AN EMPIRICAL INVESTIGATION INTO THE RELATIONSHIP BETWEEN EXCHANGE RATE VOLATILITY AND ECONOMIC GROWTH IN LIBERIA (1980 TO 2012)

A THESIS SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN ECONOMICS
OF
THE UNIVERSITY OF NAMIBIA

BY

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May 2016

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Abstract

This study investigated the relationship between the exchange rate volatility and economic growth in Liberia from 1980 to 2012. Empirical literature shows conflicting results. The study used the generalised autoregressive conditional heteroskedasticity model to estimate volatility. The order of integration of the variables was tested and the variables were found not to have the same order of integration. The bounds test confirmed co-integration between GDP growth, exchange rate volatility, exports, imports and foreign direct investment. The Autoregresive distributed lag model was then used to estimate the short and long run dynamics. The study used the coefficients from the ARDL model to calculate the long-run multipliers. The multiplier effect shows that devaluation (depreciation) of the domestic currency increases the exchange rate by –0.02718 percent, while foreign direct investment increases at 0.007973 percent and *h* or volatility reduces at -0.01084 percent in economic growth. Finally, the Granger causality test showed bidirectional causality between the exchange rate volatility and exports, causality from economic growth to the real exchange rate volatility.

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Acknowledgement

In a sense, the acknowledgement portion of any work is the most difficult aspect. This difficulty arises from the fact that the researcher is so much indebtedness to so many people that he or she becomes sort of confused in selecting whose names should be included, and whose names not on the basis of avoiding making the work too bulky with a list of names. This dilemma encompasses this researcher.

However, I feel that it is most appropriate to begin this praise section by registering my profound gratitude to God Almighty, Jesus Christ the Son and the Holy Spirit for having spared my life that I can be counted among the living. It is my fervent prayer that God will grant me His grace so that I can be able to do His will.

I wish to thank my parents, Hon. and Mrs. Edward B. M. Cassell, Sr. Professor Geegbae A. Geegbae, Associate Professor Henry R. M. Becker, Rev. Dr. Julius Sarwolo Nelson, Jr., Mth. Muriel V. Nelson, Cllr. Natu Oswald Tweh; my aunties Ma-Kemah Kawah, Mrs. Confleh Reeves-Teah, Munah Reeves, Chris Reeves, Patricia Reeves-Turay, Rev. Charlotte P. Kaicora; my uncles Professor Willie T. Belleh, Jr., Deacon George Kaicora, Mr. Joseph Torgai Cassell, all my brothers and sisters, The Rev. Julius Y. Collins, Jr., Rev. Robert Weah, Edward B. M. Cassell, Jr., Joseph A. Cassell, George M. Kawah, Jonah Parhmilin, Saye K. M. Dolo, Sebastian Totoe, Ben B. Teah, Jr., Molly Jangaba, Patrick Clinton, Evelyn M. Cassell, Victoria Cassell, Sarwo Kawah, Maima Kawah-

Baisah, and others I have not mentioned. I wish to thank you for all that you have done for me that has helped me reach this far.

Madam Ndapandula Nambinga-Cassell, my beloved wife and our blessed and loving children, Varney Alvin Abayomi Cassell, II; Teresa Reeves-Cassell, CKA "CASHLYN", Israel Natu Oswald Edward Abayomi Cassell, Angie Reeves-Cassell, Tovi Wema Abayomi Cassell, Evelyn Ndapandula Abayomina Cassell and little Fitzgerald Abayomi Cassell thanks for all the support and encouragement, without them I can't imagine what could have become of me especially in these trying times.

Turning to the world of scholars, I which to thank all of the instructors of the University of Namibia who did their best to imbue us with knowledge. In particular, let me do justice to my conscience by mentioning Dr. Ronald Tariro Chifamba who taught many challenging courses and served as my Thesis supervisor. Furthermore, thanks for the invaluable and constructive criticisms you made on this Thesis when you served in the capacity as my supervisor. Still in the world of scholars, I want to mention Dr. Jacob M. Nyambe, Head of Department, Economics and Management Sciences University of Namibia. Hon. Boima S. Kamara Deputy Governor for Planning and Research, Central Bank of Liberia and Senior Lecturer at the University of Liberia, who is wonderful role model for young scholars.

I must admit that it is quite impossible for me to express adequately my obligation and indebtedness to the countless scholars whose work I have freely quoted. I am of the

opinion that listing their names in the reference falls by far short of the due respect they deserve; and I feel that I am still under a greater obligation to them; and so it is proper to include them in this acknowledgement.

I will be an ingrate if I do not thank the African Economic Research Consortium (AERC) for having sponsored me. To all my relatives, friends and those I did not name, I love you all. Take a big thank you from me.

Dedication

This Thesis is dedicated to the loving Trinity, the Father, the blessed Son Jesus Christ our Saviour, and the sweet Holy Spirit our paraclete (helper); my loving and caring parents, Hon. Edward B. M. Cassell, Sr. and Mrs. Teresa Reeves-Cassell, the inspirational force of higher education; my Dean and father Professor Geegbae A. Geegbae who served as motivator to all students of the college of Business and Public Administration at the University of Liberia; my father's Rev. Dr. and Dr. Julius Sarwolo Nelson, Jr. and Associate Professor Henry R. M. Becker of the department of English and Literature at the University of Liberia; my aunties, uncles, brothers sisters, and the Stephen Trowen Nagbe United Methodist Church.

Declarations

I, Varney Alvin Cassell, I, declare hereby that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

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Varney Alvin Cassell, I

Chapter One

Introduction

1.0 Background

1.1 Orientation of the Study

Liberia is one of the world's poorest countries. Historically, the Liberian economy has depended heavily on foreign aid, foreign direct investment and exports of natural resources such as iron ore, diamond, gold, rubber and timber. The country used the United States dollars (USD) as its official currency until in 1937, when it issued its own coins which circulated alongside the USD. At the time of introduction, the exchange rate was set at L$1: US$1 and the country started using the dual currencies. Liberia experienced a high economic growth in the 1950s and 1960s around which time its GDP was equal to that of Japan. This growth continued until the late 1970s when the elected government was overthrown and a military government was established (Pick, 1994).

Following a peak in economic growth in 1979, the Liberian economy began a steady decline due to economic mismanagement following the 1980 coup d'état. After the coup d'état there was heavy capital flight that led to a downturn in economic activities and the military government reacted by introducing a new currency known as the seven corners Doe's coin which was pegged to the United States dollar at 1:1. The coins were later replaced in 1987 by L$5 notes. The Liberian currency was pegged until the outbreak of the Liberian civil war on December 24, 1989. During the crisis, banks were vandalized and business houses were broken into. There was a high demand for United

States dollars by individuals who contemplated on leaving the country as a result of the civil war. This led to a heavy depreciation of the domestic currency against the USD. The outbreak of war triggered another decline in economic activities. As a result GDP declined by an estimated 90 percent between 1989 and 1995, one of the fastest declines in history compared to any other country.

When the war ended in 2003, the GDP growth rate began to accelerate, reaching 9.4 percent in 2007. However, the global financial crisis slowed GDP growth to 4.6 percent in 2009. Later, a strengthening of the agricultural sector led by rubber and timber exports increased growth to 5.1 percent in 2010 and 7.3 percent in 2011, making the economy one of the 20 fastest growing in the world. Current impediments to economic growth include a small domestic market, lack of adequate infrastructure, high transportation costs, poor trade links with neighbouring countries and the high dollarization of the economy (Pick, 1994).

In the middle of the civil war, the government introduced a new currency called “Liberty” as a result of huge notes looted from the National Bank of Liberia in 1991. The new "Liberty" notes were legal tender in government-held areas (primarily Monrovia), while the old notes were legal tender in non-government areas. Each was of course illegal in the other territory (Pick, 1994).

This problem of having two currencies in circulation at the same time was resolved when the Charles Taylor led government came into power and created the Central Bank of Liberia in 1999 and introduced a new unified currency on 29th March 2000. However, Liberia continues to use the United States dollar in parallel to the domestic currency. Prior to the establishment of the central bank of Liberia, the government used the National bank to control the supply of money as well as formal and informal financial intermediaries within the economy (Pick, 1994). As a result of the introduction of the new currency in 1991, there was depreciation of the domestic currency from 5:1 to 25:1 during the period 1991 to 1997. In return, the changes in the exchange rate are expected to have had an impact on the growth of the economy through the foreign currency. The changes in the exchange rates created uncertainty in the economy. In particular, the movements in the exchange rates (volatility) described above created a lot of risk for traders and also possibly economic growth. Exchange rates are defined as the relative price of one currency in terms of another. Volatility is a measure of risk which influences economic decisions. Volatility of exchange rates describes uncertainty in international transactions both in goods and in financial assets (Azid, Jamil & Kous, 2005).

1.2 Statement of the Problem

According to Azid, Jamil and Kous (2005) there are two branches of macroeconomic theory relating to the question of how exchange rate volatility affects macroeconomic performance. The first branch examines how the domestic economy responds to foreign

and domestic real and monetary shocks under different exchange rate regimes. The second focuses on the issue of how exchange rate volatility under flexible exchange rate regimes affects international trade. The exchange rate can be considered to be a forward-looking relative asset price that reflects unanticipated changes in relative demand and supply of domestic and foreign currencies. In that case, exchange rate volatility reflects the expectations of changes in determinants of money supplies, interest rates and incomes with a subsequent effect on economic growth. In addition, international trade is directly negatively affected by the volatility through uncertainty and adjustment costs and indirectly through its effects in the allocation of resources and government policies (Cote, 1994).

