# ASSESSING THE IMPACT OF EXCHANGE RATE VOLATILITY ON ECONOMIC GROWTH IN GHANA

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# DECLARATION

I hereby declare that this submission is my own work towards the Master of Arts and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.



Date …….. Signed ……

(Candidate's name)

Date …… Signed ……

(Supervisor)

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(Head of department)

# DEDICATION

This work is dedicated to the Blessed Virgin Mary, the Mother of our Lord and Master Jesus Christ for her intercession and the favours.

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# ABSTRACT

The effects of exchange rate volatility on economic growth have over the years been an issue for both policy makers and academicians on the efficiency of alternative exchange rate policies. Proponents of fixed exchange rate maintain that floating exchange rate is associated with excessive volatility and deviations from equilibrium values. They further argue that excessive volatility and deviations from equilibrium values have reduced economic growth through their effects on trade and investment. In contrast, those in favour of flexible exchange rate argue that exchange rates are mainly driven by other factors, and that changes in factors would require similar, but more abrupt, movements in fixed parities.

Also, exchange rate volatility has been found to have adverse effect on economic growth through international trade and investment. It has been found to have negative effects international trade, directly through uncertainty and adjustment costs and indirectly through its effects in allocation of resources and government policies. It can lead to the distortion of the relative prices of domestic resources which will adversely affect investment and production through reduced efficiency.The aim of this study was to look at the impact of exchange rate volatility on economic growth in Ghana using time series data covering the period 1983 – 2010. The standard deviation of the first difference of the logarithm of real exchange rate (VOL) was employed to estimate the real exchange rate volatility and cointegration and error correction models (ECM) were used to determine both the short and long – term relationships. The Cointegration tests suggest: (a) a significant short – term negative relationship between economic growth and exchange rate volatility in Ghana. (b) An insignificant long – term negative relationship between economic growth and exchange rate volatility in Ghana. This is as a result of the timely intervention by government in the exchange rate market by either buying or selling of foreign

currencies. All the proxies of labour force, population and human development index showed a positive relationship with growth in Ghana indicating an efficient labour force, population and human development index. The results indicated that human development index with gross domestic investment, technology; exchange rate volatility explains growth in Ghana much better than when human development index is proxied by either labour force or population.

Policy makers, researchers and future research may find useful insights from the study.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Background to the Study

The Second World War impacted negatively on the world economy. Therefore immediately the war had ended, the Bretton Woods Institutions were set up to help the allied countries rebuild their economies. This development led to the Bretton Woods agreement. The main goal of the agreement was to correct the distortions created by the gold standard. Consequently, only the United States fixed the price of the dollar in terms of gold. All other convertible currencies were pegged to the dollar and free convertibility of gold into dollars was limited. However, in 1971 the Bretton Woods agreement collapsed and countries were compelled to exchange their currencies among themselves at a determined rate (floating system). This led to issues of exchange rate volatility in all countries. Issues of exchange rate volatility are believed to have negative impact on countries especially for a developing country with underdeveloped capital market and lack of stable economic policies (Prasad et al. 2003).

Exchange rate volatility has been found to have adverse effects on economic growth through international trade. It has been found to have negative effects on international trade, directly through uncertainty and adjustment costs and again indirectly through its effects in the allocation of resources and government policies (Cote, 1994).

According to past studies when exchange rate movements are not fully anticipated, an increase in exchange rate volatility may lead risk averse agents to reduce their international trading

activities. In addition, it can lead to the distortion of the relative prices of domestic resources which will adversely affect domestic investment and production through reduced efficiency.

Under the above circumstances and when an economy is heavily dependent on exports as a driving force for its economic growth then the impact of exchange rate volatility becomes an important issue for developing and emerging economies like Ghana. In addition the dependence on imported capital goods and the specialization of commodity exports can also instigate pronounced impact of exchange rate volatility on the economic activity of developing economies.



The consequences of exchange rate volatility on economic growth have long been at the centre of the debate on the optimality of alternative exchange rate regimes. Proponents of fixed rates argue that since the advent of the floating regime, exchange rates have been subject to excessive volatility and deviations from equilibrium values have persisted over sustained periods of time. In their view, exchange rate volatility deters industries from engaging in international trade and compromises progress in trade negotiations and eventually on growth. In contrast, proponents of flexible rates argue that exchange rates are mainly driven by fundamentals, and that changes in fundamentals would require similar, but more abrupt, movements in fixed parities. Therefore, a system of fixed rates would not reduce unanticipated volatility.

Moreover, greater exchange rate flexibility facilitates balance of payments adjustment in response to external shocks and hence reduces the need to raise protective tariff barriers or to impose capital controls to achieve equilibrium. Exchange rate volatility can affect growth

through trade and investment directly through uncertainty and adjustment costs and indirectly through its effect on the structure of output and investment and on government policy.

Before the introduction of the economic recovery program in Ghana in 1983, exchange rate policy had involved the maintenance of a fixed exchange rate regime with occasional devaluation, and exchange rationing. But the country adopted the flexible exchange rate regime i.e. managed float, and with this the national currency has experienced instability for most part of its existence (Mumuni and Owusu – Afriyie, 2004).



