Estimation of Exchange Rate Volatility via GARCH Model

Case Study Sudan (1978 – 2009)

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Abstract

This paper aims to estimate volatility of exchange rate that was caused by inconsistent economic policies adopted by consecutive governments who failed to realize realistic exchange rate of the Sudanese pound. The consequences were mutual influence of high inflation rate, deterioration of the productive sectors, continuous internal and external deficits and depreciation of the exchange rate. To estimate the volatility of the exchange rate EGARCH (1,1) was used. The leverage effect term is negative and statistically different from zero, indicating the existence of the leverage effect (negative correlation between past returns and future volatility. As the past few years prove highly leveraged financial systems can have crises that increase the volatility of asset prices. These results indicate the possibility of a simultaneous feedback between the exchange rate and uncertainty and the response of the exchange rate to news about general price level (CPI)l, money stock, and current account which are the main determinants..

Keywords: current account, GARCH, money supply, prices, risk, leverage, volatility

1. Introduction

International currency is demanded for buying and selling of goods and services. The exchange rate is the rate at which one currency will exchange for other units of international currency. This rate will vary over time depending on many factors. The uncertainty of exchange rates has been studied extensively in developed and developing countries. Long-run and short-run fluctuations may have negative effects on macroeconomic level therefore; exchange-rate fluctuation is usually treated as a risk. A higher risk will lead to a higher cost for risk-averse investors, therefore, result in fewer jobs created. Exchange rate itself is considered a financial asset, so the need for accurate forecasting of volatility in financial markets is critical with regard to "investment, financial risk management and monetary policy making" (Poon & Granger (2003)). Sudan experienced two exchange rate regimes. In 1957 IMF set a fixed exchange rate of one Sudanese pound to 2.87 US dollar. In September 1978 IMF devaluated the Sudanese pound was devaluated for the first time by 43 per cent, and introduced two rates i.e. the fixed (official) and floating (free) rate. This scenario continued up to February 1992 when Economic liberalization Policies (ELP) were introduced devaluating the official and free rate by 496 per cent, and 197 per cent respectively. State control and restriction on citizen for holding certain amount of foreign currency were lifted. Since the application of ELP the exchange rate fluctuated sharply in the next four years. In 1996 new comprehensive reform polices were introduced reducing devaluation rate from 75% to 27% in 1998 and to only 2 per cent in 1999, and to negative figures up to 2007. Many academics and professionals studied the behavior of the Sudanese exchange rate using conventional techniques such as OLS, descriptive statistics and statistical inference, but no one (to my knowledge) has attempted to estimate the volatility via GARCH models. The purpose of this paper is to estimate variability via GARCH models due to its suitability to such type of data. GARCH (1,1) model outperforms other models in estimating volatility of foreign exchange rate. For the ARCH model, the conditional variance changes over time as a function of past squared deviations from the mean. The GARCH processes variance changes over time as a function of past squared deviations from the mean and past variances (Johnston and Scott 2000).

2. Empirical Literature Review

AUWAL (2010) used 354 bi – weekly data points (from July 22, 2002 to March 27, 2006) of Retail Dutch Auction System (RDAS) sessions' period in Nigeria to show that RDAS as an institutional arrangement for foreign exchange does not bring about better stability in the exchange rate in the long – run. The short – run relationship is

modeled by the GARCH while the long – run relationship is modeled through the ARDL. The study revealed that volatility is persistent in demand for foreign exchange and the rate of exchange. There is evidence of long run relationship between demand for foreign exchange, marginal rate of exchange and the rate of success of bids under RDAS. Therefore, exchange rate and the effect of RDAS have significant influence towards the determination of demand for exchange rate both in the short run and in the long run. The study concluded that, RDAS, as an institutional arrangement for conducting a flexible exchange, cannot bring about better result in the long run than it can offers in the short run. The study suggests further studies on the recent phase Wholesale Dutch Auction System (WDAS).

Hung-Chung et al. (2009) have shown that a GARCH model with an underlying leptokurtic asymmetric distribution outperforms one with an underlying Normal distribution, for modeling volatility of the Chinese Stock Market.