One of the goals of Liberia is to increase economic growth and achieve sustainable economic development in order to become a middle income country by 2030 (Al-bakri Nyei, 2009). Thus exchange rate volatility would have an impact on the growth trajectory of the country. To achieve this objective, the government seeks to create a conducive economic environment for international trade and growth; it is important to know the direction in which the exchange rate volatility has impacted economic growth of the economy. For this reason this study has been conducted to analyze the relationship between exchange rate volatility and economic growth in Liberia.

1.3 Objectives of the study

The broad objective of this study is to examine the relationship between exchange rate volatility and economic growth in Liberia. The specific objectives are: to estimate an exchange rate volatility index using the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model; to examine the time series properties of the exchange rates, exchange rate volatility and economic growth; to utilise the bounds testing procedure to test for co-integration between the variables; to analyse the short-run and long-run dynamics of the model; and finally to test for Granger Causality between exchange rate volatility and economic growth.

1.4 Hypothesis

This study seeks to empirically test the following hypotheses:

Ho: Exchange rate volatility has no impact on economic growth.

H_1: Exchange rate volatility has an impact on economic growth.

1.5 Significance of the study

This work is expected to give an in-depth knowledge on the effects of exchange rate volatility on economic growth. This will assist in the designing of an exchange rate policy framework that will ensure the reduction in uncertainties in the exchange rate market to enhance the flow of trade and investment in order to facilitate economic growth. In addition, this work lays a foundation for further research into the effect of exchange rate volatility on other macroeconomic variables. The findings of this study

will contribute to the existing literature and also help policy makers to adequately formulate policies relating to exchange rate volatility and economic growth.

1.6 Limitation of the study

Data for Liberia are relatively scarce. For that reason the study covers the period from 1980 to 2012.

Chapter Two

Literature Review

2.0 Introduction

This chapter first reviews various theories that have been developed relating exchange rate volatility and economic growth. The second section of the chapter reviews the relevant empirical studies.

2.1 Theoretical Literature

According to Azid, Jamil and Kous (2005) there are two branches of macroeconomic theory that explain how exchange rate volatility affects macroeconomic performance. The first branch examines how the domestic economy responds to foreign and domestic real and monetary shocks under different exchange rate regimes. The second focuses on the issue of how exchange rate volatility under flexible exchange rate regimes affects international trade.

With free mobility of capital, an economy is affected mainly by shocks to the money market through the LM curve. Changes in money demand for example, will create large fluctuations in output and inflation if the exchange rate is flexible. If the exchange rate is fixed and capital is internationally mobile then the money supply becomes endogenous. In this case, changes in money demand determine changes in the money supply so that LM shocks will have no effect on output or inflation. Work by Bleaney and Fielding (1999) suggests that developing countries that peg their exchange rates achieved lower inflation than those whose exchange rates were floating.

Exchange rate uncertainty may be linked to devaluation of an exchange rate that induces aggregate demand contraction. The most important reasons why a devaluation might trigger aggregate demand contraction include redistribution of income towards those economic agents with high marginal propensity to save, a fall in investment, an increased debt burden, a reduction in real wealth, a low government marginal propensity to spend out of tax revenue, real income declines under an initial trade deficit, increased interest rates, and increased foreign profits (Gylfason & Radetzki, 1991 and Barbone & Rivera-Batiz, 1987). In addition, the aggregate supply side of the economy is affected by devaluation through an increase in the price of imported production inputs, wage indexation programmes as well as increased costs of working capital (Azid, Jamil & Kous, 2005).

Apart from the effects mentioned above, increases in the volatility of the real effective exchange rate are expected to exert a significant negative effect on export demand in both the short-run and the long-run. The result is a significant reallocation of resources by market participants especially when countries switch from a fixed to a flexible exchange rate regime due to the higher degree of variability associated with flexible exchange rates (Arize, Osang & Slottje, 2004).

In addition, uncertainty induced by exchange rate volatility negatively affects investment and hence economic growth. The literature suggests that uncertainty reduces investment

through adjustment costs as well as sunk costs when the investment process includes irreversibilities. Real exchange rate uncertainty create an uncertain environment for investment decisions and therefore, investors delay their investment decisions to obtain more information about the real exchange rates if investments are irreversible and exerts negative pressure on economic performance (Campa & Goldberg, 1995).

Campa and Goldberg (1999), Nucci and Pozzolo (2001), Harchaoui, Tarkhani and Yuen (2005) in different papers examined the theoretical link between the exchange rate and investment with minor differences in their formulations of a discrete dynamic optimization adjustment-cost model. In the standard adjustment-cost model, firms are assumed to operate in imperfect markets but could adjust to their cost conditions by setting prices as mark-up over costs. Three sets of dynamics were identified. Firstly, Campa and Goldberg (1999) showed that exchange rate volatility affected investment through domestic and export sales. With currency depreciation, goods domestically produced would become less expensive compared to foreign ones, thus increasing demand for domestic goods. As a result, the exports would increase because they have become cheaper. For given levels of capital and labour, marginal revenue products of the primary inputs would increase. Firms would then responded by increasing investment in capital.

Secondly, Nucci and Pozzolo (2001) showed that exchange rate volatility affected investment through the price of imported inputs. Depreciation would raise total

production costs and therefore reduce marginal profitability. The effect on the marginal profitability would be proportional to the share of imported inputs required for production.

Thirdly, Harchaoui, Tarkhani and Yuen (2005) showed that exchange rate changes could also affect investment through the price of imported investment via adjustment cost. Exchange rate depreciation would increase investment price, resulting in higher adjustment costs and lower investment. Summing up, the three effects make it difficult to reach a conclusion on the direction in which the changes in the exchange rates would affect the levels of investment and subsequently economic growth.

Campa and Goldberg (1995) used a dynamic adjustment model to show that the effects of exchange rate uncertainty on profits are ambiguous. A depreciation of the exchange rate was expected to augment expected profit if the firm exports more than it imports and lower expected profit in the opposite case provided the relevant elasticity's conditions hold. Goldberg (1993), using duality theory, and Darby, Hallet, Ireland and Piscitelli (1999) using the model of Dixit and Pindyck (1994), showed similar threshold effects of exchange rate uncertainty on investment.

Apart from the effects of exchange rate volatility on investment, there are also effects which first affect trade and subsequently economic growth. Hooper and Kohlhagen (1978) and IMF (1984) argued that higher exchange rate volatility leads to higher cost

for risk-averse traders if exchange rates are agreed on at the time of the trade contract whereas payments are not made until the future delivery actually takes place. If changes in exchange rates become unpredictable, this creates uncertainty about the profits to be made and, hence, reduces the benefits of international trade especially when the exchange rate risk is not hedged.

De Grauwe (1988) and Dellas and Zilberfard (1993) argued that the prediction by the previous authors was based on restrictive assumptions about the form of the utility function. The authors showed that the sign of the effect was expected to be ambiguous even when the restrictions were relaxed. De Grauwe (1988) pointed out that an increase in risk has both a substitution and an income effect. The substitution effect decreases export activities as an increase in exchange rate risk induced agents to shift from risky export activities to less risky ones. The income effect induced a shift of resources into the export sector when expected utility of export revenues declines as a result of increase exchange rate risk. Hence, if the income effect dominated the substitution effect, exchange rate volatility would have a positive impact on export activity. In addition, an increase in exchange rate volatility could create profit opportunities for firms that managed to hedge against the negative effects of exchange rate volatility.

Franke (1991) and Sercu and Vanhull (1992) demonstrated that an increase in exchange rate volatility could increase the value of exporting firms and thus promote exporting activities. In addition, De Grauwe (1994) showed that an increase in exchange rate

volatility could increase the output and thus the volume of trade if the firm could adjust its output in response to price changes. The market base was shown to be important by Broll and Eckwert (1999). The authors demonstrated that an international firm with huge domestic market base had the ability to benefit from exchange rate movements by reallocating products between domestic and foreign markets. Thus, higher volatility has the potential to increase the potential benefits from international trade. Brada and Mendez (1988) argued from the political economy point of view, that exchange rate movements facilitated the adjustment of the balance of payments in an event of external shocks and thus reduced the use of trade restrictions and capital controls to achieve the equilibrium, and this in turn encouraged international trade and hence, economic growth.

Other theoretical considerations relate to the issue of movements of the real exchange rate away from its equilibrium value (RER misalignments). Following that theoretical theme, it is argued that under a floating regime, exchange rates are subject to excessive volatility and deviations from equilibrium persisted over sustained periods of time. The exchange rate volatility would deter industries from engaging in international trade and compromises progress in trade negotiations and eventually on growth. However, proponents of flexible rates argued that exchange rates were mainly driven by fundamentals, and that changes in fundamentals would require similar, but more abrupt, movements in fixed parities. As a result, a system of fixed rates would not reduce unanticipated volatility

From the discussion above, it can be noted that the theoretical results are conditional on the assumptions about attitudes towards risk, functional forms, and types of trader, presence of adjustment costs, market structure and availability of hedging opportunities. Ultimately, the relationship between exchange rate volatility and trade flows is analytically indeterminate. Thus, the direction and magnitude of the impact of exchange rate volatility on trade and ultimately economic growth becomes an empirical issue.

2.2 Empirical Literature

This section reviews the empirical literature on the effect of exchange rate volatility on economic growth for both developed and developing countries. Some of the studies examined the effects on growth that are transmitted through trade and investment. Campa (1993) used two-stage least squares regressions to examine the linkage between exchange rates and investment taking into consideration export sales and production inputs. They constructed two measures of exchange rate volatility: the ratio of the standard deviation to the mean of the exchange rate index over the previous twelve quarters; and the standard deviation of the first differences of the logarithm of the exchange rate over the twelve previous quarters. Their results showed that the effects of exchange rate and its volatility on investment in the United States were more visible in the 1980s than in the 1970s.

