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INVESTIGATING THE RELATIONSHIP BETWEEN ECONOMIC FACTORS AND EXCHANGE RATE FLUCTUATIONS

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Abstract: This study aims to analyze the determinants of exchange rate and their impact on exchange rate volatility in Sudan using the ARDL model, Vector Error Correction mechanism, and various tests such as Wald test, White test, Newey-West test, and inferential statistics. The study finds that the balance of trade, gold purchases, money supply, inflation, and foreign reserves are the main factors influencing the exchange rate in Sudan. The results reveal that the exchange rate system in Sudan has no effect on the stability of the exchange rate, as the exchange rate deteriorated and fluctuated continuously throughout the study period. The study contributes to the existing literature by presenting empirical evidence on the determinants of exchange rate in a small economy like Sudan, where executing an independent monetary policy is challenging. The implications of the findings of this study for policymakers, especially those in small economies, have been discussed. In summary, this research sheds light on the crucial factors that influence exchange rate and their impact on exchange rate volatility in Sudan.

Keywords: Sudan, exchange rate, volatility, determinants, ARDL, VEC, Wald test, White test, Newey-West test, inflation, money supply, foreign reserves, balance of trade, gold purchases.

Introduction

The exchange rate measures the value of one country currency in terms of other currencies. This value is determined differently depending on the exchange rate system being followed. Under a fixed exchange rate system, this value is set by the monetary authorities, whereas in a floating exchange rate system the exchange rate is determined by the relative forces of demand and supply of the currency in the exchange market. The importance of exchange rate has been tremendously discussed in the literature due to its key role in enhancing the competitiveness of a country in international economy and strengthening its inward financial stability. Stability of exchange rate is one of the crucial objectives of all countries, particularly developing ones. It is evident that a stable exchange rate attracts inflows of foreign investment, improves productiveness and trade patterns, fosters exports of goods, restores trade balance and ultimately helps sustainable development of economic stability. In contrast, instability of exchange rate cuts down investment levels, results in misallocation of resources, deters foreign capital inflows, rises inflation rates and worsens the trade balance. Thus exchange rate determination and stability has been of great interest to academics, policymakers, and market practitioners. Though a number of theoretical models have been developed to predict exchange rate, exchange rate determination is still a controversial issue in the literature of international finance. The general consensus in the literature is that exchange rate volatility is a manifestation of fundamental macroeconomic factors volatility and fluctuation. The central focus has been on explaining the behavior of exchange rate with reference to a given set of macroeconomic fundamentals and a number of models have been developed to furnish a proper understanding of the movement of exchange rate. Such factors which include income growth, inflation, interest rate, fiscal and current account balances, foreign exchange reserves, financial and trade openness, and the size and type of capital flows are considered to be country-specific.

Nevertheless empirical studies have documented diverse viewpoints and conclusions; some of which support these theoretical models and others contradict them. Moreover, which factors are dominant in determining the value of one currency against the other is still an unsolved issue in the literature.

The collapse of the Bretton Woods system in the early 1970s and the evolution of flexible exchange rate regimes have adversely impacted the stability of exchange rates and increased the magnitude of their volatility especially for those of developing economies, and Sudan is not an exception. Since its independence in 1956 a number of exchange rate policies have been implemented by monetary authorities in Sudan; ranging from fixed to floating exchange rate regimes. For instance, during the period 1956-1978 the central bank of Sudan has adopted a fixed exchange rate system, whereby the exchange rate has been pegged at a fixed rate of one Sudanese pound to 2.85 US dollar. Since 1979 the country shifted to a flexible exchange rate system which has resulted in continuous exchange rate devaluations and government interventions. In early nineteen nineties the government announced the economic liberalization policy during which market mechanism is selected as a tool for setting exchange rates. This policy was abolished three years later and replaced by establishing two windows for exchange rate dealings; commercial bank exchange rate dealings in which the exchange rate is devalued to 3 pounds /US$ and a window of the central bank in which the exchange rate is devalued to 2.15 pounds /US$. During the period 2000-2006 and as a result of foreign currency inflows associated with Sudan petroleum exports, the foreign exchange market was unified with a sole exchange rate of 2.6 Sudanese pounds for the dollar. The exchange rate, then, kept on deteriorating at an accelerating rate throughout the period 2006-2017; from 2.6 to 6.9 US dollars, with many interventions and devaluations of currency by the central bank. For instance in 2012 the Sudanese pound was devalued by 91% in one step, from 2.67 to 4.42 pounds for the dollar to minimize the difference between the official and parallel rate. Nevertheless the problem continues and the difference between the parallel and official exchange rates continued to escalate toreach 184 percent of the parallel rate by the end of 2017.This necessitates investigating and analyzing the macroeconomic factors that lie behind this massive volatility in Sudanese exchange rate and exploring whether the exchange rate system followed does have an impact on the degree of exchange rate volatility.

The study uses a more sophisticated method to study the relationship between the exchange rate and its determinants including Autoregressive Distributed Lag (ARDL) model, co-integration analysis, Vector Error Correction (VEC) test and Granger causality test. The rest of this paper is outlined as follows: Section 2 provides a review of the literature that researches the relationship between exchange rate volatility and macroeconomic fundamentals. Section 3 describes the methodology used, Section 4 delineates the empirical results and their discussion and Section 5 presents a summary and concluding remarks.

1. Exchange rate determinants

What determines exchange rate is an unsettled matter in the literature. According to the International Parity theories the inflation differentials and interest differentials between the countries determine their currencies exchange rates. The Balance of Payment Approach argues that the equilibrium exchange rate is determined by the demand and supply of currency flows from current and financial account activities and stresses factors such as international trade, foreign direct investment, portfolio investment, official monetary reserves and exchange rate regimes. In contrast the Asset Market Approach postulates that exchange rates are assets traded in an efficient market and, hence, their values are determined based on expectations about the future. This approach focuses on prospects of economic growth, supply and demand of financial assets, political stability, capital market liquidity, real interest rate and corporate governance. Empirically numerous factors have been cited as determinants of exchange rate. However the relative importance of these factors is subject to much debate. Differentials in inflation, Differentials in interest rate, Money supply, Current account balance, Public debt, GDP growth and Openness of the economy are the most quoted factors. Raza and Afshan (2017), examine the determinants of exchange rate in Pakistan, using time-series data from 1972 to 2013. Their variables include GDP, Inflation, Interest Rate, Money Supply, Terms of Trade and Trade Openness. According to Rajakaruna, (2017), there is negative relationship between exchange rate and official intervention, terms of trade, inflation, call money rates and remittances. The only positive relationship documented is between net foreign purchases and the exchange rate. Cevik et al (2017), show that though the magnitude and statistical significance of the relationship between the exchange rate volatility and macroeconomic variables varies between advanced and emerging market economies, the type of relationship tends to be the same. The analysis reveals a positive relation between exchange rate volatility and inflation and measures of financial development, whereas trade openness has a negative effect on exchange rate volatility. The volatility of productivity growth and terms of trade appear to have an insignificant effect in the case of advanced countries. In addition a number of soft power variables are found to have statistically significant influence on exchange rate volatility.

For instance the index of voice and accountability and life expectancy have dampening effects on exchange rate volatility. Likewise, financial openness, z-score of banks, and the share of agriculture in GDP relative to the service sector lower the volatility of exchange rates. The study by Mpofu (2016), reveals that trade openness significantly reduces the South African currency volatility. The study also finds that volatility of output, commodity prices, money supply and foreign reserves significantly influence exchange rate volatility. Effiong (2014), demonstrates the existence of a unique long-run relationship between the exchange rate and monetary fundamental, namely, money supply, price level, income level and interest rate. In the short run, however, only the interest rate differential is significant and explains most of the variations in the nominal exchange rate in the short-run. Mirchandani (2013) studies the relationship between various macroeconomic variables including interest rate, inflation rate, GDP, current account and foreign direct investment and the exchange rate of Indian Rubi to US Dollar. Using Pearson’s correlation analysis his findings indicates that there is a strong correlation, whether direct or indirect, between the exchange rate and interest rate, inflation rate, foreign direct investment and GDP Growth. His study documents no relationship between current account and the exchange rate.