Shiyi (2008) presented support vector regression (SVR), a novel neural network (NN) technique, which has been successfully used for financial forecasting. He dealt with the application of SVR in volatility forecasting. Based on a recurrent SVR, a GARCH method is proposed and is compared with a moving average (MA), a recurrent NN and a parametric GACH in terms of their ability to forecast financial markets volatility. The real data in this study uses British Pound-US Dollar (GBP) daily exchange rates from July 2, 2003 to June 30, 2005 and New York Stock Exchange (NYSE) daily composite index from July 3, 2003 to June 30, 2005. The experiment shows that, under both varying and fixed forecasting schemes, the SVR-based GARCH outperforms the MA, the recurrent NN and the parametric GARCH based on the criteria of mean absolute error (MAE) and directional accuracy (DA). No structured way being available to choose the free parameters of SVR, the sensitivity of performance is also examined to the free parameters.

Shu (2008) estimated the long- and short-run effect between exchange-rate uncertainty and unemployment in South Korea and Taiwan. The exchange-rate uncertainty is measured by using two different measures: moving average standard deviation around the predicted value and GARCH (1,1) model. A long-run equilibrium relationship between exchange-rate uncertainty and unemployment is found to exist in Taiwan and South Korea, when exchange-rate uncertainty is generated by two different measures. The exchange-rate uncertainty has a short-run impact on unemployment and vice versa no matter which measures of uncertainty is used. However, the impacts of exchange-rate uncertainty on unemployment in South Korea and Taiwan are positive and negative, respectively.

Jan (2005) considered Leverage as the evil force that produces excessive volatility in market and economies. They found negative relation between investors and leverage. Leverage is raised when volatility is low and reduced when volatility is high. Thus market volatility lags rater than lead volatility.

Niklas (2005) examined the small sample properties of adaptive tail index estimators under the class of student-t marginal distribution functions including generalized autoregressive conditional heteroscedastic (GARCH) models and propose a model-based bias-corrected estimation approach. The simulation results indicate that bias relates to the underlying model and may be positively as well as negatively signed. The empirical study of daily exchange rate changes reveals substantial differences in measured tail thickness due to small sample bias. Thus, high quantile estimation may lead to a substantial underestimation of tail risk.

Kolawole (2004) investigated the effects of exchange rate volatility on the Nigeria stock markets. It was found that the exchange rate volatility generated via GARCH process exerts a stronger negative impact on the Nigeria stock markets. However the rate of inflation and interest rate did not have long run relationship with stock market capitalization since the major participant in the market is government. Based on this it is recommended that a coordinated monetary and fiscal policy should be put in place to check mate the fluctuation of exchange rate in order to deepen the depth of the Stock Market.

Hassan (2004) studied events that can alter the volatility pattern of financial assets and how unanticipated shocks determine the persistence of volatility over time by detecting time periods of sudden changes in volatility by using the iterated cumulated sums of squares (ICSS) algorithm. Examining five major sectors from January 1992 to August 2003, they found that accounting for volatility shifts in the standard GARCH model considerably reduces the estimated volatility persistence.

Carol (2003) presented a general symmetric presentation for Normal Mixture (NM) GARCH (1,1) models, derived the analytic derivatives for the maximum likelihood estimation of the model parameters and their standard errors and compute the moments of the error term. They also formulated specific conditions on the model parameters to ensure positive, finite conditional second and fourth moments.

CHOO (2002) attempted to study GARCH models with their modifications, in capturing the volatility of the exchange rates. The results indicate that the volatility of the Ringgit Malaysian/Sterling exchange rate is persistent. The within sample estimation results support the usefulness of the GARCH models and reject the constant variance model, at least within-sample.

Devajyoti (2000) established that in situations common in finance, many of the properties of stable models are shared by GARCH models, implying that many of the findings of fat-tailed stable distributions could be caused by temporal clustering of volatility. They applied studied eight financial data series, and concluded that the GARCH model characterizes the data better than the stable Partisan model. This supports the hypothesis that the fat tails in financial data are better described as being caused by volatility clustering than by a stable Partisan data generating process.