Later on, Campa and Goldberg (1999) used the three-stage least squares technique to analyse annual panel data sets of manufacturing industries from four different countries.

They found that exchange rate appreciation in the USA had a positive effect on investments that decreased with export share and increased with import input share. Japanese industry showed a lower level of response, but with an overall increase in investment from an exchange rate appreciation. The authors did not find any statistically significance in the exchange rate coefficients for the UK and Canada, even though some manufacturing sectors in these countries were highly export oriented. The authors suggested that the differences between countries were due to cross-country differences in industry composition and patterns of external exposure.

Nucci and Pozzolo (2001) used the generalized method of moments to examine the relationship between exchange rate fluctuations and the investment decisions for a sample of Italian manufacturing firms using firm-level panel data. Their results supported the view that a depreciation of the exchange rate had a positive effect on investment through the revenue channel, and a negative effect through the cost channel. They also found that the magnitude of these effects varied over time with changes in the firm's external orientation as measured by the share of foreign sales over total sales and the reliance on imported input. In addition, their study showed that the effect of exchange rate fluctuations on investment was stronger for firms with low monopoly power, facing a high degree of imported penetration in the domestic market and of a small size. They also found that the degree of substitutability between domestically produced and imported inputs influenced the effect of exchange rate depreciation through the expenditure side.

The results highlighted the importance of differentially investment response between a high and low exchange rate variability regime and that not only the level of the exchange rates but also the volatility matters for the firm's total investment decisions.

Empirical studies on the relation between the exchange rate, its volatility and investment in developing countries were also not conclusive just like those from developed countries. A study by Oshikoya (1994) showed that exchange rates appreciation had a positive impact on private investment for four African middle- income countries (Cameroon, Mauritius, Morocco and Tunisia). Serven (1998), and Bleaney and Greenaway (2001) found that the impact of the real exchange rate volatility on investment was nonlinear. The effect was large when volatility was high and there was large trade openness combined with low financial development. On the contrary, Serven (2002) found that exchange rate volatility tended to have a positive effect on investment in conditions of low openness and high financial development.

Apart from the effect of exchange rate volatility on economic growth that is channelled through investment, studies have also examined the effects channelled through trade. Wei (1999) used switching regressions to estimate the trade flows for a panel of 63 countries covering the years 1975, 1980, 1985 and 1990 using over 1000 country pairs. The author found that exchange rate volatility had a negative and significant effect on bilateral trade for country pairs with large potential trade.

Dell'Arricia (1999) used OLS regression to examine the effect of exchange-rate volatility on bilateral trade of European Union members as well as Switzerland over the period 1975-1994 using several definitions of volatility and found the impact to be negative. Asseery and Peel (1991) used an error correction model to examine the impact of volatility on multilateral export volumes of five industrial countries. The authors argued that the model would give more robust results since it took into account the time series properties of the variables. They measured exchange rate volatility using the residuals of an ARIMA process. For all countries except the United Kingdom, they found that volatility had a significant positive effect on exports during 1973 to 1987.

Kroner and Lastrapes (1993) used the conditional multivariate auto-regressive (GARCH)-in-mean model to measure exchange rate volatility in order to examine the effects on multilateral export volumes and prices for some developed countries. They found the conditional variance to be statistically significant. However, the signs and magnitudes of the effects differed widely across the countries, the magnitudes being generally stronger for prices. For the United States, France and Japan, the effect of volatility was found to have a short duration. Volatility had a negative effect on trade volumes only for the United States and the United Kingdom. For the other countries in the sample that the authors used, the coefficient was positive. The exchange rate volatility had a negative effect on U.S and German export prices, whereas it was positive for the other countries.

Koray and Lastrapes (1990) used a VAR model which did not impose exogeneity on the variables in the system to examine the effect of exchange rate volatility on U.S. bilateral imports from five countries, including Canada. Estimations were done separately for fixed and for flexible exchange rate regimes. In addition to real exchange rate volatility they included money supplies, output, prices and interest rates and the nominal exchange rate (for the fixed rate period) in their estimations. They concluded that the relationship between volatility and trade was weak although the effect of exchange rate volatility on trade increased from the fixed to the flexible rate regime. In their second paper, Lastrapes and Koray (1990) focused on U.S. multilateral exports and imports during the flexible rate period and found similar effects. Compared to the other variables in the system, exchange rate volatility had a relatively minor role in explaining imports, exports and real output. The responses to volatility shocks were small and statistically insignificant. However, they found that the state of the economy strongly affected volatility. Innovations in money, interest rates and prices made particularly large contributions. These results supported the view that exchange rate volatility is a symptom of macroeconomic instability.

Rather than examining the effect of exchange rate volatility that is channelled through investment and trade some studies have examined the effect by regressing economic growth on volatility of exchange rate incorporating some control variables. Results are less definitive. Ghosh, Ostry, Gulde, and Wolf, (1997) found no relationship between

observed exchange rate variability and economic growth for a sample of 136 countries over the period 1960-1989. Baillie, Bollerslev, and Mikkelsen (1996) reported a positive association. The contradictory results point to the possible influence of other factors correlated with exchange rate volatility and growth. These factors include political stability, institutional strength, and financial market development. A further problem with much of the literature is that it focuses on the nominal rather than the real exchange rate. Dollar (1992) reported evidence of a negative OLS relationship between real exchange rate variability and growth in a sample of 95 developing countries covering the period 1976 -1985. Using different measures and country samples, Bosworth, Collins, and Chen (1995) and Hausmann, Pritchett, and Rodrik (1995) reported similar results. Belke and Kaas (2004) found the same results from a model focusing on employment growth in the Central and Eastern European transition economies. However, two studies below explored the relationship between real exchange rate variability and economic growth in different developing country samples. Ghura and Grenness (1993) and Bleanney and Greenaway (2001) found little evidence of any relationship. Potential explanations included different country samples, different periods, different controls, different ways of measuring the real exchange rate and different degrees of omitted-variables and simultaneity bias.

Other recent studies give contradictory results. Using panel estimations for more than 180 countries, Edwards and Levy- Yeyati (2003) found evidence that countries with more flexible exchange rates grew faster. Eichengreen and Leblang (2003) found strong

negative relationship between exchange rate stability and growth for 12 countries over a period of 20 years. They concluded that the results of such estimations strongly depend on the time period and the sample. Schnabl (2007) also found robust evidence that exchange rate stability is associated with more growth in the European Monetary Union (EMU) periphery. The evidence according to the author is strong for emerging Europe which has moved from an environment of high macroeconomic instability to macroeconomic stability during the observation period.

Aghion, Bacchetta, Rancière and Rogoff (2006) examined the impact of real exchange rate variability on factor productivity rather than factor accumulation. They found that a more variable exchange rate was negatively associated with productivity growth in financially underdeveloped economies and the opposite was true for countries with deep financial markets. The implication was that financial development provided hedging instruments and opportunities enabling firms to guard against the exchange rate risk. This result is consistent with the intuition that less developed economies find it more difficult to embrace greater exchange rate flexibility because firms and households lack the instruments needed to manage risks.

Dickson (2012) applied the co-integration technique to Nigerian data covering the period 1970 to 2009 and found negative relationship between exchange rate volatility and economic growth. In contrast, Danmola (2013) used ordinary least square (OLS) and Granger Causality test to analyse the relationship between exchange rate volatility and

economic growth in Nigeria over the period 1980 to 2010 and found a positive influence. The volatility also had a positive influence on foreign direct investment and trade openness with negative influence on the inflationary rate in the country.

Kandil and Mirzaie (2002) analysed real output and price data for a sample of developing countries: Algeria, Colombia, Cyprus, Ecuador, Ghana, Guatemala, Honduras, Jordan, Korea, Malawi, Nepal, Peru, Sri Lanka, Syria, Turkey, 1955-1995: Morocco, 1957-1995: Egypt, Iran, Malaysia, 1959-1995; Costa Rica, India, 1960-1995; and Kenya, 1964-1995. Their results for the relationship between exchange rate volatility and economic growth differed with the sample period used for analysis. They found that over time real output growth and price inflation fluctuated in response to shocks to aggregate domestic demand, energy price as well as the exchange rates. Exchange rate shocks were distributed around an anticipated stochastic steady-state trend.

Kandil (2004) examined the effects of exchange rate fluctuations on real output growth and price inflation for a sample of twenty-two developing countries over considered two periods 1955 to 1973 and 1974 to 1995. The author used a model that decomposed movements in the exchange rate into anticipated and unanticipated components using rational expectations model. Exchange rate fluctuations were assumed to be randomly and symmetrically distributed around a steady-state stochastic trend over time. This trend varied with agents' observations of macroeconomic fundamentals. Positive shocks

to the exchange rate indicated an unanticipated increase in the domestic currency price of foreign currency, that is, unanticipated currency depreciation (devaluation). They found the effects of demand and supply channels on the output and price responses to unanticipated changes in the exchange rate. Their model incorporated demand and supply shifts as well as exchange rate shifts.

McPherson and Rakovski (2000) conducted an econometric analysis on exchange rates and economic growth in Kenya using data for the period 1970 to 1996. The authors used a VAR model to estimate the direct and indirect relations between the exchange rate and economic growth and found no evidence of a strong direct relationship between changes in the exchange rate and GDP growth.