The empirical results of Proti (2013) study report a negative relationship between exchange rate and total national debt, real interest rate and GDP growth, whereas no significant relation is found between exchange rate movement and inflation and value of imports and exports.Khattak et al (2012), show that both monetary and real factors, namely, money supply, trade balance, foreign exchange reserves, inflation and interest rate have long run relationship with the exchange rate of Pak-rupee. However, the granger causality test results show that the relationship between most of the macroeconomic variables and nominal exchange rate is bi-directional.Abbas, Khan and Rizvi (2011),document that a set of common macroeconomic factors including interest rate differential, inflation, foreign terms of trade, trade restrictions and net capital inflows causes fluctuations in emerging Asian economies.Though there are some differences in the direction and significance of relationship of exchange rate with the variables, exchange rates of all five sample economies seem to have long run relationship with macroeconomic fundamentals. Morana (2009), proclaims that there is an evidence of significant long-term linkages and trade-offs between macroeconomic and exchange rate volatility in the

G-7 countries, involving output and inflation volatility in particular, and money growth volatility to a lesser extent. Moreover, although evidence of bidirectional causality has been found, the linkages are much stronger from macroeconomic volatility to exchange rate volatility than the other way around. Chong and Tan (2007), documents the presence of long-run movement between the exchange rates and terms of interest rates, money supplies, consumer price indices, trade balances and composite indices (RCI) three out of the four selected Asian economies countries.

The study also finds that volatility of output, commodity prices, money supply and foreign reserves significantly influence exchange rate volatility. Drine and Rault (2006), affirm that an improvement in terms of trade, an increase of per capita GDP and an increase of capital flows entail a long-run appreciation of the real exchange rate. On the other hand, an increase in domestic investment and degree of openness of the economy entails a real exchange rate depreciation. However their results show the effect of public spending increase to be ambiguous. Elbadawi and Soto (1997), assert that only long-run capital flows and foreign direct investment are cointegrated with the long-term equilibrium exchange rate, while degree of openness is negatively associated exchange rate and results of impact of terms of trade are somewhat ambiguous. The ADRL Test, J.J. co-integration approach and Gregory and Hansen (1996) structural break co-integration approach used confirm the significant long run relationship among the exchange rate and its determinants. Their results indicate the significant negative association of exchange rates with terms of trade, trade openness and economic growth, whereas money supply and inflation rate have a positive and significant effect on exchange rates.

2. Data and Methodology

The study covers the period 2000-2017 and utilizes quarterly based data published by the central bank of Sudan and Central bureau of statistic.IMF website has also been used to help cross-checkof data consistency to facilitate robustness of findings. Data employed include statistics on exchange rate premium and money supply, foreign reserves, balance of trade, and gold purchases which represent the macroeconomic factors selected as determinants of the exchange rate in Sudan. The research data amounts to 384 observations.The paper uses the Autoregressive Distributed Lag (ARDL) of Pesaran and Shin (1999) to examine the relationship between the study variables.

This method has the advantage that variables in co-integrating relationship can be either I(0) or I(1) without the need to pre-specify, which are I(0) or I(1). Further ARDL representation does not require symmetry of lag length, each variable can have different number of lag terms.An ARDL model may be written as:

$$y_t = \propto + \sum_{i=1}^{p} \gamma_i y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{qi} x_{j,t-i} B_{j,i}^{'} + \varepsilon_t \qquad (1)$$

Some of explanatory variables, xj may have no lagged terms in the model qj=0). These variables are called static or fixed regressors. Explanatory variables with at least one lagged term are called dynamic regressors. To specify an ARDL model, the research determine how many lags of each variable should be included (specify P and q, …qk). Since ARDL model can be estimated via least square regression, standard Akaike, Schwarz and Hannan–Quin information criteria is used for model selection. The calculation of these estimated long-run coefficients is given by:

$$\theta_j = \frac{\sum_{i-1}^{j} \widehat{B}_{j,i}}{1 - \sum_{i=1}^{P} \gamma_i} \qquad (2)$$

The co-integrating regression from an ARDL model is obtained by transforming equation (1) into differences and substituting the long-run coefficient from equation (2).

$$Ec_{t-1} + \varepsilon_t \qquad (3)$$

Where:

θ

γ

$$\sum_{i=0}^{q_{j-1}} \Delta x_{j,t-} \Delta y_t = \sum_{i=1}^{P-1} \gamma_i^* \Delta y_{t-1} + \sum_{j=1}^{k} {}_j' \oint B_{,i}^* - 1'$$

γ γ

$${}_t - \propto - \sum \qquad Ec_t = y \;\hat{}\; {}_j \; {}_1 x_{j,t} \; {}_{j=}$$

UsingPesaran Shin and Smith (2001) methodology for testing whether the ARDL model contains a level (or long-run) relationship between the independent variable and regressors, equation (3) is transformed into the following representation:

$$= 1 - \sum_{i=1}^{P} \quad \oint \; {}_i \; \hat{}$$

$${}_i^* = \sum_{m=i+1}^{P} \; \hat{} \; {}_m$$

$$\sum^{qj} B_{j,m} \qquad B_{j,i}^* = \quad (\quad 4)$$

$$\Delta y_t = \sum_{i=1}^{P-1} \gamma_i^* \Delta y_{t-1} + \sum_{j=1}^{k} \sum_{i=0}^{qj-1} \Delta x_{j,t-1} B_{j,i}^{*\prime} - \rho \; y_{t-1} - \propto - \sum_{j=1}^{k} x_{j,t-1} \delta_j' + \varepsilon_t \qquad (5)$$

The test for the existence of level relationships is then simply a test of:

ρ=0

$\delta_1 = \delta_2 = \cdots = \delta_k = 0$ (6)

The coefficient estimates used in the test may be obtained from regression, using equation (1), or can be Estimated directly from a regression using equation (5)

The specified model of the research is a multiple regression, which estimates the regression of Y on X's in which multiple refers to the independent variables as follows:

Premium = MS + GP + FRS + BOT + INF(7)

Where:

Premium whichis the dependent variable, is the difference between parallel and official exchange rates, MS refers to money supply and includes M1 and quasi money, GP is the gold purchases by the central bank at free market rate, FRS represents foreign reserves built by the central bank, including reserves from export of gold, BOT is the difference between exports and imports, INF is the rate of inflation. The research model satisfies the use of Autoregressive Distributed Lag model (ARDL) for the estimation of the data, by having logFRS and logINF stationary at level I(0) and logPREM, logMS, logGP, logBOT, stationary at first difference I(1). The research model is specified in line with the hypothesis that none of the xs' predict y, which can be expressed as:

H_0: $B_1 = 0$ since $B = (B_1, B_2 \ldots B_P)$

H_1: $B_1 \neq 0$, implies that even one $B_i \neq 0$

$(j = 1, 2, \ldots q)$

Where B1, B2..Bprepresents the coefficients of the independent variables. Thus, rejecting the null means that all non-intercept coefficients are not equal to zero, indicating that X's can predict Y.

The study makes use of EViewssoftware which is an ideal package for time series, cross-section, or longitudinal data. The software helps managing data and performing econometric and statistical analysis. Basic regression techniques are used in E-views for specifying the estimated regression model. This is done by performing diagnostic analysis, and using the specified results in further analysis.E-views provide tools for evaluating the quality of specification along a number of dimensions. In turn, the results of these tests influence the chosen specification. Each test procedure involves the specification of a null hypothesis, which is the hypothesis under test. Output from a test command consists of the sample values of one or more test statistics and their associated probability numbers (pvalues). The latter indicate the probability of obtaining a test statistics whose absolute value is greater than or equal to that of the null hypothesis if the null hypothesis is true. Thus, low p-values lead to the rejection of the null hypothesis.