3. Data and Methodology

3.1 Data

Nominal exchange rate X, current account balance CAB, interest rate I, international reserves RSV, domestic credit DC, and money supply MS data are provided by the Central Bank of Sudan, while the general price level P, and consumer price index CPI are supplied by Central Bureau of Statistics. Annual data is used and the start date is 1978 when the country shifted from fixed peg to monitored floating exchange rate.

3.2 Methodology

Tests of unit roots and Co integration were carried in addition to the use of ARCH and GARCH models to estimate volatility the exchange rate which is considered a financial asset. Recent Studies of financial markets suggest that the phenomenon is quite common (Greene 1994).

3.3 ARCH

The ARCH model has become a popular one because its variance specification can capture commonly observed features of the time series of financial variables; in particular, it is useful for modeling volatility and especially changes in volatility over time (Hill etal 2008) The basic idea of ARCH models is that (a) the mean a_t is serially uncorrelated, but dependent and (b) the dependence of a_t can be described by a simple quadratic function of its lagged values Ruey (2002). Specifically, an ARCH (m) model assumes that

$$a_t = \sigma_t \varepsilon_t; \ \varepsilon_t \sim iid(0,1); \ a_0 > 0 \tag{1}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \dots + \alpha_m a_{t-m}^2; \ \alpha_0 > 0; \alpha_i \ge 0; i > 0$$
(2)

These models suffer from many weaknesses) Ruey 2002): first they assume that positive and negative shocks have the same effects on volatility because it depends on the square of the previous shocks. Second they are rather restrictive e.g. α_2 of an ARCH (1) model must be in the interval [0, 0.333]. Third they do not provide any new insight for understanding the source of variations of a financial time series. They only provide a mechanical way to describe the behavior of the conditional variance. It gives no indication about what causes such behavior to occur. Finally they are likely to over-predict the volatility because they respond slowly to large isolated shocks to the return series.

3.4 GARCH

GARCH (m,s) is the Generalized ARCH by Bollerslev (1986) models are widely used in various branches of econometrics, especially in financial time series analysis.

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^m \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^s \beta_j \sigma_{t-j}^2; \varepsilon_t \sim N(0.1); \alpha_0 > 0; \alpha_i \ge 0; \beta_j \ge 0$$
(3)

The variance equation σ_t^2 is composed of three terms: the mean (long term average) α_0 news about volatility from the previous period (the ARCH term) a_{t-i}^2 and the GARCH term σ_{t-j}^2 . It is a weighted average of the variance a (the constant), the ARCH term and the GARCH term. If there was unexpectedly large move in either the upward or the downward direction, then the forecaster will increase the estimate of the variance for the next period. If the asset return was unexpectedly large in either the upward or the downward direction, then the trader will increase the estimate of the variance for the next period. This model is also consistent with the volatility clustering often seen in financial returns data, where large changes in returns are likely to be followed by further large changes ω .

3.5 EGARCH

EGRACH model or Exponential GARCH was proposed by Nelson (1991). The specification for the conditional variance is as follows:

$$ln(\sigma_t^2) = \omega + \left| \frac{(\sigma_t | \xi_{t-1})}{\sigma_{t-1}} \right| + \sqrt{\frac{2}{\pi} + \frac{\gamma \xi_{t-1}}{\sigma_{t-1}}} + \beta ln(\sigma_{t-1}^2)$$
(4)

The left-hand side is the log of the conditional variance. This implies that the leverage effect γ is exponential, rather than quadratic, and that forecasts of the conditional variance are guaranteed to be nonnegative. Exchange rate is considered as a financial asset. The price of a financial asset is set as the present value of the cash flows expected from the asset. Asset prices change when the expectations of future cash flows change, the uncertainty around them or the rate at which cash flows are discounted changes. Price change by larger amount or more frequently i.e. become more volatile, the greater the number of reasons for investors to alter their views on future cash flows the greater the fluctuation in the discount rate. This requires news (surprises) or unexpected events. CPI (surprises) news affects inflation uncertainty (the vulnerability or sensitivity of prices to the surprise). In many financial and macro variables volatility responds asymmetrically to past negative and positive return shocks, with negative returns resulting in larger future volatilities i.e. leverage effect (Jan 2005). The presence of leverage effects can be tested by the hypothesis that $\gamma < 0$ otherwise the impact is asymmetric if $\gamma \neq 0$.

