exogenous variables in cointegration specification.

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Annexes

Annex (I): Definitions and sources of data used in the Analysis

Variable	Definition	Source
EV	Is the Real effective exchange rate volatility, measured by the ARCH model. The data on REER was obtained from CBOS which calculated using the following formula. $REER_t = \frac{\sum_{i=1}^{k} \omega_{it} e_{it} P_{it}^{*}}{P_t}$ where $\omega_{it}\ \omega_{it}$ is the trade weight corresponding to each trading partner; $e_{it}\ e_{it}$ is the real bilateral exchange rate; P_{it}^{*} P_{it}^{*} is the foreign price index calculated as the weighted CPI index; $P_t\ P_t$ is domestic CPI for Sudan. The main trade partners of Sudan are: China, Egypt, Germany, India, Saudi Arabia, South Korea, UAE, and United Kingdom (CBOS, 2010).	Central Bank of Sudan (CBOS)
GDP	Annual real GDP growth rate.	Central Bureau of Statistics, Sudan
FDI	Foreign Direct Investment, measured as ratio of FDI inflow to GDP.	UNCTAD and Central Bank of Sudan (CBOS)
CA	the ratio of Current account balance to GDP	Central Bank of Sudan (CBOS)
OPN	Trade openness, defined as value of exports plus imports divided by GDP.	Central Bureau of Statistics, Sudan
INV	Domestic Investment, measured by fixed capital formation as share of GDP %	Central Bank of Sudan (CBOS)
GOV	General spending, is the government final consumption expenditure for purchases of goods and services, measured as share of (GDP %).	Central Bureau of Statistics, Sudan
INF	Is inflation rate, measured by the annual average of inflation rates.	Central Bureau of Statistics, Sudan
INFR	Level of infrastructure, measured by the number of telephones per 1,000 populations.	World Bank's World Development Indicators
FD	Financial Deepening, measured by ratio of broad money (M2) to GDP.	Central Bank of Sudan (CBOS)

Annex ⟨II⟩: Descriptive Statistics of the Variables used in the Analysis

Varaible	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jar-Bera	Probability	Obs
GDP	2.154	3.093	11.554	-8.9189	4.7265	-0.6616	3.411	2.399	0.3011	31
FDD	2.279	0.192	9.710	0.250	3.0056	1.0146	2.783	5.205	0.0740	31
CA	-4.624	-4.092	1.234	-13.22	3.3063	-0.4837	2.994	1.170	0.5570	31
EV	0.032	0.0007	0.365	4.20E-05	0.0777	3.1122	12.727	166.700	0.0000	31
OPN	26.392	24.820	46.346	11.087	11.2526	0.1968	1.721	2.237	0.3267	31
INV	13.920	12.083	26.536	5.539	5.3092	1.0201	3.147	5.230	0.0731	31
POP	2.607	2.536	3.364	2.245	0.3313	1.2589	3.391	8.116	0.0172	31
INF	41.763	24.964	132.823	4.871	39.9135	1.0917	2.865	5.981	0.0502	31
INFR	0.686	0.246	2.743	0.2179	0.7034	1.647	4.884	18.008	0.0001	31
FD	16.972	17.339	27.587	6.789	6.7652	0.0806	1.711	2.107	0.3487	31

Source: Eviews7 output.

Annex (III)

Table ⟨1⟩: Unit Root Tests –variables used in the regression models

Variable	ADF		PP	
	Constant	Constant + Trend	Constant	Constant + Trend
FDI	-1.17	-0.523	-0.901	-2.23
GDP	-1.24	-3.28★	-5.01★★★	-5.20★★★
OPN	-1.32	-1.76	-1.16	-1.71
INF	-1.15	-1.63	-5.40★★★	-5.37★★★
INFR	-2.24	-2.09	-1.00	-1.74
FD	-2.26	-0.30	-1.34	-0.74
INV	-1.81	-2.22	-1.71	-2.17
GOV	-1.44	-1.51	-1.53	-1.40
CA	-2.92	-3.90★★	-2.88	-3.15
EV	-3.75★★	-3.87★★	-3.80★★	-3.91★★
Δ FDD	-5.86★★★	-5.61★★★	-5.36★★★	-5.10★★★
Δ GDP	-6.08★★★	-5.93★★★	-15.58★★★	-15.96★★★
Δ OPN	-7.02★★★	-7.31★★★	-6.90★★★	-7.35★★★
Δ INF	-3.89★★★	-3.91★★	-5.42★★★	-5.37★★★
ΔINFR	-3.07★★	-3.61★★	-3.69★★★	-3.63★★
Δ FD	-3.92★★★	-4.22★★	-4.08★★	-4.20★★
ΔINV	-6.57★★★	-6.50★★★	-6.88★★★	-7.59★★★
ΔGOV	-4.69★★★	-4.98★★★	-4.69★★★	7.09★★★
Δ CA	-5.20★★★	-5.09★★★	-9.87★★★	-9.47★★★
Δ EV	-6.25★★★	-6.13★★★	-7.45★★★	-7.33★★★

Note: ★★ and ★★★ indicate significance at 5 and 1 per cent respectively.
Lag 3 is the maximum lag length used in the test, selected by Akaike Information Criterion ⟨AIC⟩.
Δ is the first difference operator
All series are expressed in logarithm