The specification of the estimated research model is carried out by employing three categories of tests, residual diagnostics, stability diagnostics and coefficient diagnostics. In addition itemploys ARMA structure analysis to assess the structure of ARMA portion of the estimated research model. To identify the determinant factors of exchange rate the research tests the hypothesis that none of explanatory variables predicts the dependent variable by using four tests: Wald test, heteroskedasticity consistence covariance (White) test, HAC consistent covariance (NeweyWest) test and inferential statistics.To test the impact of explanatory variables' fluctuation on exchange rate premium, the study applies long-run elasticity tests to the bounds of the research model. In determining what variables are responsible for long-run fluctuations, the research applies Vector Error Correction (VEC) mechanism.Wald test is employed to examine the long-term and short-run causal effects and determines the speed of adjustment of endogenous variables.

3. Results and Discussion

Descriptive statistics and correlation matrix are employed by the study to provide insight into characteristics of the data in order to enable the best selection of the model. The descriptive statistics presented in Table (1) below shows skewness in the data, which is the departure from asymmetry, having foreign reserves (FRS) and Balance of Trade (BOT) with negative skewness and other variables with positive skewness. Also, the statististicsshow kurtosis, which indicates that distributions of variables are characterized by peakness and flat tail relative to normal distribution. JargueBera test provides clear evidence to reject the null hypothesis of the normality for unconditional distribution of the quarterly exchange rate changes.

Table (1): Descriptive Statistics

	PREM	**MS**	**FRS**	**GP**	**INF**	**BOT**
Mean	0.848281	29422.30	1767.313	750.2406	15.39063	10451.49
Median	0.080000	20000.75	1793.900	41.05000	12.00000	11679.66
Maximum	5.180000	93642.60	3814.200	3787.600	48.00000	17122.93
Minimum	0.010000	3466.700	1.400000	18.80000	1.000000	1.000000
Std. Dev.	1.301689	26115.16	598.9386	1090.128	11.78729	3508.112
Skewness	1.470112	1.025691	-0.616472	1.306624	1.327094	-1.104524
Kurtosis	4.041084	2.945971	6.333459	3.436600	3.867643	3.904365
Jarque-Bera	25.94338	11.22958	33.68559	18.71917	20.79337	15.19406
Probability	0.000002	0.003644	0.000000	0.000086	0.000031	0.000502
Sum	54.29000	1883027.	113108.0	48015.40	985.0000	668895.6
Sum Sq. Dev.	106.7469	4.30E+10	22599830	74867894	8753.234	7.75E+08
Observations	64	64	64	64	64	64

The correlation matrix in Table (2) shows that there is a correlation among the variables in the data of the research. This necessitates testing for perfect collinearity. The results of ADF shown in Table (3) and PP in Table (4) reveal that test statistics values are greater than critical value for logFRS and logINF at level. Thus, they are described as stationary at level I(0). Other variables (logPREM, logMS, logGP, logBOT) have statistics values less than critical value at level, they are described as stationary at first difference I(1). Thus, both tests reject the null hypothesis of the unit root for logFRS and logINF at level, and do not reject the null at level for the other variables.

Table (2): Correlation

	PREM	**MS**	**INF**	**GP**	**FRS**	**BOT**
PREM	1.000000	0.941961	0.669326	0.826738	-0.056721	-0.813118
MS	0.941961	1.000000	0.706974	0.799793	-0.098448	-0.762611
INF	0.669326	0.706974	1.000000	0.836947	-0.100400	-0.528335
GP	0.826738	0.799793	0.836947	1.000000	-0.099312	-0.605990
FRS	-0.056721	-0.098448	-0.100400	-0.099312	1.000000	0.146301
BOT	-0.813118	-0.762611	-0.528335	-0.605990	0.146301	1.000000

Table (3): Unit Root Test (ADF) Augmented Dickey-Fuller

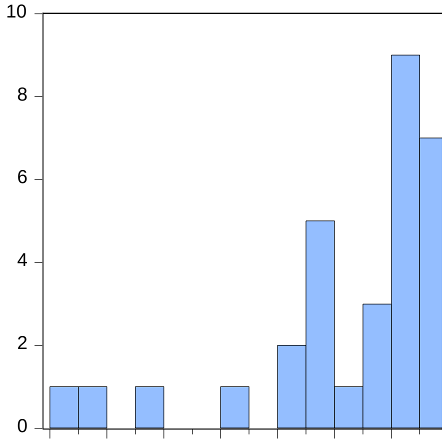
Variables	**ADF statistics**	**Test critical value**	**Prob***	**ADF test statistic**	**Test critical value**	**Prob***
LogGP	-2.417102	-3.462763	0.3675	-9.311856	-3.483970	0.0000
LogBOT	4.023637	-3.496960	1.0000	-0.026871	-3.492149	0.9945
LogFRS	-6.431192	-3.482763	0.0000	-7.411243	-3.486509	0.0000
LogINF	-6.270246	-3.482763	0.0000	-8.669799	-3.487845	0.0000
LogPREM	-2.879798	-3.482763	0.1759	-8.301111	-3.784970	0.0000
LogMS	-2.200787	-3.482763	0.4808	-7.822127	-3.483970	0.0000

Prob* Macinnon (1996) one-sided p-values Source: author's summary of the unit root test

Table (4): Unit Root Test (Phillips-Perron)

Variables	**Adjusted tstatistics**	**Test critical value**	**Prob***	**Adjusted t-statistics**	**Test critical value**	**Prob***
LogGP	-2.302938	-3.482763	0.4261	-9.608008	-3.483970	0.0000
LogBOT	11.421164	-3.482768	1.0000	-5.624072	-3.483970	0.0000
logFRS	-6.289436	-3.482763	0.0000	-34.23684	-3.483970	0.0000
LogINF	-6.390005	-3.482763	0.0000	-18.43704	-3.483970	0.0000
LogPREM	-2.894661	-3.482763	0.1722	-10.97639	-3.483970	0.0000
LogMS	-2.233128	-3.482763	0.4633	-7.911026	-3.483970	0.0000

To check specification of the estimated equation for the research data, residual diagnostics displayed in the Appendix (Specification and diagnostic Tests) reveals that correlograms and Q-statistic show spikes at lags that are insignificant, which indicates insignificant serial correlation. The Histogram and normality test demonstrates that the probability for JargueBera in Figure (1), is (0.10488), which is higher than the level of significance (0.05); indicating that null of normality is not rejected. This suggests that residuals are normally distributed. The stability of the parameters of the model across various sub-samples of the data is tested by estimating Recursive residuals, which are shown in Figure (2). The test advocates instability in the parameters of the estimated equation. However this suggestion is rejected by Cusum test in Figure (3), which shows that cumulative sum of recursive residuals lies inside the area between two critical lines, which is suggestive of coefficient stability



Series: Residuals
Sample 2001Q1 2015Q4
Observations 60
Mean 3.41e-17
Median -0.008287
Maximum 0.918289
Minimum -1.307065
Std. Dev. 0.457985
Skewness -0.571005
Kurtosis 3.707452
Jarque-Bera 4.511691
Probability 0.104785

Figure (1): Normality test (JargueBera)

Recursive Residuals ---- ± 2 S.E.

Figure (2): Recursive residuals

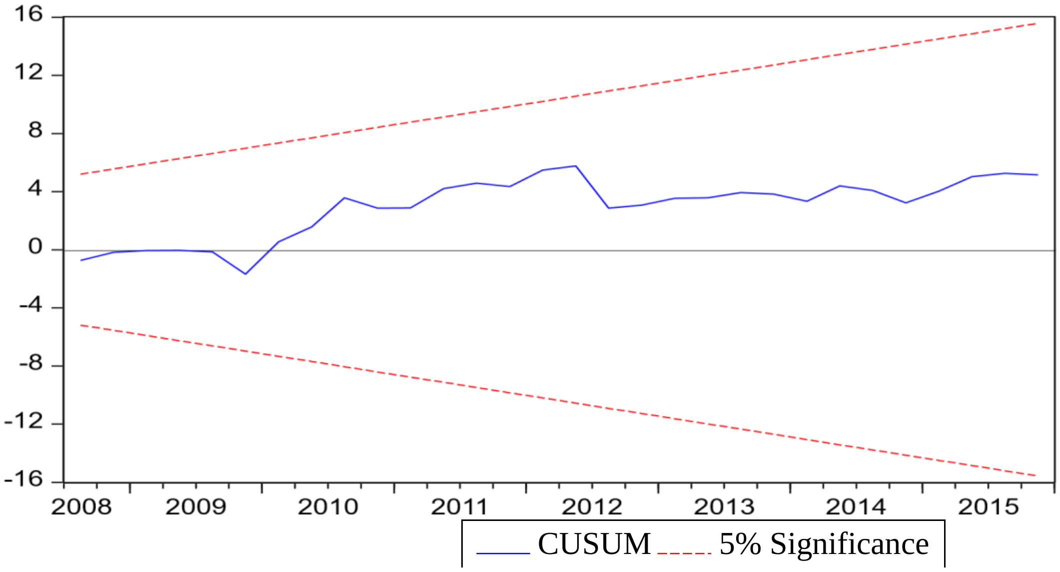


Figure (3): Cusum test

3.1 Test of hypotheses

The research uses the data collected to reject or "not reject" the hypothesis. Rejecting $H_0 = B_1 = 0$means that the research rejects the null hypothesis of coefficients excluding intercepts are equal to zero, which means explanatory variables are the exact determinants of the dependent variable.