3.6 Determinants of Exchange Rate

Exchange rate as a policy instrument plays an important role in macroeconomic policies. The systematic patterns of exchange rate behavior are explained by many theories before 1970's (during the dominance of gold standard) exchange rate was considered financial asset affected mainly by the balance of payment and flows of international reserves. This monetary approach MA assumes that the exchange rate for any two currencies is determined by relative money demand and money supply between the two countries. Relative supplies of domestic and foreign bonds are unimportant (domestic and foreign bonds are perfect substitutes). Monetary policymakers found that exchange rates were influenced by changes in monetary policy. The rise of the home interest rate is usually followed by the appreciation of the home currency, and a fall in the home interest rate is followed by a depreciation of the home currency. This indicates that the price of assets plays a role in exchange rate variations. The theory also has two forms: covered interest rate parity (CIRP) and uncovered interest rate parity (UCIRP).

CIRP describes the relationship of the spot market and forward market exchange rates with interest rates on bonds in two economies.

UCIRP describes the relationship of the spot and expected exchange rate with nominal interest rates on bonds in two economies. i.e. equates the difference between the internal rate of interest and the external one to the difference between current exchange rate and long-run exchange rate i.e. $r - r^* = \phi(e - e^*)$, where r is the internal rate of interest, r^* is the external rate of interest, ϕ is an adjustment factor, e is the current exchange rate, and e^* is the expected exchange rate. PPP and CIRP (and UCIRP) only express forms of partial equilibriums and do not clearly relate producer behavior and consumer behavior.

The portfolio-balance approach PB allows relative bond supplies and demands as well as relative money-market conditions to determine the exchange rate (domestic and foreign bonds are imperfect substitutes). In the basic floating exchange rate MA equation equates the percentage change in the exchange rate, to sum of foreign inflation rate and percentage change in domestic income, minus the percentage change in domestic credit. PB equation equates the percentage rate, to sum of foreign inflation rate and percentage change in the exchange rate, to sum of foreign inflation rate and percentage change in the exchange rate, to sum of foreign inflation rate and percentage change in the exchange rate, to sum of foreign inflation rate and percentage change in domestic income, and foreign bonds supplies minus domestic credit minus domestic bonds supplies.

Asset models for exchange rate determination could not make CAPM assumptions i.e. fixed stock of assets and there are many securities each of is small, since the supply of foreign currency and official government assets dominated in foreign currency not fixed, and there are only six currencies dominates 90% of world financial wealth Empirical work demonstrated that the nominal exchange rate is a function of both nominal variables (e.g. current and anticipated values of money supply and inflation) and real variables (e.g. real income and current account balance) (Richard 1983). Inconsistencies may arise between the exchange rate regime and other macroeconomic policy instruments. On the other hand theoretical and empirical studies have emphasized the pervasive effect that devaluation's may exert on output, even when they lead to an improvement in the trade balance. Two main regimes are usually followed i.e. the fixed peg and floating regime. Industrial countries followed managed floating exchange rate in the 1970's and 1980's in which the exchange rate is determined by market forces accompanied with frequent central bank intervention. By contrast, most of the developing countries set exchange rate as policy instrument through fixed peg and crawl over time. The former approach includes pegs

to a single currency and a basket of currencies. The latter has been against a single and basket of currencies following either discretionary or non-discretionary feedback rule.