Apart from analysing effects of exchange rate volatilities that work through trade and investment some empirical studies considered the extent of exchange rate misalignment. In that respect Aguirre and Calderon (2005) constructed three fundamentals-based indexes of RER overvaluation for a panel of 60 developed and developing countries over 1965-2003 and found that they were negatively correlated with GDP per capita growth. The relationship also appeared to be asymmetric and non-linear since the estimated coefficients were larger for cases of overvaluation than those of undervaluation and they tended to decrease in absolute terms with higher degrees of undervaluation. The negative relationship between overvaluation and growth continued to hold when the fundamentals-based indexes were replaced by PPP-based indexes.

Levy-Yeyati and Sturzenegger (2009) used regression model to analyse the relationship between GDP growth and the level of the real exchange rate for 108 developing countries covering the period 1974 to 2001. They created two indexes of foreign exchange intervention to represent two types of foreign exchange interventions: one aimed at defending the domestic currency, and the other aimed at depressing it and to represent the two types and found a positive correlation between GDP growth and the level of the real exchange rate. They interpreted their results as evidence that foreign exchange reserve accumulation by central banks in developing countries were used to maintain an undervalued real exchange rate in order to stimulate economic growth.

Rodrik (2007 & 2008) examined the relationship between real undervaluation and economic growth for seven developing countries: China, India, South Korea, Taiwan, Uganda, Tanzania, and Mexico from 1950 to 2004. He found that the economic slowdowns in the two East Asian tigers South Korea and Taiwan were preceded or accompanied by increased overvaluation or reduced undervaluation. Thus both growth and undervaluation exhibited an inverse U-shape over time. The two African experiences, Uganda and Tanzania, showed that the undervaluation index captured the turning points in economic growth exceptionally well. A slowdown in growth was accompanied by increasing overvaluation, and a pickup in growth was accompanied by a rise in undervaluation. In the Latin American case, for Mexico the two series were out of sync, especially since 1981, when the correlation between growth and undervaluation

became negative. In more recent years there was a cyclical effect of capital inflows on economic growth in the country. Periods of capital inflows in Mexico are associated with consumption led growth booms and currency appreciation. However, when the capital flow reversed, the economy shrank and the currency depreciated. The Mexican experience served as a useful reminder that there was no reason a priori to expect a positive relationship between growth and undervaluation. The author suggested that there was a need to go beyond individual cases and undertake a more systematic empirical analysis. The author also found that the degree to which economic growth in China tracked the movement of undervaluation index was not consistent. India's growth in GDP per capita has steadily climbed from slightly above 1 percent a year in the 1950s to 4 percent by the early 2000s, while its real exchange rate has moved from a small overvaluation to an undervaluation of around 60 percent.

Gala (2008) found a negative relationship between GDP per capita growth and a purchasing power parity based index of the real exchange rate overvaluation in a panel of 58 developing countries between 1960-1999. The result was robust to changes in control variables and econometric techniques.

Hausmann, Pritchell and Rodrik (2005) identified 83 episodes of sustained growth acceleration in developed and developing countries from 1960 to 2000. They found that these tended to be preceded by real exchange rate undervaluation. In a similar study, Berg and Zettelmeger (2008) investigated the factors that made growth episodes

sustainable in both developing and developed countries. They found that real exchange rate overvaluation adversely affected the duration of growth spells. Polterovich and Popov (2002) carried a cross-country study for developing countries, in which foreign exchange reserve accumulation appeared to be positively associated with GDP per capita growth and the level of the real exchange rate.

Prasad, Rajan and Subramanian (2007) analysed countries from East Asia and Tunisia from 1950 to 2004 and found that fast-growing developing countries have tended to run current account surpluses rather than deficits and developing countries that relied less on foreign capital tended to grow faster. They also found that capital inflows were positively associated with a purchasing power parity based index of real exchange rate overvaluation. However results for the developed nations in the sample showed a converse relationship. The authors explained that capital inflows appreciated the real exchange rate and hurt growth through reduced investment incentives in manufacturing industries. Their model focused on the costs of overvaluation rather than the benefits of undervaluation.

Easterly (2005) found that the black market premium interpreted as a measure of exchange rate over-valuation is one of the few reasonably robust policy determinants of growth in a panel regression. Johnson, Ostry, and Subramanian (2007) found evidence that avoidance of exchange rate overvaluations is associated with long growth booms, while under-valuations did not matter. Aguirre and Calderon (2005) found that exchange rate misalignment measured as residuals from a real effective exchange rate regression

helps predict growth in a sample of developed and emerging countries (Fischer, 1993; Razin & Collins, 1997; Rajan & Subramanian, 2007; and Dollar & Kraay, 2003).

Aghion, Bacchetta, Rancière and Rogoff (2009) used GMM methodology on the data for 83 countries with relatively low levels of financial development from 1960 to 2000 and the results appear robust to time window as RER volatility is negatively associated with long-term productivity growth in countries with underdeveloped financial markets only**.**

As illustrated in Guitian (1976) and Dornbusch (1988), the success of currency depreciation in promoting trade balance largely depends on switching demand in proper direction and amount, as well as on the capacity of the home economy to meet the additional demand by supplying more goods. Using the Marshall-Lerner condition, he observed that if the Marshall-Lerner condition is not satisfied, currency depreciation could produce contraction.

Choi, Chung, and Kim (2013) used the monthly data for the bivariate GARCH-in-Mean VAR over the period from 1990:2 to 2011:7. Their results revealed that low exchange rate volatility induces speculative capital inflows. The reason is that speculative investors are usually concerned with the interest rate differential rather than the exchange rate risk. They further identify the relationship between exchange rate volatility and capital inflows in Korea using a Markov Switching model and the result shows that capital inflows increase under low volatility regimes. Going further in their

investigation using impulse response function from the multivariate GARCH-in-Mean Model the result also provide evidence that lower exchange rate volatility tends to increase capital inflows other than FDI. Their results suggest that maintaining proper levels of exchange rate volatility would further improve stability of the Korean economy.

Kroner and Lastrapes (1993) used a multivariate GARCH-in-mean model of the reduced form of multilateral exports to examine the relationship between nominal exchange rate volatility and export flows and prices. The model imposes rationality on perceived exchange rate volatility, unlike conventional, two-step strategies. Tests are performed for five industrialized countries (the US, the UK, Germany, Japan and France) over the post-Bretton Woods era. They found that the GARCH conditional variance has a statistically significant impact on the reduced form equations for all countries. For most of the countries, the magnitude of the effect is stronger for export prices than quantities. Additionally, the estimated magnitude of the impact of volatility on exports is not robust to using the conventional estimation strategy.

Bollen, Gray and Whaley (2000) used a Markov regime-switching model to describe the time series behaviour of US short-term interest rates, using 1252 weekly observations. The currencies under consideration are British Pound (GBP), Japanese Yen (JPY), and Deutsche Mark (DM) compared to the United States dollar. A number of GARCH models are used in comparing the regime-switching model in analyzing the results. The

findings show significant differences between observed market prices and theoretical option values are found and a trade strategy that uses regime-switching option valuation is shown to generate higher profits than alternatives that do not. The overall results indicate that regime switching model may have practical implication for investors. The regime switching model captures the dynamics of exchange rate better than alternative time series models.

Klaassen (2002) uses generalized single-regime GARCH to regime-switching GARCH to obtain more flexibility regarding the volatility persistence of shocks that shows GARCH forecasts are too high in volatile periods. Using data for 4,982 daily observations from January 3, 1978 to July 23, 1997 on US dollar exchange rates versus the British pound, German mark and Japanese yen, suggest that better volatility forecasts can be obtained if the problem is solved. The result shows that excessive GARCH forecasts in volatile periods may be well-known by the high persistence of individual shocks in those forecasts. They developed a regime-switching GARCH model that differs from existing variants. It allows for GARCH dynamics, thereby generalizing the regime-switching ARCH models of Cai (1994) and Hamilton and Susmel (1994). The data reveal that the variance dynamics differ across regimes.

The literature shows that different variables have been used in different countries to measured volatility. The literature above suggests that exchange rate volatility, trade and investment are important determinants of economic growth.

In conclusion, it must be emphasized that empirically the results of the impact of exchange rate volatility on economic growth is mixed and inconclusive and requires empirical investigation for different countries. Therefore, this study seeks to examine the relationship for Liberia.

Chapter Three

Methodology

3.0 Introduction

After reviewing various theoretical and empirical studies in the previous chapter on exchange rate volatility and economic growth, this chapter explains the methodology that will be used to analyse the relationship for Liberia. The model and the relevant variables to be used are specified in Section 3.1. Section 3.2 outlines the methods used to measure volatility. Section 3.3 outlines the methods used to examine the time series properties of the variables in the model. The procedures for testing co-integration are explained in Section 3.4. Procedures for estimating the short and long run relationship and the dynamic multipliers are outlined in Section 3.5. The Granger causality procedures are explained in Section 3.6. Finally, the source of data is stated in Section 3.7.