In June 1978, Ghana introduced a flexible exchange rate system under which the exchange rate for the Cedi in terms of the U.S dollar was to be adjusted to reflect the underlying economic, financial and balance of payments situation. Such adjustment were discontinued in August 1978 when the rate of exchange was fixed at 2.75 = U.S $1.00 (Tutu *et al*, 1991). The official exchange rate was adjusted in several discrete steps during the period April 1983 – January 1986. In 1986 Ghana adopted the two – window system and thus moved to a dual exchange rate markets. Window one maintained a fixed but adjustable exchange rate whilst window two used a weekly auction system. The rate in window one was applicable to government transactions, petroleum imports, cocoa and other traditional export receipts. The rate in the window two applied to all other transactions. In 1992, the two window auction system were unified and replaced by an interbank wholesale system in which a weekly wholesale auction is used to determine the interbank rate. Only banks were permitted to participate in the wholesale system. The Forex Bureaux were explicitly prohibited from participating in the interbank market; conversely, banks cannot retail to the forex bureau. In theory, there is therefore no arbitrage between the interbank market and the forex bureau market. Even though the Bank of Ghana

intervenes in the forex bureau by selling foreign exchange to them, the two markets are effectively segmented. Thus, the forex bureau operated an essentially self – financing system (Jebuni, 2006).

### 1.2 Statement of the Problem

Exchange rate has been defined as the price of one currency in relation to another (Azid *et al*, 2005). Basically exchange rates exist in either a fixed form or in a flexible form. Since 1983 the exchange rate regime in Ghana has been the flexible type which is managed sometimes. The flexible exchange rate system has been relatively stable in some periods while in other periods it has been highly volatile. For example, on annual basis in the year 1991, the Ghanaian cedi depreciated by 11.5%. In 1992, the cedi saw a depreciation of 25%. In 1994 depreciation was 21.8% and in 1996, it was 16.9%. (Bank of Ghana Annual Report, 1991; 1992; 1994 and 1996) Also, in 1997, the Ghanaian cedi saw a depreciation of 22.7% and a depreciation of 33.0% in 1998. In the year 2000, the cedi continued it depreciating run by showing a depreciation of 49.8% that year with a depreciation of 13.2% in 2002 and a depreciation of 20.1% in the year 2008.

Yet, within these periods the real growth rate of the country has been fluctuating. The growth performance in 1992 was 3.9% which indicated a fall from 5.3% in 1991. Real GDP rate fell from 4.9% in 1993 to 3.3% in 1994. Also, in 1997, the real GDP rate was 4.2% lower than the rate in 1996 which was 4.6%. The growth rate saw a further decline between 1998 and 1999 from 4.7% to 4.4%. In 2009, the real growth rate was 4.7% which indicated a decrease from the

8.4% rate in 2008 (Bank of Ghana Annual Reports 1991, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2008 and 2009).

The analysis above appears to indicate some correlation between exchange rate and economic growth. In periods of exchange rate depreciation economic growth rate seemed to be declining and vice versa. This seems to have been confirmed in 2000 when the exchange rate depreciated by 25% whilst GDP growth rate fell to 3.7% from 4.4% the previous year. In 2008, the real growth rate showed a decrease from 7.3% to 4.7% when in the first and second quarter the cedi recorded a high depreciation rate of 12.2% and 6.1% against the US dollar respectively.

Surprisingly, in the review of relevant literature it was observed that studies on the effect of exchange rate volatility on economic growth performance in Ghana is very scarce. Adjasi *et al*. (2008) and Kyereboah-Coleman and Agyire-Tetty (2008) have analyzed the effect of exchange rate volatility on the stock market and the effect of the exchange rate volatility on foreign direct investment in Ghana respectively while Siaw and Anokye (2010) also examined the effect of exchange rate changes on consumer prices in Ghana. Tutu *et al*. (1991) also examined the impact of exchange rate policy (regime) on macroeconomic performance in Ghana, specifically; he examined the effect of the exchange rate regime on economic growth between 1970 and 1988. The result showed that real devaluation had an expansionary effect on GDP.

Obviously, no study was found that examines the relationship between exchange rate variation and economic growth in Ghana. Therefore this thesis proposes to fill this knowledge gap and the primary research objective is: does exchange rate variation in Ghana has effect on growth?

### 1.3 Objectives of the Research

The main objective of the study is to analyze the impact of changes in the exchange rates on economic growth in Ghana using annual data for the years 1983 – 2010.

The specific objectives are as follows: to

- Analyze the trends in exchange rates and economic growth between the years 1983 and 2010.
- Measure the effects of variations in the exchange rate on economic growth between the years 1983 and 2010 in Ghana.



### 1.4 Hypothesis

This study seeks to empirically test the following hypotheses based on research objectives:

$H_o$: Exchange rate volatility has no impact on economic growth.