Quantity Theory of Money specifies exchange rate as a function of the change in the stock of money (MS) or the velocity of circulation (V). An increase in money stock or velocity leads to a rise in domestic prices which in turn cause a considerable change in terms of trade since some countries stop buying the goods and services from the country. Foreign goods become cheaper which leads to capital outflow and a rise of the price of foreign currency. The rise in exchange causes a rise in the prices of foreign goods and services eventually leads to a reduction in the domestic price and more exports.

The theory of purchasing power parity PPP is also known as Inflation Theory of Exchange Rates. According to this theory the price of one good should be equal to the price of the same good in another country, exchanged at the current rate and this is known as Law of One Price. The PPP theory in Currency Exchange rate determination has two different versions: the absolute version and the relative version.

Absolute PPP theory first dealt with the price relationship of goods in different currencies. Very strong preconditions are required by this theory. According to the absolute version, the exchange rates are equal to the ratio of the two countries and general price levels, which is the weighted average of all goods produced in a country. However, this version can work only if two countries produce or consume the same goods. Also according to the Currency exchange theory with absolute version the transportation costs and trade barriers are insignificant. However, transportation costs are significant and always different across the globe. Also under this theory the brand names were disregarded. The absolute PPP is considered as a partial equilibrium theory and not the general one because it doesn't deal with the money markets and the balance international payments. The success of this theory depends on: (1) free trade without barriers (2) free movements of currency form one country to another (3) remittance and profits and dividends have been neglected and capital movement is minimal

Relative PPP was developed as a more general version of the absolute PPP. It describes the relationship of prices with the exchange rate different economies. It had been assumed that the transactional costs are related proportionately to price level in order to generate the relative PPP. According to the relative version, the percentage change in the currency exchange rate in a given time period should be equal to the difference between the change in the domestic and the foreign price level. The relative PPP has its shortcomings too because of the fact that the currency exchange rates move independently of the changes in the domestic prices and the foreign prices.

Sterilization refers to central banks offsetting international reserve flows to follow an independent monetary policy i.e. the central bank must be able to neutralize, or sterilize, any reserve flows induced by monetary policy if the policy is to achieve the central bank's money-supply goals. This is done by decreasing domestic credit by an amount equal to the growth of international reserves, thus keeping base money and the money supply constant.

Currency Substitution: it has been long argued that one of the advantages of flexible exchange rates is that countries become independent in terms of their ability to formulate domestic monetary policy. This independence of domestic policy under flexible exchange rates may be reduced if there is an international demand for monies. If currencies were perfect substitutes to money demanders, then all currencies would have to have the same inflation rates, or demand for the high-inflation currency would fall to zero perfectly substitutable monies indicates that demanders are indifferent between the use of one currency or another.

Balance of Trade: if balance-of-trade deficits are financed by depleting domestic stocks of foreign currency, and trade surpluses are associated with increases in domestic holdings of foreign money, we can see the role for the trade account. If the exchange rate adjusts so that the stocks of domestic and foreign money are willingly held, then the country with a trade surplus will be accumulating foreign currency. Spot exchange rates are affected by international trade flows and expectations concerning future trade flows.

The Role of News: The real world is characterized by unpredictable shocks or surprises. Then some unexpected event takes place, it is referred to as news. Since interest rates, prices, and incomes are often affected by news, it follows that exchange rates too will be affected by news. By definition, the exchange rate changes linked to news will be expected.

Market Microstructure: As news related to money supplies, trade balances, or fiscal policies is received by the market, exchange rates will change to reflect this news. Such news affects the entire economy and other prices change along with exchange rates. However, there is also a micro level, at which exchange rates are determined by interactions among traders. There also exists private information from which some traders know more than others about the current state of the market.

Mundell-Fleming model considers a small open economy exerts weak influence on the international economy

adopts floating the exchange rate regime in general equilibrium of goods and money market. Hence the exchange rate is determined by the competitiveness, internal and foreign interest rate.

Dornbush model postulates that the exchange rate is determined by interaction of output, money supply, internal interest rate, and foreign interest rate. The nominal exchange rate is a function of nominal variables current account balance, money stock, and general price level.