The estimated model of the research data shown in Table (5) below, which is estimated by Autoregressive Distributed Lag (ARDL) model displayed in Table(6).The F-statistic probability shown in Table (5) rejects both the null hypothesis of the non-intercept coefficient are zero and the null hypotheses that the slope of non-intercept coefficients are zero, indicating that that the determinant factors of exchange rate in Sudan are logMS, logGP, logFRS, logBOT, and logINF.

Table (5): Estimated Model of the Research Data

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.258684	10.66248	0.024261	0.9808
DLOGMS	1.428832	2.940055	0.485988	0.6305
DLOGBOT	0.099375	0.185874	0.534636	0.5968
DLOGGP	0.390363	0.224061	1.742214	0.0917
LOGFRS	-0.008627	0.129220	-0.066761	0.9472
LOGINF	-0.169477	0.245103	-0.691449	0.4946
DLOGPREM(-1)	0.317344	0.289159	1.097471	0.2812
DLOGPREM(-2)	0.248105	0.237616	1.044143	0.3048
DLOGPREM(-3)	-0.185241	0.203605	-0.909805	0.3702
DLOGMS(-1)	-4.280344	3.308877	-1.293594	0.2057
DLOGMS(-2)	0.105209	2.782565	0.037810	0.9701
DLOGMS(-3)	1.761023	2.643178	0.666252	0.5103
DLOGBOT(-1)	1.001707	0.774856	1.292765	0.2060
DLOGBOT(-2)	1.070758	0.737106	1.452653	0.1567
DLOGBOT(-3)	0.855806	0.751780	1.138373	0.2640

LOGINF(-3)	0.031864	0.229399	0.138902	0.8905
LOGPREM(-1)	-0.977510	0.318507	-3.069038	0.0045
LOGMS(-1)	0.521971	0.346086	1.508215	0.1420
LOGBOT(-1)	-1.024946	0.752530	-1.361999	0.1833
LOGGP(-1)	0.881736	0.303997	2.900478	0.0069
FRS(-1)	-0.001084	0.000322	-3.361678	0.0021
INF(-1)	0.021245	0.029159	0.728593	0.4719

R-squared	0.645100	Mean dependent var	0.104166
Adjusted R-squared	0.302030	S.D. dependent var	0.768772
S.E. of regression	0.642268	Akaike info criterion	2.259230
Sum squared resid	12.37524	Schwarz criterion	3.306403
Log likelihood	-37.77691	Hannan-Quinn criter.	2.668837
F-statistic	1.880374	Durbin-Watson stat	1.802638
Prob(F-statistic)	0.045371		

DLOGGP(-1)	0.070848	0.334834	0.211590	0.8339
DLOGGP(-2)	-0.251541	0.247034	-1.018244	0.3167
DLOGGP(-3)	-0.023918	0.213664	-0.111942	0.9116
LOGFRS(-1)	0.611586	0.166194	3.679945	0.0009
LOGFRS(-2)	-0.099253	0.126346	-0.785561	0.4383
LOGFRS(-3)	-0.229998	0.105061	-2.189179	0.0365
LOGINF(-1)	-0.580448	0.383923	-1.511886	0.1410
LOGINF(-2)	-0.322356	0.252897	-1.274652	0.2122

Table (6): ARDL estimation x

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DLOGPREM(-1)	-0.134419	0.166347	-0.808064	0.4244
DLOGPREM(-2)	-0.093487	0.180260	-0.518624	0.6072
DLOGPREM(-3)	-0.363708	0.185199	-1.963876	0.0573
DLOGMS	4.611916	2.585729	1.783604	0.0829
DLOGMS(-1)	-0.603097	2.758443	-0.218637	0.8282
DLOGMS(-2)	4.197498	2.480465	1.692222	0.0992
DLOGMS(-3)	1.649124	2.547833	0.647266	0.5216
DLOGBOT	-0.029609	0.134378	-0.220339	0.8269
DLOGBOT(-1)	-0.007071	0.411193	-0.017195	0.9864
DLOGBOT(-2)	0.311034	0.505520	0.615275	0.5422
DLOGBOT(-3)	0.360931	0.520969	0.692807	0.4929
DLOGGP	0.126000	0.243599	0.517243	0.6082
DLOGGP(-1)	0.256990	0.239444	1.073277	0.2903

DLOGGP(-2)	0.066441	0.233146	0.284974	0.7773
DLOGGP(-3)	0.006645	0.227595	0.029197	0.9769
LOGFRS	-0.168466	0.116509	-1.445944	0.1568
LOGFRS(-1)	0.158820	0.126810	1.252425	0.2185
LOGFRS(-2)	-0.174203	0.124664	-1.397380	0.1709
LOGFRS(-3)	-0.196533	0.108591	-1.809851	0.0787
LOGINF	-0.034762	0.251818	-0.138043	0.8910
LOGINF(-1)	-0.192190	0.268283	-0.716369	0.4784
LOGINF(-2)	0.184991	0.262117	0.705758	0.4849
LOGINF(-3)	0.095794	0.240478	0.398348	0.6927
C	2.237085	1.455286	1.537214	0.1330

R-squared	0.366465	Mean dependent var	0.104166
Adjusted R-squared	-0.038293	S.D. dependent var	0.768772
S.E. of regression	0.783354	Akaike info criterion	2.638709
Sum squared resid	22.09114	Schwarz criterion	3.476447
Log likelihood	-55.16128	Hannan-Quinn criter.	2.966395
F-statistic	0.905392	Durbin-Watson stat	1.932474
Prob(F-statistic)	0.591785		

*Note: p -values and any subsequent tests do not account for model

The ARDL model demonstrates the presence of co-integration as proved by Wald test, the results of which are shown in Table (7). The calculated value of F-statistic; 3.9 is higher than the upper value of F-statistic in Table (8), which ranges between 2.62 and 3.79 for the five explanatory variables at 0.05 level of significance.

Table (7): Wald Test coefficient restriction

Test Statistic	Value	df	Probability
F-statistic	3.925539	(6, 30)	0.0052
Chi-square	23.55324	6	0.0006

Null Hypothesis: C(25)=C(26)=C(27)=C(28)=C(29)=C(30)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(25)	-0.977510	0.318507
C(26)	0.521971	0.346086
C(27)	-1.024946	0.752530
C(28)	0.881736	0.303997
C(29)	-0.001084	0.000322
C(30)	0.021245	0.029159

Restrictions are linear in coefficients.