3.1 The Model

De Vita and Abbott (2004) in a study on real exchange rate volatility, economic growth and US exports used an ARDL bounds testing approach to test for the long-run export relationship. The literature review suggests that economic growth is a function of the volatility of the real exchange rate and other factors such that

$$y = f(r, h, X) \tag{1}$$

where y is the real *GDP* growth, r is the real exchange rate, h is the volatility of the real exchange rate and X is the vector of other variables that influence economic growth

including investment and trade. The ARDL version of the model that will be used to estimate the relationship between volatility in exchange rate and economic growth is:

$$\Delta y_t = \alpha_0 + \sum_{t=1}^{\rho} \alpha_{1i} \Delta y_{t-i} + \sum_{j=1}^{q} \alpha_{2j} \Delta I_{t-j} + \sum_{k=1}^{r} \alpha_{3k} \Delta r_{t-k} + \sum_{l=}^{s} \xi_{4l} \Delta h_{t-i} + \phi_m \Delta m_{t-1} + \psi_1 \Delta x_{t-1} + \lambda_1 y_{t-1} + \lambda_2 I_{t-1} + \lambda_3 r_{t-1} + \lambda_4 h_{t-1} + \lambda_5 T^2{}_{t-1} + \lambda_6 D_4 + \varepsilon_t \quad (2)$$

Where y is the log of the gross domestic product (real *GDP*), I is foreign direct investment that has been used as a proxy for investment, r is the real exchange rate, h is volatility, m is the import index, x is the export index, T is the time variable, D is a dummy for periods in which there were sharp increases in the real exchange rate, and ε is the error term. The subscript t refers to time. α_{vi}, , ξ, ϕ, ψ and λ_v are parameters to be estimated. Δy_{t_t} is the change in log of the dependent variable real gross domestic product *GDP* at time *t*. Δy_{t-1} is the change in the log of gross domestic product at time *t-i*. ΔI_{t-j} is the change in the growth in foreign direct investment. Δr_{t-k} is the change in the real exchange rate. Δh_{t-1} is the change in volatility and *p, q, r,* and *s* are the lag lengths. Table 3.1.1 shows the expected signs of the coefficients on the explanatory variables. Foreign direct investment inflows are expected to have a positive effect on GDP growth. The effect of an exchange rate depreciation are ambiguous as these depend on the relevant elasticity conditions (such as the Marshal-Lerner) pertaining to trade values and volumes. Volatility as a measure of uncertainty is expected to have a negative effect. An increase in the export values is expected to increase economic growth whereas an increase in imports reduces it.

Table 3.1.1 Variable and expected signs

Variables	Symbol	Expected Sign
Foreign Direct Investment Liberia	I	+
Real Exchange Rate	r	$\pm$
Volatility	h	–
Exports	x	+
Imports	m	-

Equation (2) contains a volatility term that must be estimated before the model can be utilised for subsequent analysis. Some of the methods that can be used to estimate volatility are outlined below.

3.2 Volatility Measurement

The most critical issue in exchange rate volatility is the definition and measurement of volatility. Different methods are used in the literature to measure volatility. A survey of some of the methods was done be McKenzie (1999). These include the use of a moving average of the standard deviation, ARCH and its variants such as (GARCH). More recent methods such as the Markov Switching methods require the use of complicated Bayes formulas.

3.2.1 Moving Average of the Standard Deviation

One of the most common measures of exchange rate volatility is the standard deviation of the growth rates of real exchange rates. This measure is approximated by a time-varying measure defined as follows:

$$h_{t+m} = \left[\frac{1}{m} \sum_{i=1}^{m} (r_{t+i-1} - r_{t+i-2}) \right]^{\frac{3}{2}} \quad (3)$$

where *r* is natural log of the real exchange rate and *m* is the order of the moving average between years t and t + m -1. The measure has been used by Arize, Osang and Slottje (2000) amongst others. An alternative measure of exchange rate volatility is defined as the time-varying m-year coefficient of variation (CV) of the real exchange rate and can be specified as

$$CV_{t+m} = \frac{\left[\frac{1}{m} \sum_{i=1}^{m} (\varepsilon_{t+i-1} - \bar{\varepsilon}) \right]^{\frac{3}{2}}}{\bar{\varepsilon}} \quad (4)$$

where $\bar{\varepsilon}$ is the mean of the real exchange rate between years t and t + m -1. The estimation utilizes only one measure, the standard deviation of the growth of the real exchange rate. This measure in equation (4) is arguably a measure of dispersion of the real exchange rate. The measure has the problem of being affected by extreme measures of deviations of some observations.

3.2.2 GARCH

Another method of measuring volatility is the generalized autoregressive conditional heteroscedasticity (GARCH) model. The GARCH model incorporates the stochastic process in generating exchange rate uncertainty (Du & Zhu, 2001; Pozo, 1992). The GARCH model is deemed to be more desirable in the sense that it performs better for

high frequency data than any other methods (West, Edison & Cho, 1993; West & Cho, 1995).

The general GARCH (p, q) model is specified as

$$h_t^2 = \varpi + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{q} \alpha_j e_{t-i}^2 \quad (5)$$

Where *h* is the variance and *e* is the error term. ω, β and α are coefficients to be estimated. In this study the GARCH(1,1) version has been utilized. This is the case when $p = q = 1$. Therefore, the full GARCH model used to measure exchange rate volatility in this study is as follows:

$$\Delta r_t = c_1 + \Delta r_{t-1} + e_t \quad (6)$$

$$e_t / I_{t-1} \approx N(0, h_t) \quad (7)$$

$$h_t = c_2 + e_{t-1}^2 + h_{t-1} \quad (8)$$

where:

Δr is the difference in log of the real exchange rate from period t to $t-1$. I_{t-1} is the set of all relevant and available information at time $t-1$. h_t is variance of the error term e_t. e_{t-1}^2 is the ARCH term. h_{t-1} is the GARCH term

3.2.3 Markov Switching

The more complicated model that could be used to measure volatility is the Markov-switching. In the model, it is based on different exchange rate regimes (e.g. regimes 0 and 1 in the case of two regimes) and can be specified as follows:

$$\Delta\log(r_t) = \mu_t = \mu_{s_t} + \varepsilon_t, \varepsilon_t \mid S_t \sim iid \quad N(0, \sigma_s^2) \tag{9}$$

$$\mu_{s_t} = \mu_0(1 - S_t) + \mu_1 S_t, \tag{10}$$

$$\sigma_{s_t}^2 = \sigma_0^2(1 - S_t) + \sigma_1^2 S_1, \ \sigma_0^2 < \sigma_1^2, \tag{11}$$

where $\Delta\log(r_t)$represents the changes in the log of the exchange rate relative to the foreign currency. μ_t is the mean of the exchange rate. Here, under regime 0, the parameters are given by μ_0 and σ_0^2, and under regime 1 they are given by μ_1 and σ_1^2. S_t is a latent variable modelled as a first-order Markov process (two regimes) with transition probabilities given by:

$$P[S_t = 0 \mid S_{t-1} = 0] = q, \ P[S_t = 1 \mid S_{t-1} = 1] = p \tag{12}$$

where *q* and *p* are the transition probabilities governing the evolutions of S_t in the low and high variance regimes, respectively. The expected duration of the high volatility regimes is given by $E(S_1 = 1) = 1/(1 - p)$.

In estimating this model, we derive the joint density of r_t, S_t and S_{t-1} conditionally on the past information I_{t-1} :

$$f(\mu_t, S_t, S_{t-1} \mid I_{t-1}) = f(\mu_t \mid S_t, S_{t-1}, I_{t-1}) \Pr[S_t, S_{t-1} \mid I_{t-1}] = \frac{1}{\sqrt{2\pi\sigma_{s_t}^2}} \exp\left[-\frac{(\mu_t - \mu_{s_t})^2}{2\sigma_{s_t}^2} \right] \Pr[S_t, S_{t-1} \mid I_{t-1}] \tag{13}$$

Equation (13) is therefore used to derive $f(\mu_t \mid I_{t-1})$ as follows:

$$f(\mu_t \mid I_{t-1}) = \sum_{S_t=0}^{1} \sum_{S_{t-1}=0}^{1} f(\mu_t, S_t, S_{t-1} \mid I_{t-1}) = \sum_{S_t=0}^{1} \sum_{S_{t-1}=0}^{1} f(\mu_t \mid S_t, S_{t-1}, I_{t-1}) \Pr[S_t, S_{t-1} \mid I_{t-1}] \tag{14}$$

From equation (14), the following log likelihood can be found:

$$\ln L = \sum_{t-1}^{T} \ln \left[\sum_{S_t=0}^{1} \sum_{S_{t-1}=0}^{1} f(\mu_t \mid S_t, S_{t-1}, I_{t-1}) \Pr[S_t, S_{t-1} \mid I_{t-1}] \right] \tag{15}$$

where $\Pr[S_t = j, S_{t-1} = i \mid I_{t-1}] = \Pr[S_t = j \mid S_{t-1} = i] \Pr[S_{t-1} = i \mid I_{t-1}]$, for $i, j = 0,1$. We computed the weight term, $\Pr[S_t, S_{t-1} \mid I_{t-1}]$, in equation (15) by updating it once r_t is observed at time t, as follows:

$$\Pr[S_t = j, S_{t-1} = i \mid I_{t-1}] = \frac{f(\mu_t \mid S_t = j, S_{t-1} = i, I_{t-1}) \Pr[S_t = j, S_{t-1} = 1 \mid I_{t-1}]}{\sum_{S_t=0}^{1} \sum_{S_{t-1}=0}^{1} f(\mu_t \mid S_t = j, S_{t-1} = i, I_{t-1}) \Pr[S_t = j, S_{t-1} = i \mid I_{t-1}]}$$

$$\Pr[S_t = j \mid I_t] = \sum_{S_{t-1}=1}^{1} \Pr[S_t = j, S_{t-1} = i \mid I_t] \tag{16}$$

and then iterate equations (15) and (16) for $t = 1,2,...,T$, which will give the appropriate weighting terms in $f(\mu_t \mid I_{t-1})$.

It is well known that one of the critical problems of volatility measurement is its ad hoc nature. From the methods specified above the one that has been used in this study is the GARCH model.