Theory of Discount Rate first defines discount rate as a deduction allowed on a financial obligation. It takes many forms the most important is the bank discount which may be regarded as an interest paid in advance. Weichsel says that a rise in discount rate of a country will lead to an increase in the interest rate, which in turn attract foreign capital and hence foreign demand for local currency and eventually raises the exchange rate. On the contrary, a reduction in discount at a time of high interest rates will lead to capital outflow, deficit in the balance of payments, and an increase in money supply. This theory depended on the experience of central banks that raise discount rate to improve the situation of local currency.

4. Empirical Evidence

Annex (1) shows results of unit root tests based on the ADF where the exchange rate and general price level are found to be stationary containing no intercept and trend, money supply is stationary with an intercept while current account balance is integrated of order one without intercept or trend. Annex (2) indicates the presence of four co integrating equations among these variables at 5% significance level i.e. Exchange rate (X), Money Supply (MS), General Price Level (P) or interchangeably Consumer Price Index (CPI), and Current Account Balance (CAB) which means that there is long-run relationship. Current Account Balance is used as a proxy for BOP for two reasons: first economic sanctions imposed on Sudan lowered the inflow of foreign capital, second BOP showed poor results. Due to the application of Islamic Laws in the Sudan interest rate is prohibited so it was dropped from the analysis.

4.1 EGARCH Estimation Output

Annex (6) presents: first the mean equation

$$\hat{X}_t = 0.0086CPI_t - 0.000156MS_t - 0.000003CAB_t + [AR = 0.75] z - stat = 34.7 - 22.29 - 17.09 20.5$$

Second the Variance equation

$$ln(\hat{\sigma}_{t}^{2}) = 2.12 + 3.67 \left| \frac{(\sigma_{t}|\xi_{t-1})}{\sigma_{t-1}} \right| - 2.66707 \frac{\xi_{t-1}}{\sigma_{t-1}} + 0.436 ln(\sigma_{t-1}^{2})$$
$$z - stat = 2.86 \ 2.84 - 3.08 \ 3.98$$
$$R^{2} = 0.985 \ \bar{R}^{2} = 0.98 \ DW = 1.64 \ ARCH(F(Prob)) = 0.89 \ ARCH(\chi^{2}(Prob)) = 0.88$$

The estimated coefficients of the mean equation are highly significant. The sign of money supply, prices and current account are as expected. An increase in money supply leads to a rise in domestic prices which in turn cause a considerable change in terms of trade since some countries stop buying the goods and services from the country. Foreign goods become cheaper which leads to capital outflow and a rise of the price of foreign currency. Current account deficits are financed by depleting domestic stocks of foreign currency. The role of news is shown by the variance equation. The leverage effect term (-2.66), denoted as RES/SQR [GARCH](1) in the output, is negative and statistically different from zero, indicating the existence of the leverage effect (negative correlation between past returns and future volatility. As the past few years proves highly leveraged financial systems can have crises that increase the volatility of asset prices. If the previously constant volatility of A moves E toward zero, the leveraged entity must sell assets to deleverage. If prices on the asset are not perfectly elastic, the sale of the asset results in a further decline in asset prices which can trigger subsequent sales of the asset by the original entity or other highly leveraged entities that hold similar assets (i.e., trigger much higher volatility). Of course, it gets worse because not only does volatility grow under the influence of inelastic asset prices, but inelasticity increases as credit disappears from the overleveraged system. That is, no one has spare risk capital and asset prices become even more inelastic to create a deflationary cycle which triggers much higher volatility.