Table (8):Unrestricted intercept and no trend

	90%		95%		97.5%		99%		mean		variance	
k	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
0	6.58	6.58	8.21	8.21	9.80	9.80	11.79	11.79	3.05	3.05	7.07	7.07
1	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	2.03	2.52	2.28	2.89
2	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	1.69	2.35	1.23	1.77
3	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61	1.51	2.26	0.82	1.27
4	2.45	3.52	2.86	4.01	3.25	4.49	3.74	5.06	1.41	2.21	0.60	0.98
5	2.26	3.35	2.62	3.79	2.96	4.18	3.41	4.68	1.34	2.17	0.48	0.79
6	2.12	3.23	2.45	3.61	2.75	3.99	3.15	4.43	1.29	2.14	0.39	0.66
7	2.03	3.13	2.32	3.50	2.60	3.84	2.96	4.26	1.26	2.13	0.33	0.58
8	1.95	3.06	2.22	3.39	2.48	3.70	2.79	4.10	1.23	2.12	0.29	0.51
9	1.88	2.99	2.14	3.30	2.37	3.60	2.65	3.97	1.21	2.10	0.25	0.45
10	1.83	2.94	2.06	3.24	2.28	3.50	2.54	3.86	1.19	2.09	0.23	0.41

To carry out co-integration analysis using Johansen model, the study estimates unrestricted VAR for the log of the dependent and explanatory variables, determines the lag length as selected by AIC and specifies the cointegrating equations using Johansen co-integration model. Johansen co-integration test in Table (9) with one lag, under the assumption of intercept (no trend) in CE and VAR, shows co-integration as revealed by Trace statistics and Max-Eigen values, which are greater than the critical values at 5% level of significance. This shows that there is unique long-run relationship between the dependent and independent variables.

Table (9): Johansen co-integration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.592600	124.5553	95.75366	0.0001
At most 1	0.416917	68.88176	69.81889	0.0592
At most 2	0.244269	35.43738	47.85613	0.4251
At most 3	0.193754	18.07303	29.79707	0.5607
At most 4	0.069938	4.720297	15.49471	0.8378
At most 5	0.003623	0.225064	3.841466	0.6352

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Co-integration Rank Test (Maximum Eigen value)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.592600	55.67351	40.07757	0.0004
At most 1	0.416917	33.44438	33.87687	0.0562
At most 2	0.244269	17.36435	27.58434	0.5488
At most 3	0.193754	13.35273	21.13162	0.4203
At most 4	0.069938	4.495233	14.26460	0.8037
At most 5	0.003623	0.225064	3.841466	0.6352

Max-Eigen value test indicates 1 co-integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values

3.2 Testing the Impact of Explanatory Variables on Exchange Rate Premium

Both ARDL and Johansen co-integration model agree to the presence of co-integration between the variables in the model. Thus, the study moves further to test the response of the dependent variable to change in either of the independent variables. This is measured by the elasticity of each of the explanatory variable with the dependent variable, as depicted in Table (10). Using the model data and results of elasticity and applying the following formula:

$$E = -(\theta_1/\theta_0) \qquad (10)$$

Where: E is the elasticity or multiplier, θ1 is the coefficient of explanatory variable, θ0 is the coefficient of the dependent variable, the long-run elasticity analysis shows that balance of trade is a major influencing factor in premium. The decline in the balance of payment by one unit leads to decline in the premium by 1.04

units. The second influencing factor is gold purchases; an increase in gold purchases by one unit results in 0.90 unit increase in premium. The factor which ranks third is money supply. The long-run elasticity test shows that one unit increase in money supply results in 0.53 units increase in premium. The forth factor that influences the exchange premium is inflation; as revealed by elasticity test an increase of one unit in inflation leads to increase in premium by 0.02 units. The impact of foreign reserves on exchange premium is negligible; a decline by one unit in foreign reserves leads to decline in premium by 0.001 unit.

Table (10): Elasticity test x

	θ_0	θ_1	Change in θ_0 due to one unit change in θ_1
PREM	-0.977510	-	-
MS	-	0.521971	0.53
BOT	-	-1.024946	-1.04
GP	-	0.881736	0.90
FRS	-	-0.001084	-0.001
INF	-	0.021245	0.02

3.3 Testing the speed of adjustment of endogenous variable and significance of long-term causal effect of variables

Vector Error Correction estimates, which are displayed in Table (11) are estimated by one lag and one cointegrating equation. The system of the VEC estimates by variable, provides a short-run model in Table (12). Shortrun dynamics of the model shows the speed of adjustment; VECM of 26% to restore equilibrium, which have negative sign and statistically significant at 26%, ensuring that long-run equilibrium can be attained. The size of Error Correction Term (ECT) is small, indicating that the speed of adjustments towards long-run equilibrium is rather slow. Testing the significance of long-term causal effect, the paper uses the probability of t-statistic in the VEC system reported in Table (13).

Table (11): Vector Error Correction Estimates

Co-integrating Eq.	CointEq1
LOGPREM(-1)	1.000000
LOGMS(-1)	-0.881314
	(0.28278)
	[-3.11665]
LOGBOT(-1)	-0.796710
	(0.43527)
	[-1.83039]
LOGGP(-1)	-0.925223
	(0.15194)
	[-6.08927]

LOGFRS(-1)	-1.061901
	(0.15336)
	[-6.92411]
LOGINF(-1)	0.571071
	(0.37658)
	[1.51648]
C	28.96250

Error Correction:	D(LOGPRE)	D(LOGMS)	D(LOGBOT)	D(LOGGP)
CointEq1	-0.255012	-0.008237	-0.062888	-0.006612
	(0.08252)	(0.00584)	(0.11975)	(0.06387)
	[-3.09038]	[-1.41063]	[-0.52514]	[-0.10352]
D(LOGPREM(-1))	0.145668	-0.004537	-0.026745	0.133127
	(0.14189)	(0.01004)	(0.20592)	(0.10983)
	[1.02662]	[-0.45182]	[-0.12988]	[1.21215]
D(LOGMS(-1))	-2.656803	-0.073645	0.422013	-0.890928
	(2.05552)	(0.14546)	(2.98308)	(1.59102)
	[-1.29252]	[-0.50630]	[0.14147]	[-0.55997]
D(LOGBOT(-1))	-0.175365	-0.006181	-0.776418	0.070246
	(0.27280)	(0.01930)	(0.39590)	(0.21115)
	[-0.64284]	[-0.32020]	[-1.96117]	[0.33268]
D(LOGGP(-1))	-0.212359	0.000582	0.272484	-0.193806
	(0.18228)	(0.01290)	(0.26454)	(0.14109)
	[-1.16501]	[0.04510]	[1.03004]	[-1.37364]
D(LOGFRS(-1))	-0.029782	-0.004426	0.022071	0.031163
	(0.08186)	(0.00579)	(0.11880)	(0.06336)
	[-0.36383]	[-0.76410]	[0.18579]	[0.49185]
D(LOGINF(-1))	-0.030179	-0.017635	0.064709	-0.041384
	(0.14903)	(0.01055)	(0.21628)	(0.11535)
	[-0.20250]	[-1.67214]	[0.29919]	[-0.35876]

C	0.235275	0.057282	-0.209432	0.108650
	(0.13938)	(0.00986)	(0.20228)	(0.10788)
	[1.68801]	[5.80772]	[-1.03537]	[1.00710]
R-squared	0.190832	0.098633	0.088219	0.070444
Adj. R-squared	0.085940	-0.018211	-0.029975	-0.050054
Sum sq. resids	28.23239	0.141376	59.46135	16.91437
S.E. equation	0.723064	0.051167	1.049350	0.559669
F-statistic	1.819319	0.844140	0.746392	0.584606
Log likelihood	-63.58760	100.6134	-86.67815	-47.70610
Akaike AIC	2.309277	-2.987528	3.054134	1.796971
Schwarz SC	2.583746	-2.713059	3.328603	2.071440
Mean dependent	0.100806	0.053166	-0.151947	0.060892
S.D. dependent	0.756292	0.050707	1.033968	0.546167
Determinant resid (dof adj.)		7.78E-05		
Determinant resid covariance		3.40E-05		
Log likelihood		-208.8497		
Akaike information criterion		8.479023		
Schwarz criterion		10.33169		

Table (12): Vector Error Correction System

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.255012	0.082518	-3.090378	0.0032
C(2)	0.145668	0.141891	1.026618	0.3092
C(3)	-2.656803	2.055515	-1.292524	0.2017
C(4)	-0.175365	0.272795	-0.642844	0.5230
C(5)	-0.212359	0.182281	-1.165008	0.2491
C(6)	-0.029782	0.081857	-0.363830	0.7174
C(7)	-0.030179	0.149031	-0.202501	0.8403
C(8)	0.235275	0.139381	1.688007	0.0972

R-squared	0.190832	Mean dependent var	0.100806
Adjusted R-squared	0.085940	S.D. dependent var	0.756292
S.E. of regression	0.723064	Akaike info criterion	2.309277
Sum squared resid	28.23239	Schwarz criterion	2.583746
Log likelihood	-63.58760	Hannan-Quinn criter.	2.417041
F-statistic	1.819319	Durbin-Watson stat	2.022067
Prob(F-statistic)	0.102300		

Table (13): Wald Test (MS variable)

Test Statistic	Value	df	Probability
t-statistic	1.292524	54	0.2017
F-statistic	1.670619	(1, 54)	0.2017
Chi-square	1.670619	1	0.1962

Null Hypothesis: C(3)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-2.656803	2.055515

Restrictions are linear in coefficients.