3.3 Examining the order of Integration of the variables

If the time series are not co-integrated, the regression analysis will produce spurious results. Prior to conducting the co-integration test, it is essential to ascertain the order of integration of each of the variables. If the series are integrated of the same order then the traditional tests for co-integration may be performed. However, if they have different orders of integration then the methods would not be appropriate. The augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) approaches were used to examine the time series properties of the variables. To allow for the various possibilities, the DF test is estimated in three different forms under three different null hypotheses:

Y_t follows a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$ (17)

Y_t follows a random walk with drift: $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$ (18)

Y_t follows a random walk with drift around a stochastic trend: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t$ (19)

where y is a random variable, Δ represent changes, β and δ are parameters, μ_t is the error term. t is the time or trend variable. In each situation, the null hypothesis is that $\delta = 0;$ exhibiting that there is a unit root, the time series is non-stationary. The alternative hypothesis is that $\delta < 0;$ and the time series is stationary. If the null hypothesis is rejected, it means that Y_t is a stationary time series with zero mean in the case of equation 17, that Y_t is stationary with a nonzero mean $\left[= \beta_1 / (1 - \rho)\right]$ in the case of equation 18, and that Y_t is stationary around a deterministic trend in equation 19. It is

extremely important to note that the critical values of the tau test to test the hypothesis that $\delta = 0,$ are different for each of the three preceding equations (17-19) of the DF test.

The actual estimation procedure is as follows: estimate equation 17, or 18 or 19 by ordinary least square (OLS); divide the estimated coefficient of Y_{t-1} in each case by its standard error to compute the tau statistic (τ); and refer to the DF tables or any statistical package. If the computed absolute value of the tau statistic ($|\tau|$) exceeds the DF or McKinnon critical tau values, then reject the hypothesis that $\delta = 0,$ in which case the time series is stationary. On the other hand, if the computed $|\tau|$ does not exceed the critical tau value, then do not reject the null hypothesis, in which case the time series is non-stationary. Make sure that the appropriate critical tau value is used.

In conducting the DF test as in the case of equations 17, 18 or 19, it was assumed that the error term u_t was uncorrelated. But in the cases that u_t are correlated, Dickey and Fuller have developed a test, known as the augmented Dickey-Fuller (ADF) test. This test is conducted by "augmenting" the preceding three equations by adding the lagged values of the dependent variable ΔY_t. If equation 18 is use, the ADF test consists of estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (20)$$

Where ε_t is a pure noise error term and where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The number of lagged difference terms to include is often determined empirically, the idea being to include enough terms so that the error term in equation 20 is serially uncorrelated. Still test in ADF whether $\delta = 0$ and the ADF test follows the same asymptotic distribution as the DF statistic, so the same critical value can be used.

An important assumption of the DF test is that the error term u_t is independently and identically distributed. The DF test does not take into consideration serial correlation into account. The ADF test adjusts the DF test by taking serial correlation into account by using the parametric statistic method in the error terms by adding the lagged difference terms of the regressand. An alternative to the ADF is the Phillips-Perron that uses nonparametric statistical method to account for serial correlation in the error terms without adding lagged difference terms. The asymptotic distribution of the PP test is the same as the ADF test statistic.

3.4.1 Testing for co-integration

Two or more time series are co-integrated if they share a common stochastic drift. If two or more series are individually integrated (in the time series sense) but some linear combination of them has a lower order of integration, then the series are said to be co-integrated. There are four main methods for testing for co-integration, they are: Engle–Granger two-step method, Johansen test, the Phillips–Outlier and the Bounds testing

procedure by Pesaran, Shin and Smith (2001). If the variables are integrated of the same order then the study will used the Johansen test and the Engle–Granger methods, but if they are not then the bounds testing procedures will be used.

3.4.2 Engle–Granger two-step method

If two time series x_t and y_t are co-integrated, a linear combination of them must be stationary. In other words:

$$y_t - \beta x_t = u_t \tag{21}$$

where y_t is the dependent variable or output, x_t is the independent variable, β is a parameter and u_t is stationary. If u_t, was known then we could just test it for stationarity with something like a Dickey-Fuller test, Phillips-Perron test and be done. But because we don't know β, we must estimate this first, generally by using ordinary least squares, and then run our stationarity test on the estimated u_t series, often denoted $\hat{u}_t$. A second regression is then run on the first differenced variables from the first regression, and the lagged residuals $\hat{u}_{t-1}$ is included as a regressor. This is the Engle–Granger two-step method.

3.4.3 Johansen test

The Johansen test is a test for co-integration that allows for more than one co-integrating relationship, unlike the Engle–Granger method, but this test is subject to asymptotic

properties, that is, large samples. If the sample size is too small then the results will not be reliable and one should use Auto Regressive Distributed Lags (ARDL).

3.4.4 Phillips–Outlier co-integration test

Phillips and Outlier (1990) show that residual-based unit root tests applied to the estimated co-integrating residuals do not have the usual Dickey–Fuller distributions under the null hypothesis of no co-integration. Reason being because of the spurious regression phenomenon under the null hypothesis, the distribution of these tests have asymptotic distributions that depend on (1) the number of deterministic trend terms and (2) the number of variables with which co-integration is being tested. These distributions are known as Phillips–Outlier distributions and critical values have been tabulated. In finite samples, a superior alternative to the use of these asymptotic critical values is to generate critical values from simulations.

3.4.5 Bounds testing procedure

When the orders of integration of the variables in the model are not the same then the Bounds testing method provides a way of testing for co-integration. The ARDL model or Bounds Testing methodology of Pesaran and Shin (1999) and Pesaran *et al*. (2001) has a number of features that many researchers feel give it some advantages over conventional co-integration testing.

- It can be used with a mixture of $I(0)$ and $I(1)$ data.

- It involves just a single-equation set-up, making it simple to implement and interpret.
- Different variables can be assigned different lag-lengths as they enter the model.

The general form of the ARDL regression model is:

$$\Delta y_t = \alpha_0 + \sum_{t=1}^{\rho} \alpha_{1i} \Delta y_{t-i} + \sum_{j=1}^{q} \alpha_{2j} \Delta I_{t-j} + \sum_{k=1}^{r} \alpha_{3k} \Delta r_{t-k} + \sum_{l=}^{s} \xi_{4l} \Delta h_{t-i} + \phi_m \Delta m_{t-1} + \psi_1 \Delta x_{t-1} + \lambda_1 (y_{t-1}) + \lambda_2 I_{t-1} + \lambda_3 r_{t-1} + \lambda_4 h_{t-1} + \lambda_5 T^2{}_{t-1} + \lambda_6 D_4 + \varepsilon_t \quad (22)$$

where Δ denotes the first difference operator, α_0 is the intercept, ε_t is the residual, and other variables are as defined earlier. The parameter α_{ij} is for the short-run whereas the long-run can be calculated using the parameters, λ_{ij} in the equation.

Co-integration between variables in model (22) is tested using the F statistic calculated from estimated coefficients from and OLS regression of equation (22). Specifically, the null hypothesis of no long-run relationship between variables, defined by

$H_0 : \lambda_y = \lambda_I = \lambda_r = \lambda_h = 0$ (there is no co-integration among the variables)

is tested against the alternative hypothesis, defined by

$H_1 : \lambda_y \neq 0, \lambda_I \neq 0, \lambda_r \neq 0, \lambda_h \neq 0$ (there is co-integration among variables).

The F-statistics in this model has a non-standard distribution (Pesaran, Shin & Smith, 2001) which depends upon (i) whether the variables included in the ARDL model are

I(0) or *I*(1); (ii) the number of parameters; and (iii) whether the model includes restricted/unrestricted drift and (or) a restricted or unrestricted time trend. Pesaran, Shin & Smith (2001) provides two sets of adjusted critical value bounds for all classifications of the regressors that established lower (purely 1(0)) and upper (purely *I*(1)) bounds of significance. If the computed F-statistics is less than the lower bound of the critical value bound, then the null hypothesis that there exists no long-run relationship amongst the variables is not rejected. If the computed F-statistics exceeds the upper bound of the critical value bound, then the null hypothesis that there exists no long-run relationship amongst the variables is rejected. However, the verdict is inconclusive if the computed F-statistics lies between the two bound limits.

3.5.1 ARDL model for obtaining long-run and short-run effect

After doing the bounds test, the ARDL model is estimated and the long-run relationship examined. Following Pesaran and Shin (1999), in the presence of co-integration, the long-run model derived from estimation of the conditional ECM is obtained as follows:

$$y_t = \lambda_0 + \lambda_1 I_t + \lambda_2 r_t + \lambda_3 h_t + v_t \tag{23}$$

where

$$\lambda_0 = -\alpha_0 / \lambda_1 \tag{24}$$

$$\lambda_1 = -\lambda_2 / \lambda_1 \tag{25}$$

$$\lambda_2 = -\lambda_3 / \lambda_1 \tag{26}$$

$$\lambda_3 = -\lambda_4 / \lambda_1 \tag{27}$$

The vectors I_{t-j}, r_{t-k} and h_{t-1} are assumed to consist of long-run forcing variables for y_{t-1}. Given this assumption, the co-integrating rank is restricted to unity. To test for the absence of feedback from the level of y_{t-1}, we use a variant of the bounds test suggested originally by Banerjee, Dolado and Mestre (1998) which is based on the t-test for $H_0 : \lambda_1 y_{t-1} = 0$, from OLS estimation of the following:

$$\Delta h_{t-1} = \alpha_0 + \lambda_1 y_{t-1} + \lambda_2 I_{t-1} + \lambda_3 r_{t-1} + \lambda_4 T^2{}_{t-1} + \lambda_5 D_4 + \phi_m \Delta m_{t-1} + \psi_1 \Delta x_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \sum_{j=1}^{q} \beta_j \Delta I_{t-j} + \sum_{k=1}^{r} \gamma_k \Delta r_{t-k} + \sum_{l=1}^{s} \xi_l \Delta h_{t-1} + \mu_t \quad (28)$$

If the null hypothesis cannot be rejected then we can conclude that $\lambda_2 I_{t-1}, \lambda_3 r_{t-1},$ and $\lambda_4 h_{t-1}$ are confirmed to be long-run forcing variables.