4.2 Discussion

The devaluation of the exchange rate in 1978 by 43% lead to a series of devaluations but the most influential was in 1992 by 496% which has had profound effects on major economic variables and triggered large fluctuation and depreciation of the exchange rate. As said before exchange rate is treated as a risk. It is well known that about 80% of manufacturing inputs are imported; the same is true for the input of agriculture and other productive sectors. The

mean ratios of total imports to total exports in the period before ELP and the period after are 206% and 219% respectively which means a loss of potential foreign currency earnings and in turn a cause for depreciating the exchange rate. Descriptive statistics in Annex (1) and (2) show sharp increase in the means, medians and standard deviation of exchange rate, money supply, general price level, consumer price index and current account balance respectively from the pre ELP period to the period after. Inflation has been rising continuously specially in the period after to reach the height of 160% increases the costs of exports and decreases their competitiveness and flow of foreign currency. Besides economic sanctions there are inherited problem of the external debt that caused by the failure of development projects and the prevalence of public expenditure on consumption rather than production. Drought and famine, civil wars in the southern, eastern and western Sudan and economic embargo aggravated the situation and depleted the meager stock of foreign currency causing excess demand for foreign currency and hence more devaluations. To set an optimal exchange rate was the goal of the consecutive governments and to attain that goal many policies were formulated and applied but ended in a continuous depreciation and volatility of the Sudanese pound. There is a possibility of a simultaneous feedback relationship between exchange rate and uncertainty. The main determinants of the exchange rate are money supply, current account balance and prices. News related to money supplies, trade balances, or fiscal policies is received by the market; exchange rates will change to reflect this news as apparent in empirical evidence. The money supply as an indicator of monetary policy with its various tools and components can be used to stabilize foreign exchange market. For instance the domestic credit is an effective tool for sterilization .An increase in money stock leads to a rise in domestic prices which in turn cause a considerable change in terms of trade since some countries stop buying the goods and services from the Sudan. Current Account was negative all along the period of study which means an increasing demand for foreign currency and a reduction of external value of local currency. Since 1996 the government was concentrating in producing oil, so it imported the required equipments and inputs which widen the external gap coupled with negative effects of liberalization policies on agricultural production knowing that 90% of Sudan exports are agricultural products. Moreover, manufacturing sector is based mainly on agro-industries, it was affected too. Oil cake and edible oil have been exported mainly to Europe were affected by the adverse relations and ineffective economic polices. To reverse the sign the government should adopt different reform policies.

5. Conclusion

The main characteristic of the foreign exchange market of Sudan at present is its permanent leaning towards instability. This can be traced from the start of the year 1978. The failure of the consecutive governments to set a realistic exchange rate had negative effects on major economic variable for instance the inflation, and unemployment rates reached a height of 160% and 19% respectively. EGARCH model was used to estimate exchange rate volatility, the mean equations were found to be determined by consumer price index (CPI), money stock and current account balance. So the conditional variance (risk) indicates the existence of the leverage effect in future exchange returns during the sample period.

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1979 – 1991	Х	Р	MS	CAB	СРІ	
Mean	3.376923	939.5521	12010.87	-1635.285	688.6000	
Median	2.500000	316.3725	5274.000	-1282.800	254.1000	
Maximum	15.10000	5028.664	52696.00	-190.3000	3913.400	
Minimum	0.500000	69.99107	936.5100	-7397.800	50.70000	
Std. Dev.	3.869142	1411.197	15376.54	1853.754	1088.401	
Skewness	2.284723	2.123808	1.659772	-2.511953	2.251967	
Kurtosis	7.704201	6.566895	4.791789	8.512646	7.099781	
Jarque-Bera	23.29673	16.66437	7.707851	30.13232	20.09238	
Probability	0.000009	0.000241	0.021196	0.000000	0.000043	

Annex 1. Descriptive Statistics

Annex 2. Descriptive statistics

	Х	MS	CPI	CUR	
Mean	1893.239	7794054.	335773.5	-1679879.	
Median	2248.000	3533975.	351715.0	-1209924.	
Maximum	2637.000	28314500	738046.1	571000.0	
Minimum	132.0000	141595.0	8581.800	-7537000.	
Std. Dev.	897.4950	8889129.	224288.2	2123218.	
Skewness	-1.071228	1.069171	0.040705	-1.766046	
Kurtosis	2.571183	2.792854	1.988072	5.270023	
Jarque-Bera	3.580502	3.461563	0.772969	13.22151	
Probability	0.166918	0.177146	0.679441	0.001346	