Wald Test:

Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	1.292524	54	0.2017
F-statistic	1.670619	(1, 54)	0.2017
Chi-square	1.670619	1	0.1962

Null Hypothesis: C(3)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-2.656803	2.055515

Restrictions are linear in coefficients.

If the probability is less than significance level (0.05), the short-run effect is said to be significant and vice versa. The analysis in the VEC system shows that the short-run effect of all variables is insignificant. Further the short-run causality, which is measured using Wald test shows that all variables; MS, BOT, GP, FRS and INF have no short-run effect. Results are shown in tables 14, 15, 16, 17 and 18 respectively. Thusboth VEC system analysis and Wald test agree that all determinant factors of exchange rate are responsible for long-run fluctuations.

Table (14): Wald Test (BOT variable)

Test Statistic	Value	df	Probability
t-statistic	0.642844	54	0.5230
F-statistic	0.413248	(1, 54)	0.5230
Chi-square			

Null Hypothesis: C(4)=0	Null	0.413248	1	0.5203

Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.175365	0.272795

Restrictions are linear in coefficients.

Table (15): Wald Test (GP variable)

Test Statistic	Value	df	Probability
t-statistic	-1.165008	54	0.2491
F-statistic	1.357244	(1, 54)	0.2491
Chi-square	1.357244	1	0.2440

Null Hypothesis: C(5)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.212359	0.182281

Restrictions are linear in coefficients.

Table (16): Wald Test (FRS variable)

Test Statistic	Value	df	Probability
t-statistic	-0.363830	54	0.7174
F-statistic	0.132372	(1, 54)	0.7174
Chi-square	0.132372	1	0.7160

Null Hypothesis: C(6) =0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(6)	-0.029782	0.081857

Restrictions are linear in coefficients.

Table (17): Wald Test (INF variable)

Test Statistic	Value	df	Probability
t-statistic	0.202501	54	0.8403
F-statistic	0.041007	(1, 54)	0.8403
Chi-square	0.041007	1	0.8395

Null Hypothesis: C(7)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7)	-0.030179	0.149031

Restrictions are linear in coefficients.

Table (18): Premium as a Dependent Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGGP	0.238639	0.134544	1.773692	0.0815
LOGMS	-0.282195	0.087229	-3.235097	0.0020
LOGPREM(-1)	0.608593	0.107731	5.649214	0.0000
PREM(-1)	-0.441969	0.267009	-1.655258	0.1034
GP(-1)	0.000145	0.000202	0.717851	0.4758
MS(-1)	3.94E-05	1.36E-05	2.895767	0.0054

R-squared	0.905979	Mean dependent var	-1.949565
Adjusted R-squared	0.897732	S.D. dependent var	2.163677
S.E. of regression	0.691931	Akaike info criterion	2.191731
Sum squared resid	27.28979	Schwarz criterion	2.395839
Log likelihood	-63.03953	Hannan-Quinn criter.	2.272008
Durbin-Watson stat	1.834554		

Based on causality relationships estimated, the research specify Granger causality test in the form of Vector Error Correction (VEC) framework for the following equations:

LogINF c logPREMlogGPlogMS(12)

LogPREM c logGPlogMS(13)

The above two equations are estimated by ARDL model and subjected to specification tests as applied to the research model. The analysis revealed that LogPREM in equation (13) is caused by logGP and logMS, with a predicting power of 90% as shown in Table (18). The short-run model derived by VEC system, which is depicted in Table (19), reveals that logGP has significant effect on logPREM. Employing Wald test, with Chi-square (0.05) lower than the significance level at 5%, explains that logGP has significant short-run effect on logPREM. Using short-run elasticity test, one unit change in logGP leads to a positive change in premium by 1.75. Other explanatory variables, logMS and LogINF have insignificant impact.

Table (19): VEC system (short-term model)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.407859	0.127696	-3.193983	0.0023
C(2)	0.190896	0.147381	1.295250	0.2005
C(3)	-0.335719	0.177245	-1.894092	0.0633
C(4)	-1.248059	1.889235	-0.660616	0.5115
C(5)	0.168305	0.133051	1.264962	0.2110

R-squared	0.170465	Mean dependent var	0.100806
Adjusted R-squared	0.112252	S.D. dependent var	0.756292
S.E. of regression	0.712581	Akaike info criterion	2.237362
Sum squared resid	28.94301	Schwarz criterion	2.408905
Log likelihood	-64.35821	Hannan-Quinn criter.	2.304714
F-statistic	2.928307	Durbin-Watson stat	2.024749
Prob(F-statistic)	0.028481		

The research findings coincide with the theoretical and empirical literature. However what is unique with this study is the considerable impact of gold purchases on premium fluctuations which exceeds that of money supply. This can be justified on the basis that the exchange rate used by the Sudanese central bank for gold purchases is higher than the rate prevailing in the market. This in turn pushes up the exchange rate. The negligible impact of reserves on premium is another point to note. This is attributed to the country's low reserves position.

4. Conclusions

VEC and Wald tests show that all explanatory variables possess long-term causal effect on premium. This finding agrees with the existence of long-run relationship between variables confirmed by ARDL and agreed upon Johansen Joselius models. The statistical analysis demonstrates that the determinant factors of exchange rate in Sudan are balance of trade, gold purchases, money supply, inflation and foreign reserves. Further, the results reveal that explanatory variables explain and account for about 80% of variation in premium. Testing the impact of fluctuations of explanatory variables on exchange rate, the paper applies long-run elasticity tests, which shows that fluctuations in determinant factors influence exchange rate stability in varying degrees. Short-run dynamics of the model shows that the speed of adjustment to restore equilibrium in the long run is slow. The determinant variables that cause short-run volatility are gold purchases and money supply. However the impact of money supply on short volatility in premium is through its impact on inflation volatility, which in turn leads to fluctuation in exchange rate premium.

The continuous deterioration and fluctuation in exchange rate throughout the period under study suggest that the exchange rate system followed has no impact on the stability of the exchange rate. The numerous interventions by the central bank and the swings between different monetary and fiscal policies, which aims among other objectives to stabilize the exchange rate, failed completely. Alleviating exchange rate variability requires managing exchange rate determinant factors through the central bank interference. For instance, improving the balance of trade through implementing policies that enhance productivity, controlling government expenditure, encourage savings and minimize trade barriers could have a favorable impact on the exchange rate. Likewise, gold purchases done by the central bank of Sudan should be made at the prevailing market exchange rate and not a higher one. The expansionary monetary policy followed by the central bank since 2014, which targeted money supply growth by more than 16%, heightened inflation and led to a high and fluctuating exchange rate for the Sudanese pound. Thus coordination of fiscal and monetary policies could pave the way to mitigating the exchange rate instability in Sudan. In addition exchange rate stability can be maintained through effective application of inflation targeted policy rather, as it evident from the study that inflation management is crucial for exchange rate stability in Sudan.