3.6 Granger Causality Test

The Granger causality test can be used to determine the causation between economic growth and exchange rate volatility, after GARCH techniques and ARDL model have been applied to test for volatility from the data. The idea behind the Granger causality test is that earlier events may be the cause of immediate events, that is, everything causes everything.

To explain the Granger test between the exchange rate volatility and the growth rate of GDP then: Is it the exchange rate (*r*) that causes the real GDP growth (*y*) i.e. $(h \to y)$ or is it real GDP growth that causes changes in the exchange rate volatility i.e. $(y \to h)$.

The Granger causality test assumes that the information relevant to the prediction of the respective variables, GDP and *r* is contained solely in the time series data of these variables. The test involves estimating the following pair of regressions:

$$y_t = \sum_{i=1}^{n} \alpha_i h_{t-i} + \sum_{j=1}^{n} \beta_j y_{t-j} + \mu_{1t} \tag{29}$$

$$h_t = \sum_{i=1}^{n} \lambda_i h_{t-i} + \sum_{j=1}^{n} \delta_j y_{t-j} + \mu_{2t} \tag{30}$$

where it is assumed that the disturbances μ_{1t} and μ_{2t} are uncorrelated. Since we have two variables we consider the possibility that bilateral causality exists.

Unidirectional causality comes from one variable to another. If the estimated coefficients on the lagged *r* are statistically different from zero as a group $\left(ie, \sum \alpha_i \neq 0\right)$ and the set of estimated coefficients on the lagged *y* are not statistically different from zero $\left(\sum \delta_j = 0\right)$. Feedback or bilateral causality is suggested when the sets of *h* and *y* coefficients are statistically different from zero in both regressions; and the independence is suggested when the sets of *h* and *y* coefficients are not statistically significant in both the regressions. That is, the future cannot predict the past, if variable *h* Granger causes the variable *y*, then changes in *h* should precede changes in *y*. Therefore, in a regression of *y* on other variables including its own past values, if we include past or lagged value of *h* and it significantly improves the prediction of *y*, then

we can say *h* Granger causes *y*. A similar definition applies if *y* Granger causes *h.* But our study considered multivariable causality (Granger 1988).

3.7 Data and Source

The data collected from World Development Indicators (World Bank, 2015). However, only complete series for the value indices are available for exports and imports. Data for investment are not available and foreign direct investment has been used as a proxy. The growth rate of GDP has been estimated using the change in the log of the series. The exchange rate is the amount of domestic currency for one foreign currency and it is already a rate and so has been used as is. The real exchange rate was calculated as the ratio of the Liberian CPI divided by the US CPI times the nominal exchange rate. The reason is for the use of the US dollar that the United States is the major trading partner for Liberia.

Chapter Four

Data Analysis and Interpretation of Results

4.0 Introduction

This chapter examines the time series properties of the data and uses the bounds testing procedures to find whether there is a co-integration relationship between real gross domestic product (y) and real exchange rates (r). We then use the ARDL model to estimate the short-run and long-run parameters. The variables used are log GDP, *y*, the growth rate of foreign direct investments, *I*, the real exchange rate, *r* and exchange rate volatility, *h*, the export value index, *x* and the import value index *m*. The next section presents the summary statistics.

4.1 Descriptive Analysis of the Data

The structure of the data informed the researcher about the status of the variables under examination. Table 4.1.1 shows the descriptive statistics of the variables used in the model. The descriptive statistics show that data are skewed as the means and medians have widely differing values. In addition, the Jarque-Bera statistic is used to test the null of whether the residuals are normally distributed. The test statistic measures the difference of the skewness and kurtosis of the series with those from the normal distribution. If the standardized residuals are normally distributed, the Jarque-Bera statistic should not be significant. The calculated statistic is rejected in all cases showing that the data are not normally distributed.

Table 4.1. 1. Descriptive Statistics for variables in the model (1960 – 2012)

Variable	*x*	*r*	*y*	*m*	*h*	*I*
Mean	141.9	27.1	3.5	70.4	53.1	19.3
Median	130.3	0.0	3.6	62.9	23.3	14.6
Maximum	670.8	170.4	5.8	181.1	218.1	91.0
Minimum	31.6	0.0	0.5	25.4	1.9	-82.9
Std. Dev.	113.5	47.9	1.5	38.1	59.7	30.8
Skewness	3.0	1.7	-0.5	1.4	1.6	-0.1
Kurtosis	15.0	4.7	2.1	4.4	4.3	5.2
Jarque-Bera	256.1	31.2	4.0	13.6	27.1	8.8
Probability	0.0	0.0	0.1	0.0	0.0	0.0
Sum	4825.9	1464.4	190.1	2394.9	2812.4	850.1
Sum Sq. Dev.	425387.0	121717.8	127.0	47938.7	185330.1	40718.3
Observations	34	54	54	34	53	44

Table 4.1.2 shows the correlation coefficients between the export value index, the real exchange rate, change in the log of GDP, the import value index, exchange rate volatility and the growth rate of foreign direct investment. The correlation between the real exchange rate and imports and exports value indices do not have the expected signs which probably show the effects of macroeconomic instability on the level of trade. In particular the economy has suffered episodes of political instability that severely affected international trade with Liberia's partners.

Table 4.1. 2 Correlation Coefficients

	r	*y*	*x*	*m*	*I*
r	1.00				
y	0.28	1.00			
x	-0.39	-0.27	1.00		
m	0.71	0.31	-0.13	1.00	
I	0.09	-0.03	-0.18	-0.21	1.00

4.2 Estimation of Volatility

The GARCH equation outlined in Chapter 3 was used to estimate the volatility of the real exchange rate. The results are presented in Table 4.2.1. The equation was used to calculate the volatility series to be use in the subsequent estimation procedures. All the coefficients in the equation are significant hence the GARCH effects are present.

Table 4.2. 1 GARCH estimation results

Dependent Variable: D(r)
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 06/23/15 Time: 17:19
Sample: 1980 2013
Included observations: 34
Failure to improve Likelihood after 9 iterations
Presample variance: backcast (parameter = 0.7)
$\log(h)$ = C(2) + C(3)*ABS(RESID(-1)/@SQRT(h_{t-1}) + C(4)
*RESID(-1)/@SQRT(h_{t-1}) + C(5)*LOG(h_{t-1})

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	3.223147	0.001890	1705.683	0.0000
Variance Equation				
C(2)	1.696084	0.239092	7.093850	0.0000
C(3)	-0.879015	0.058450	-15.03868	0.0000
C(4)	0.301661	0.089275	3.379021	0.0007

C(5)	0.746195	0.065307	11.42594	0.0000

R-squared	-0.027280	Mean dependent var	5.010382
Adjusted R-squared	-0.027280	S.D. dependent var	10.98345
S.E. of regression	11.13226	Akaike info criterion	7.131031
Sum squared resid	4089.598	Schwarz criterion	7.355496
Log likelihood	-116.2275	Hannan-Quinn criter.	7.207580
Durbin-Watson stat	1.770750		

4.3 Time series properties of variables

When time-series data are non-stationary it implies that the means and variances are not constant over time. The time series properties of all the variables were tested using the Augmented Dickey-Fuller test (ADF) and Phillip-Perron unit root test. The results of the unit root test are shown in the Table 4.3.1.

On the basis of the McKinnon (1996) one sided p-values at these levels both the augmented Dickey-Fuller test and the Phillip-Perron unit root test for the log of the gross domestic product, y, is stationary at first difference at a five percent level of significance. Also, the growth rate in the foreign direct investment, I, is stationary at first difference at the one percent level on the basis of both the augmented Dickey-Fuller test and the Phillip-Perron unit root test. Both the augmented Dickey-Fuller test and Phillip-Perron unit root test show that the real exchange rate r is stationary at first difference at the one percent level. Similarly, the variable for volatility, h is stationary (at the one percent level) at first difference using both Augmented Dickey-Fuller test and Phillip-Perron unit root test. Finally, both the import and export variables are stationary

at first difference on one percent level on the basis of both the augmented Dickey-Fuller test and Phillip-Perron unit root test.

Table 4.3. 1 Unit root tests: Augmented Dickey-Fuller and Phillip-Perron in levels

			Augmented Dickey-Fuller Test		Phillip-Perron Unit Root Test	
Variables	Model Specification	Point of Significant	Calculated Value	Critical Value	Calculated Value	Critical Value
y_t	Intercept and trend	First Difference	-4.108**	1 % = -4.145 5 % = -3.499 10 % = -3.179	-4.058**	1 % = -4.145 5 % = -3.499 10 % = -3.179
I	Intercept and trend	Level	-6.513***	1 % = -4.192 5 % = -3.521 10 % = -3.191	-6.514***	1 % = -4.192 5 % = -3.521 10 % = -3.191
R	Intercept and trend	First Difference	-7.280***	1 % = -4.145 5 % = -3.499 10 % = -3.179	-7.305***	1 % = -4.145 5 % = -3.499 10 % = -3.179
h	Intercept and trend	First Difference	-4.221***	1 % = -4.192 5 % = -3.521 10 % = -3.191	-8.145***	1 % = -4.148 5 % = -3.500 10 % = -3.180
m	Intercept and trend	First Difference	-6.975***	1 % = -4.272 5 % = -3.558 10 % = -3.212	-6.975***	1 % = -4.272 5 % = -3.558 10 % = -3.212
x	Intercept and trend	First Difference	-9.180***	1 % = -4.273 5 % = -3.558 10 % = -3.212	-11.693***	1 % = -4.273 5 % = -3.558 10 % = -3.212

Source: Author compilation from Eviews
Notes: (**) means rejection of the null hypothesis at 5 percent; (***) rejection of the null hypothesis at 1 percent.