Annex 3. Unit Roots Test

General Price Level (none) I(0)			
ADF Test Statistic	1.815114	1% Critical Value*	-2.6522
		5% Critical Value	-1.954
		10% Critical Value	-1.6223
Consumer Price Index I(1)			
ADF Test Statistic	1.873423	1% Critical Value*	-3.6289
		5% Critical Value	-2.9472
		10% Critical Value	-2.6118
Money Supply (intercept) I(0)			
ADF Test Statistic	3.9537	1% Critical Value*	-3.6959
		5% Critical Value	-2.975
		10% Critical Value	-2.6265
Exchange Rate (none) I(0)			
ADF Test Statistic	2.012518	1% Critical Value*	-2.6486
		5% Critical Value	-1.9535
		10% Critical Value	-1.6221
Current Account Balance (none) I(1)			
ADF Test Statistic	-1.82024	1% Critical Value*	-2.6649
		5% Critical Value	-1.9559
		10% Critical Value	-1.6231

Annex 4. Devaluation of Official and Free Rate

Month/Year	Official	Devaluation rate	Free	Devaluation rate	free/Official	Duration
Sep-78	0.5	43%	0.8	129%	160%	
Mar-83	1.3	160%	1.8	125%	138%	54
Oct-84	1.3	0%	2.1	17%	162%	18
Feb-85	2.5	92%	3.03	44%	121%	4
Mar-86	2.5	0%	4.1	35%	164%	12
Oct-87	4.5	80%	12.3	200%	273%	18
Oct-91	15.1	236%	30.3	146%	201%	12
Feb-92	90	496%	90	197%	100%	4
Dec-92	216	140%	333	270%	154%	22
Mar-94	216	0%	404	21%	187%	17

Annex 5. Co integration Results

Date: 06/30/12 Tin	ne: 22:55				
Sample: 1978 2010	0				
Included observati	ons: 32				
Test assumption: I	inear deterministic trend	in the data			
Series: X MS CPI	CUR				
Lags interval: 1 to	1				
	Likelihood	5 Percent	1 Percent	Hypothesized	
Eigen value	Ratio	Critical Value	Critical Value	No. of CE(s)	
0.799592	113.9517	47.21	54.46	None **	
0.677705	62.51482	29.68	35.65	At most 1 **	
0.533736	26.28161	15.41	20.04	At most 2 **	
0.056631	1.865521	3.76	6.65	At most 3	
*(**) denotes reje	ection of the hypothesis a	t 5%(1%) significance level			
L.R. test indicates	s 3 cointegrating equation	n(s) at 5% significance level			

Annex 6. EGARCH Output

Dependent Variable: X				
Method: ML – ARCH				
Date: 06/30/12 Time: 21:52				
Sample(adjusted): 1978 2009				
Included observations: 32 after adj	usting endpoints			
Convergence achieved after 23 iter	rations			
	Coefficient	Std. Error	z-Statistic	Prob.
MS	-0.000165	7.41E-06	-22.28574	0.0000
СРІ	0.008594	0.000247	34.73906	0.0000
CUR	-3.78E-05	2.21E-06	-17.08565	0.0000
AR(1)	0.749184	0.036548	20.49880	0.0000
Variance Equation				
С	2.120171	0.741013	2.861179	0.0042
RES /SQR[GARCH](1)	3.669384	1.290521	2.843335	0.0045
RES/SQR[GARCH](1)	-2.655470	0.861560	-3.082164	0.0021
EGARCH(1)	0.435693	0.109415	3.982035	0.0001
R-squared	0.985071	Mean dependent	var	1066.331
Adjusted R-squared	0.980716	S.D. dependent v	ar	1161.564
S.E. of regression	161.3013	Akaike info crite	rion	10.47309
Sum squared resid	624434.6	Schwarz criterior	1	10.83953
Log likelihood	-159.5695	Durbin-Watson s	tat	1.640248
Inverted AR Roots	.75			

Annex 7. ARCH Test

ARCH Test:			
F-statistic	0.019758	Probability	0.889187
Obs*R-squared	0.021106	Probability	0.884490