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Appendix

Specification and diagnostic Tests

Correlograms and Q-statistic

<table>
<tr><th></th><th></th><th></th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob*</th><th></th></tr>
<tr><td>Partial</td><td>. |*. |</td><td>. |*. |</td><td>1</td><td>0.083</td><td>0.083</td><td>0.4389</td><td>0.508</td><td>Autocorrelation Correlation</td></tr>
<tr><td></td><td>.*| . |</td><td>.*| . |</td><td>2</td><td>-0.085</td><td>-0.093</td><td>0.9045</td><td>0.636</td><td></td></tr>
<tr><td></td><td>.*| . |</td><td>.*| . |</td><td>3</td><td>-0.110</td><td>-0.096</td><td>1.6907</td><td>0.639</td><td></td></tr>
<tr><td></td><td>.*| . |</td><td>.*| . |</td><td>4</td><td>-0.080</td><td>-0.072</td><td>2.1118</td><td>0.715</td><td></td></tr>
<tr><td></td><td>.*| . |</td><td>.*| . |</td><td>5</td><td>-0.134</td><td>-0.144</td><td>3.3285</td><td>0.649</td><td></td></tr>
<tr><td></td><td>.*| . |</td><td>.*| . |</td><td>6</td><td>-0.175</td><td>-0.188</td><td>5.4417</td><td>0.489</td><td></td></tr>
</table>

.*| . |	.*| . |	7	-0.069	-0.100	5.7787	0.566
. | . |	. | . |	8	0.029	-0.044	5.8402	0.665
. | . |	. | . |	9	0.040	-0.049	5.9568	0.744
. |*. |	. |*. |	10	0.190	0.130	8.6286	0.568
. | . |	.*| . |	11	-0.062	-0.151	8.9187	0.629
**| . |	**| . |	12	-0.243	-0.292	13.511	0.333
. |*. |	. |*. |	13	0.077	0.087	13.985	0.375
.*| . |	.*| . |	14	-0.068	-0.176	14.354	0.424
.*| . |	**| . |	15	-0.167	-0.254	16.673	0.339
. | . |	. | . |	16	-0.013	-0.031	16.687	0.406
. |*. |	. | . |	17	0.123	-0.053	17.986	0.390
. |*. |	.*| . |	18	0.124	-0.108	19.351	0.371
. | . |	.*| . |	19	-0.062	-0.197	19.704	0.413
. |*. |	. | . |	20	0.115	-0.005	20.943	0.401
. | . |	.*| . |	21	-0.007	-0.189	20.947	0.462

Correlograms of Squared Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | . |	.*| . |	22	-0.047	-0.097	21.166	0.510
. |*. |	. | . |	23	0.121	0.036	22.643	0.482
. | . |	.*| . |	24	0.002	-0.151	22.644	0.541
. | . |	. |*. |	25	0.050	0.123	22.906	0.583
. | . |	. | . |	26	0.054	-0.017	23.223	0.620
. | . |	. | . |	27	0.059	-0.055	23.622	0.651
.*| . |	. | . |	28	-0.100	-0.058	24.773	0.640

C	0.258684	8.593480	0.030102	0.9762
DLOGMS	1.428832	3.263159	0.437868	0.6646
DLOGBOT	0.099375	0.116926	0.849891	0.4021
DLOGGP	0.390363	0.223490	1.746667	0.0909
LOGFRS	-0.008627	0.102148	-0.084455	0.9333
LOGINF	-0.169477	0.251141	-0.674827	0.5050
DLOGPREM(-1)	0.317344	0.282111	1.124892	0.2696
DLOGPREM(-2)	0.248105	0.282173	0.879267	0.3862
DLOGPREM(-3)	-0.185241	0.211964	-0.873926	0.3891

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOGMS(-1)	-4.280344	3.302318	-1.296164	0.2048
DLOGMS(-2)	0.105209	2.643820	0.039794	0.9685
DLOGMS(-3)	1.761023	2.605708	0.675833	0.5043
DLOGBOT(-1)	1.001707	0.608165	1.647098	0.1100
DLOGBOT(-2)	1.070758	0.500081	2.141168	0.0405

. | . |	. | . |	1	0.006	0.006	0.0024	0.961
. |*. |	. |*. |	2	0.075	0.075	0.3599	0.835
. |*. |	. |*. |	3	0.085	0.084	0.8260	0.843
. | . |	. | . |	4	-0.003	-0.009	0.8268	0.935
. | . |	. | . |	5	0.034	0.021	0.9028	0.970
.*| . |	.*| . |	6	-0.137	-0.145	2.1869	0.902
. | . |	. | . |	7	0.021	0.019	2.2179	0.947
. | . |	. | . |	8	0.038	0.055	2.3209	0.970
. | . |	. |*. |	9	0.054	0.079	2.5327	0.980
. |*** |	. |*** |	10	0.448	0.455	17.444	0.065
. | . |	. | . |	11	0.021	0.032	17.476	0.095
. |*. |	. | . |	12	0.125	0.046	18.686	0.096
. | . |	.*| . |	13	-0.029	-0.151	18.755	0.131
. | . |	.*| . |	14	-0.009	-0.070	18.761	0.174
. | . |	. | . |	15	0.013	-0.007	18.775	0.224
.*| . |	. |*. |	16	-0.083	0.081	19.350	0.251
.*| . |	.*| . |	17	-0.138	-0.148	20.998	0.226
. | . |	. | . |	18	-0.002	-0.012	20.998	0.279
. |*. |	. | . |	19	0.099	0.043	21.893	0.290
. |*. |	.*| . |	20	0.110	-0.092	23.028	0.287
.*| . |	.*| . |	21	-0.100	-0.160	23.984	0.294
. |*. |	. | . |	22	0.110	0.026	25.161	0.289
.*| . |	. | . |	23	-0.068	-0.053	25.627	0.319
. | . |	. | . |	24	-0.005	0.045	25.630	0.372
.*| . |	.*| . |	25	-0.122	-0.107	27.212	0.345
.*| . |	.*| . |	26	-0.087	-0.067	28.033	0.357
.*| . |	. | . |	27	-0.080	0.023	28.749	0.373
.*| . |	.*| . |	28	-0.108	-0.077	30.117	0.358

Heteroskedasticity-Consistent Covariance (White) x

DLOGBOT(-3)	0.855806	0.514408	1.663673	0.1066
DLOGGP(-1)	0.070848	0.289795	0.244475	0.8085
DLOGGP(-2)	-0.251541	0.244753	-1.027737	0.3123
DLOGGP(-3)	-0.023918	0.172699	-0.138495	0.8908
LOGFRS(-1)	0.611586	0.151231	4.044065	0.0003
LOGFRS(-2)	-0.099253	0.093851	-1.057557	0.2987
LOGFRS(-3)	-0.229998	0.072627	-3.166840	0.0035
LOGINF(-1)	-0.580448	0.388191	-1.495264	0.1453
LOGINF(-2)	-0.322356	0.218885	-1.472718	0.1512
LOGINF(-3)	0.031864	0.336570	0.094673	0.9252
LOGPREM(-1)	-0.977510	0.361034	-2.707529	0.0111
LOGMS(-1)	0.521971	0.330011	1.581678	0.1242
LOGBOT(-1)	-1.024946	0.632803	-1.619692	0.1158
FRS(-1)	-0.001084	0.000287	-3.779044	0.0007
INF(-1)	0.021245	0.024010	0.884846	0.3833
LOGGP(-1)	0.881736	0.373502	2.360728	0.0249

R-squared	0.645100	Mean dependent var	0.104166
Adjusted R-squared	0.302030	S.D. dependent var	0.768772
S.E. of regression	0.642268	Akaike info criterion	2.259230
Sum squared resid	12.37524	Schwarz criterion	3.306403
Log likelihood	-37.77691	Hannan-Quinn criter.	2.668837
F-statistic	1.880374	Durbin-Watson stat	1.802638
Prob(F-statistic)	0.045371	Wald F-statistic	5.443882
Prob(Wald F-statistic)	0.000007		