Table (2): The Cointegration Results: Growth Equation

Null Hypothesis	Eigenvalue	Trace statistics	95%	Maximum Eigenvalue	95%
None	0.856003	129.7179⋆	95.75366	54.26301⋆	40.07757
At most 1	0.598577	75.45491⋆	69.81889	25.55674	33.87687
At most 2	0.508305	49.89817⋆	47.85613	19.87712	27.58434
At most 3	0.369118	30.02105⋆	29.79707	12.89784	21.13162
At most 4	0.329963	17.12322⋆	15.49471	11.21181	14.26460
At most 5	0.190325	5.911410⋆	3.841466	5.911410⋆	3.841466

Table (3): The Cointegration Results: FDI Equation

Null Hypothesis	Eigenvalue	Trace statistics	95%	Maximum Eigenvalue	95%
None	0.761314	96.50124⋆	83.93712	40.11300⋆	36.63019
At most 1	0.633753	56.38824	60.06141	28.12451	30.43961
At most 2	0.417303	28.26373	40.17493	15.12248	24.15921
At most 3	0.246158	13.14125	24.27596	7.912029	17.79730
At most 4	0.160470	5.229219	12.32090	4.897560	11.22480
At most 5	0.011775	0.331659	4.129906	0.331659	4.129906

Table (4): The Cointegration Results: Current Account Equation

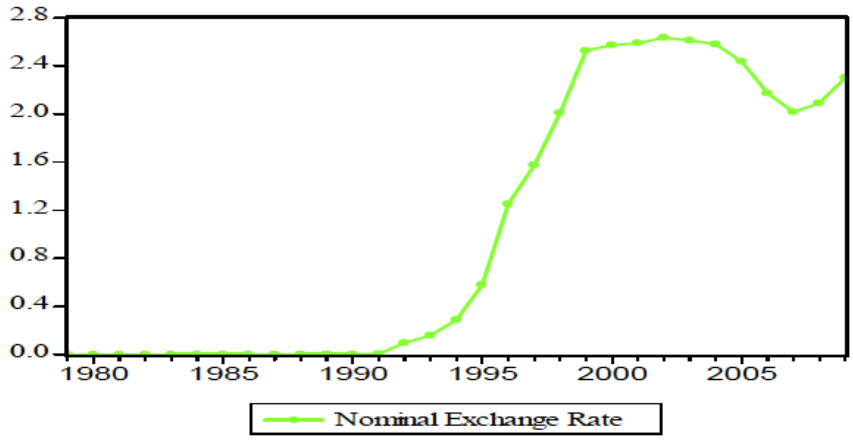
Null Hypothesis	Eigenvalue	Trace statistics	95%	Maximum Eigenvalue	95%
None	0.911515	146.1344⋆	95.75366	67.89769⋆	40.07757
At most 1	0.591024	78.23676⋆	69.81889	25.03478	33.87687
At most 2	0.586640	53.20198⋆	47.85613	24.73621	27.58434
At most 3	0.519977	28.46577	29.79707	20.54981	21.13162
At most 4	0.239707	7.915969	15.49471	7.673421	14.26460
At most 5	0.008625	0.242548	3.841466	0.242548	3.841466

Table (5) :The Cointegration Results: VAR Equation

Null Hypothesis	Eigenvalue	Trace statistics	95%	Maximum Eigenvalue	95%
None	0.988018	190.2793⋆	47.85613	115.0327⋆	27.58434
At most 1	0.900144	75.24660⋆	29.79707	59.90456⋆	21.13162
At most 2	0.402082	15.34203	15.49471	13.37183	14.26460
At most 3	0.072977	1.970204	3.841466	1.970204	3.841466

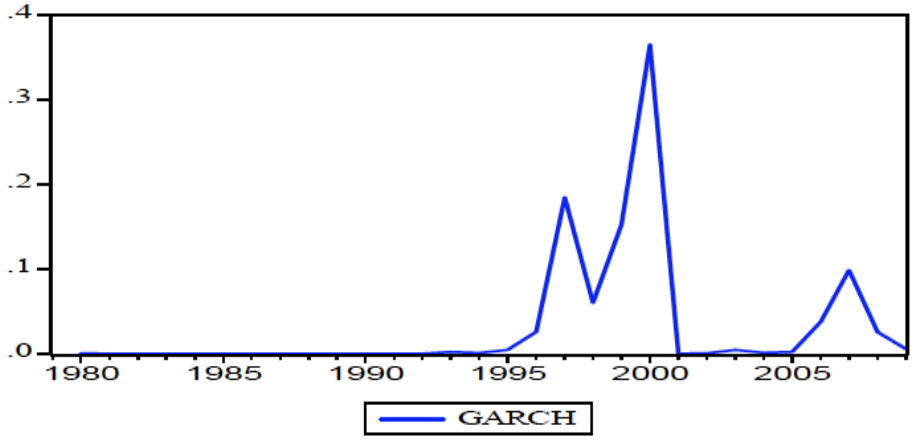
Note: ⋆ significance at 5% level

Annex (IV): The Trends of nominal exchange rate in Sudan (1979–2009)



Source: Adopted from the Central Bank of Sudan (COBS) Annual Report– Various Issues

Annex (V): GARCH Variance Graph: Volatility of the Real Effective Exchange Rate



Source: Eviews7, based on the estimation of ARCH (1) model (Table 1).