4.4 Bounds testing procedure

One of the most important issues in applying the ARDL model is the choice of the order of the lag length. According to Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001), the SBC is generally used in preference to other criteria because it tends to define more parsimonious specifications and supports small data samples. The test for

co-integration was done from the income empirical equation using the ordinary least squares regression of the equation

$$\Delta y_t = \alpha_0 + \sum_{t=1}^{\rho} \alpha_{1i} \Delta y_{t-i} + \sum_{j=1}^{q} \alpha_{2j} \Delta I_{t-j} + \sum_{k=1}^{r} \alpha_{3k} \Delta r_{t-k} + \sum_{l=}^{s} \xi_{4l} \Delta h_{t-i} + \phi_m \Delta m_{t-1} + \psi_1 \Delta x_{t-1} + \lambda_1 (y_{t-1}) + \lambda_2 I_{t-1} + \lambda_3 r_{t-1} + \lambda_4 h_{t-1} + \lambda_5 T_{t-1} + \lambda_6 D_4 + \varepsilon_t \quad (31)$$

Lag length selection was done using the SBC, AIC and HQ criteria. We then tested for serial correlation using logarithm method (LM) to test the null hypothesis that the errors are serially independent, against the alternative hypothesis that the errors are either AR or MA, for m=1,2,3,…etc. The lag lengths used in the final equation were based on the length that reduced the extent of serial correlation. The inverse roots were examined and found to be inside the unit circle.

The results of the estimation of the VAR model are presented in Table 4.4.1. The results are the ones that were used to conduct the tests above.

Table 4.4. 1 Vector Autoregression Estimates

Vector Autoregression Estimates			
Date: 06/20/15 Time: 13:23			
Sample (adjusted): 1982 2013			
Included observations: 32 after			
Adjustments			
Dependent variable:			Δy
Variables	Coefficient	Standard errors	t-statistic
C	0.853749	0.33000	2.58710
Δy_{t-1}	0.807086	0.25752	3.13409
Δy_{t-2}	0.239292	0.27508	0.86989
Δy_{t-3}	0.217777	0.17882	1.21788
Δr_{t-1}	-0.010445	0.00578	-1.80672
ΔI_{t-1}	0.002930	0.00176	1.66893
h_{t-1}	-0.000453	0.00155	-0.29224
y_{t-1}	-0.312694	0.09930	-3.14896
r_{t-1}	0.008141	0.00398	2.04355
I_{t-1}	-0.003462	0.00127	-2.71726
h_{t-1}	0.003220	0.00137	2.35581
T^2	-0.000680	0.00029	-2.37042
Δm_{t-1}	-0.001784	0.00208	-0.85904
Δx_{t-1}	0.000742	0.00038	1.96793
R-squared	0.96793	Adj. R-squared	0.540069
Sum sq. resids	0.566727	S. E. equation	0.177440
F-statistic	3.800109	Log likelihood	19.13178
Akaike AIC	-0.320736	Schwarz SC	0.320523
Main dependent	0.002937	S. D. dependent	0.261640

Given the above tests, we proceeded to use the ARDL model to conduct the Bounds test. Table 4.4.2 shows the results from the OLS estimation of the ARDL model. Using the results in the table the F statistic was calculated for testing for co-integration between the variables.

Table 4.4. 2 The results of the ARDL model

Dependent Variable: Δy_t
Method: Least Squares
Date: 06/20/15 Time: 13:38
Sample (adjusted): 1982 2013
Included observations: 32 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.112	0.422	2.638	0.019
Δy_{t-1}	0.775	0.283	2.739	0.015
Δy_{t-2}	0.417	0.308	1.353	0.196
Δy_{t-3}	0.287	0.250	1.145	0.270
Δr_{t-1}	-0.014	0.006	-2.301	0.036
Δr_{t-2}	-0.007	0.006	-1.184	0.255
ΔI_{t-1}	0.003	0.002	1.835	0.086
ΔI_{t-2}	0.002	0.002	1.222	0.241
Δh_{t-1}	-0.003	0.002	-1.362	0.193
y_{t-1}	-0.392	0.114	-3.431	0.004
r_{t-1}	0.011	0.005	2.319	0.035
I_{t-1}	-0.003	0.001	-2.238	0.041
h_{t-1}	0.004	0.002	2.746	0.015
D_4	0.035	0.282	0.125	0.902
T^2	-0.001	0.000	-2.172	0.046
Δm_{t-1}	-0.001	0.002	-0.596	0.560
Δx_{t-1}	0.001	0.000	1.709	0.108

R-squared	0.779930	Mean dependent var	0.002937
Adjusted R-squared	0.545190	S.D. dependent var	0.261640
S.E. of regression	0.176449	Akaike info criterion	-0.326753
Sum squared resid	0.467015	Schwarz criterion	0.451919
Log likelihood	22.22805	Hannan-Quinn criter.	-0.068646
F-statistic	3.322516	Durbin-Watson stat	2.444189
Prob(F-statistic)	0.012474		

The bounds test statistics based on the Pesaran, Shin and Smith (2001) are presented in Table 4.4.3. The table shows that the F-statistic falls below the upper bound at the one percent (1%) significance level. The calculated F-statistic (5.526866) is greater than the upper bound (4.89) at the 2.5% level. Therefore, we can conclude that there is evidence of a long-run relationship between the variables.

Table 4.4. 3 Results of the Bounds Test for co-integration

Variables	Calculated F-statistic	Significant Level	Critical Values	Lower Bounds I(0)	Upper Bounds I(1)
y, I, r, h	5.526866	1 percent	1 percent 2.5 percent 5 percent 10 percent	4.29 3.69 3.23 2.72	5.61 4.89 4.35 3.77

4.5 Estimation of the long-run multipliers

After establishing the existence of co-integration between the variables, the long-run dynamic multipliers were calculated using the coefficients from the ARDL model. The estimated long-run coefficients for GDP (*y*), Investment (*I*), real exchange rate (*r*) and the real exchange rate volatility (*h*) are all statistically significant at the 5 percent level. These estimates have been used to calculate the long-run multipliers below. The multiplier effect that shows a devaluation and depreciation of the domestic currency when there is an increase in the exchange rate by -0.0271 percent, while the multiplier effect shows an increased in *I* by 0.0079 percent and volatility *h* effect is -0.0108 percent.

4.6 Granger Causality

After computing the long-run multipliers, the Granger causality was applied to show the direction of causality between real exchange rate and GDP. The results are presented in Table 4.6.1. The results of the Granger causality test predict that changes in the gross domestic product does Granger cause changes in real exchange rate volatility *h* as the p-value is 0.0339. The converse that *h* does not Granger cause *y* since the p-value is 0.4940 which shows that we cannot reject the null hypothesis. These results can be concluded that there is a uni-directional causality between *y* and *h*. Thus, it is the fluctuation in the growth rate of Liberia that causes volatility in the exchange rate rather than the reverse.

Also the next test results show that growth in foreign direct investment *I* does Granger causes real exchange rate volatility *h* since the *p*-value is 0.0013. Conversely, the result exhibits that *h* does not causes Granger causality in *I* as *p*-value 0.8203. We cannot reject the null hypothesis. These results reflect a uni-directional causation between the variables. In addition there is uni-directional causality from economic growth to growth in foreign direct investment (p -value of 0.0649) and also a uni-directional causality from economic growth to changes in the real exchange rate (p -value of 0.0004).

Table 4.6. 1 The Granger Causality Test Result

Pairwise Granger Causality Tests
Date: 06/22/15 Time: 13:13
Sample: 1960 2013
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
y does not Granger Cause *h*	51	3.64654	0.0339
h does not Granger Cause *y*		0.71617	0.4940
I does not Granger Cause *h*	42	7.94992	0.0013
h does not Granger Cause *I*		0.19912	0.8203
r does not Granger Cause *h*	51	39.3113	1.E-10
h does not Granger Cause *r*		4.91342	0.0116
I does not Granger Cause *y*	42	1.66199	0.2036
y does not Granger Cause *I*		2.94786	0.0649
r does not Granger Cause *y*	52	0.62104	0.5417
y does not Granger Cause *r*		9.42769	0.0004
r does not Granger Cause*I*	42	3.92923	0.0284
I does not Granger Cause r		6.91900	0.0028

Chapter Five

Conclusion

The ARDL model was used to examine the relationship between exchange rate volatility and economic growth in Liberia from 1980 to 2012. The orders of integration of the variables were examined and they were found not to have the same order. Tests for optimal lag lengths and serial correlation were conducted before the Bounds testing procedure was used to test for co-integration between the variables in the model. The variables were found to be co-integrated at the 2.5% level. The study used the coefficients form ARDL model to calculate the long-run multipliers. The multiplier effect shows that devaluation (depreciation) of the domestic currency increases the exchange rate (r) by –0.027 percent, while foreign direct investment (I) increases at 0.0080 percent and h or volatility reduces at -0.011percent in economic growth. Also, a test for Granger causality between exchange rate volatility and economic growth were performed and causation seems to go from GDP to the exchange rate rather than the other way round.

In conclusion, the result does not authenticate the idea from literature that volatility accounted for the decline in economic growth. It is rather fluctuations in the economic growth rate that caused fluctuations in the exchange rate. From the results, the study establishes the desirability of stabilizing the economic growth.

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