HAC Covariance x Consistent (Newey-West)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.258684	9.063887	0.028540	0.9774
DLOGMS	1.428832	3.454854	0.413572	0.6821
DLOGBOT	0.099375	0.124972	0.795177	0.4328
DLOGGP	0.390363	0.210714	1.852569	0.0738
LOGFRS	-0.008627	0.099973	-0.086292	0.9318
LOGINF	-0.169477	0.264165	-0.641556	0.5260
DLOGPREM(-1)	0.317344	0.323472	0.981055	0.3344
DLOGPREM(-2)	0.248105	0.316657	0.783513	0.4395
DLOGPREM(-3)	-0.185241	0.178973	-1.035023	0.3089
DLOGMS(-1)	-4.280344	4.445217	-0.962910	0.3433
DLOGMS(-2)	0.105209	2.910622	0.036147	0.9714
DLOGMS(-3)	1.761023	2.068172	0.851488	0.4012
DLOGBOT(-1)	1.001707	0.601945	1.664116	0.1065
DLOGBOT(-2)	1.070758	0.496494	2.156638	0.0392
DLOGBOT(-3)	0.855806	0.537490	1.592226	0.1218
DLOGGP(-1)	0.070848	0.287871	0.246109	0.8073
DLOGGP(-2)	-0.251541	0.214981	-1.170064	0.2512
DLOGGP(-3)	-0.023918	0.194238	-0.123138	0.9028
LOGFRS(-1)	0.611586	0.177923	3.437359	0.0017
LOGFRS(-2)	-0.099253	0.111679	-0.888730	0.3812
LOGFRS(-3)	-0.229998	0.065215	-3.526763	0.0014
LOGINF(-1)	-0.580448	0.460011	-1.261812	0.2167
LOGINF(-2)	-0.322356	0.205247	-1.570575	0.1268

LOGINF(-3)	0.031864	0.311982	0.102134	0.9193
LOGPREM(-1)	-0.977510	0.416285	-2.348179	0.0257
LOGMS(-1)	0.521971	0.285824	1.826198	0.0778
LOGBOT(-1)	-1.024946	0.613880	-1.669618	0.1054
FRS(-1)	-0.001084	0.000296	-3.655514	0.0010
INF(-1)	0.021245	0.028159	0.754479	0.4564
LOGGP(-1)	0.881736	0.418722	2.105781	0.0437

R-squared	0.645100	Mean dependent var	0.104166
Adjusted R Squared	0.302030	S.D. dependent var	0.768772
S.E. of regression	0.642268	Akaike info criterion	2.259230
Sum squared resid	12.37524	Schwarz criterion	3.306403
Log likelihood	-37.77691	Hannan-Quinn criter.	2.668837
F-statistic	1.880374	Durbin-Watson stat	1.802638
Prob(F-statistic)	0.045371	Wald F-statistic	36.79385
Prob(Wald F-statistic)	0.000000		

Wald Test single restriction

Test Statistic	Value	df	Probability
t-statistic	-1.751960	30	0.0900
F-statistic	3.069363	(1, 30)	0.0900
Chi-square	3.069363	1	0.0798

Null Hypothesis: C(25)+C(26)+C(27)+C(28)+C(29)+C(30)=1

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
-1 + C(25) + C(26) + C(27) + C(28) + C(29) + C(30)	-1.578587	0.901041

Restrictions are linear in coefficients.

ARMA Maximum Likelihood

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.494411	13.96439	-0.250237	0.8042
DLOGMS	1.517059	3.001718	0.505397	0.6172
DLOGBOT	0.074410	0.735837	0.101123	0.9202
DLOGGP	0.306628	0.227794	1.346079	0.1891
LOGFRS	0.058423	0.171327	0.341001	0.7356
LOGINF	-0.126894	0.267067	-0.475139	0.6384
DLOGPREM(-1)	0.397180	0.345771	1.148679	0.2604
DLOGPREM(-2)	0.297755	0.250296	1.189608	0.2442
DLOGPREM(-3)	-0.005964	0.219123	-0.027216	0.9785
DLOGMS(-1)	-5.088901	4.261502	-1.194156	0.2424
DLOGMS(-2)	-0.923262	3.489125	-0.264611	0.7932
DLOGMS(-3)	0.813191	3.233980	0.251452	0.8033
DLOGBOT(-1)	0.844793	1.255219	0.673024	0.5064
DLOGBOT(-2)	0.837169	1.748154	0.478887	0.6357
DLOGBOT(-3)	0.632727	1.330980	0.475385	0.6382
DLOGGP(-1)	-0.159077	0.352933	-0.450730	0.6557
DLOGGP(-2)	-0.254977	0.274644	-0.928393	0.3611
DLOGGP(-3)	-0.018155	0.266624	-0.068093	0.9462
LOGFRS(-1)	0.553195	0.164766	3.357468	0.0023
LOGFRS(-2)	-0.050308	0.214770	-0.234244	0.8165
LOGFRS(-3)	-0.210809	0.200416	-1.051858	0.3019
LOGINF(-1)	-0.668274	0.423208	-1.579067	0.1256
LOGINF(-2)	-0.440533	0.339371	-1.298087	0.2048
LOGINF(-3)	0.039130	0.252134	0.155196	0.8778
LOGPREM(-1)	-1.005437	0.353831	-2.841576	0.0083
LOGMS(-1)	0.657207	0.391836	1.677249	0.1046
LOGBOT(-1)	-0.822706	1.027415	-0.800753	0.4300
LOGGP(-1)	0.910345	0.267806	3.399270	0.0020
FRS(-1)	-0.000936	0.000342	-2.733821	0.0107
INF(-1)	0.023661	0.038936	0.607690	0.5483
AR(3)	-0.371152	0.265221	-1.399404	0.1727
SIGMASQ	0.197197	0.057127	3.451919	0.0018

R-squared	0.660684	Mean dependent var	0.104166
Adjusted R-squared	0.285013	S.D. dependent var	0.768772
S.E. of regression	0.650050	Akaike info criterion	2.288402

Sum squared resid	11.83182	Schwarz criterion	3.405386
Log likelihood	-36.65207	Hannan-Quinn criter.	2.725316
F-statistic	1.758678	Durbin-Watson stat	1.874547
Prob(F-statistic)	0.067436		

Inverted AR Roots	.36+.62i	.36-.62i	-.72

Granger causality x

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGMS does not Granger Cause LOGPREM	63	6.35845	0.0144
LOGPREM does not Granger Cause LOGMS		1.31798	0.2555
LOGINF does not Granger Cause LOGPREM	63	1.19319	0.2791
LOGPREM does not Granger Cause LOGINF		14.4115	0.0003
LOGGP does not Granger Cause LOGPREM	63	4.64376	0.0352
LOGPREM does not Granger Cause LOGGP		7.22066	0.0093
LOGFRS does not Granger Cause LOGPREM	63	2.47393	0.1210
LOGPREM does not Granger Cause LOGFRS		6.4E-05	0.9936
LOGBOT does not Granger Cause LOGPREM	63	0.46675	0.4971
LOGPREM does not Granger Cause LOGBOT		0.18659	0.6673
LOGINF does not Granger Cause LOGMS	63	0.44973	0.5050
LOGMS does not Granger Cause LOGINF		23.3864	1.E-05
LOGGP does not Granger Cause LOGMS	63	0.09736	0.7561

LOGMS does not Granger Cause LOGGP		4.01797	0.0495
LOGFRS does not Granger Cause LOGMS	63	0.03422	0.8539
LOGMS does not Granger Cause LOGFRS		0.47148	0.4950
LOGBOT does not Granger Cause LOGMS	63	0.02831	0.8669
LOGMS does not Granger Cause LOGBOT		0.26268	0.6102
LOGGP does not Granger Cause LOGINF	63	20.3895	3.E-05
LOGINF does not Granger Cause LOGGP		0.21196	0.6469
LOGFRS does not Granger Cause LOGINF	63	0.06941	0.7931
LOGINF does not Granger Cause LOGFRS		0.85314	0.3594
LOGBOT does not Granger Cause LOGINF	63	0.83112	0.3656
LOGINF does not Granger Cause LOGBOT		0.53885	0.4658
LOGFRS does not Granger Cause LOGGP	63	1.10922	0.2965
LOGGP does not Granger Cause LOGFRS		0.00535	0.9419
LOGBOT does not Granger Cause LOGGP	63	0.07964	0.7788
LOGGP does not Granger Cause LOGBOT		0.00866	0.9261
LOGBOT does not Granger Cause LOGFRS	63	0.72346	0.3984
LOGFRS does not Granger Cause LOGBOT		0.22757	0.6351