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

### 1.5 Justification of the Study

The significance of this study is based on the score that among the research works conducted on the effect of exchange rate volatility on the economy of Ghana (Adjasi et al. 2008; Kyereboah-Coleman and Agyire-Tettey, 2008) none has examined the impact of volatility of the cedi on economic growth. This work will give an in-depth knowledge on the workings in the exchange rate market and its transmission mechanism into other sectors of the economy especially its impact on growth.

This will assist the government in designing 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 most especially capital inflow to facilitate economic growth and increase the welfare of the people.

Also, investors and other stakeholders in the economy such as industries that rely mostly on imported inputs will benefit from the information that will be revealed in this work so as to adopt the necessary measures and techniques to ensure stable profit margins which may be affected without proper understanding on the exchange rate market (hedging will help).

Equally this work could set off the mark for further research into the effect of exchange rate volatility on other macroeconomic variables or on this same variable to bring to light other factors that may be in play.

### 1.6 Scope of the Study

This study is based on the Ghanaian economy over a twenty-eight (28) year period that is between 1983 and 2010. This is purposely to capture the period within which the economy witnessed a highly volatile exchange rate due to the 2007/2008 global financial crises and that the country recorded its highest cedi depreciation in 2000, a depreciation over 20% and to check for structural changes within the period. Also within this same period the country has recorded a stable growth rate and due to the issue of availability of data which was one of the problems I had to face the research will focus on this period.

Economic growth, the choice of this macroeconomic variable is due to the fact that economic growth ensures availability of goods and services in an economy, a measure of the wellbeing (welfare) of the population which is actually an indicator of an improvement in the standard of

living of the population. Therefore these two variables are worth studying especially looking at the impact of the volatility of the exchange rate on them which might affect the eventual wellbeing of the people.

### 1.7 Limitations

This research work faced basically three difficulties as time, financial constraints and lack of adequate knowledge. In the first place, since the study is based on the entire Ghanaian economy and a complex issue as the workings of the exchange rate markets, an ample time is required to construct a detailed work that is best and more representative of the economy. However, the stretch of time available will not augur for all the observation to be captured.

Also, financial constraints will almost certainly reduce the extent of travelling to acquire data and/or check for consistency of gathered secondary information since there are various institutions in the country that has data on the macroeconomic variables and must be crossed checked for consistency and also the ability to purchase the relevant textbooks to aid the research work.

And there is also the limitation of inadequate requisite skills in the estimation technique that will be employed, analysis and knowledge of the activities of the observable units on the field. There is also the weak point associated with the data keeping and recording systems of units in Ghana. These are but a few of the constraints in undertaking this work.

### 1.8 Organization of the Study

For the purposes of this study I have divided this work into five chapters and they are as follows. Chapter one treats the general background issues relating to the study. The statement of the

research problem as research questions are in this chapter. Also the objectives of this research are set out in this section with its justification. In chapter two there is a comprehensive review of both theoretical and empirical literature. That is to say it explores the issues surrounding the causal relationship between movements in exchange rates and macroeconomic variables such as inflation and economic growth.

Chapter three describes the methodology employed in this study. The next chapter entails the presentation and analysis of the empirical results obtained from the investigation. That is indicates the effects or linkage and causal relationship between the exchange rate volatility and growth and inflation. And finally, the last chapter which is the fifth chapter gives a summary of the main findings of the research with a provision of suggestions and recommendations for policy considerations.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 Introduction

This chapter is divided into two parts. The first part involves definitions and theoretical reviews on the effects of exchange rate volatility on international trade and investment (the transmission channels) and eventually on economic growth. In the second part of this chapter there is the review of empirical works relating to the effects of volatility in the exchange rate on economic growth and an overview of exchange rate regimes practiced by Ghana over the years.

## 2.1 Definitions of Concepts and Theoretical Reviews in Exchange Rates

i. *Exchange Rate*

According to Azid *et al.* (2005), *exchange rate* is the price of one currency in relation to another. In slightly different perspective, it expresses the national currency's quotation in respect to foreign ones. Thus, exchange rate is a conversion factor, a multiplier or a ratio, depending on the direction of conversion. It is believed that if exchange rates can freely move, it may turn out to be the fastest moving price in the economy, bringing together all the foreign good with it. Transactions within the same country involve the use of the domestic currency which may be the form of cash, cheque or other means. But with regards to transactions involving parties from different currency areas or countries, there is the use of the following: the seller's domestic currency, the buyer's domestic currency or an entirely different currency. Thus, one or both countries will pay or receive payments in a foreign currency and the market for such transactions

is termed the *foreign exchange market* i.e. where domestic currencies are traded for foreign ones (Incoom,1998).

In the exchange rate markets, there are dealers and/or principals. *A dealer* buys or sells currencies for third parties (*supra cit*.). The rate at which the dealer purchases the currencies is lower than the rate at which he sells them and therefore the difference between the rates at which he buys and sells currencies is termed as *the turn*.



ii. *Principal*

Also we have the *principal*; this person buys and sells currencies for himself. And for such people, profits are made by studying the exchange rate movements in order to take advantage of favourable ones. They may even keep currency until its exchange rate improves (*supra cit*.). There are occasional interventions by the monetary authorities or central banks of countries in the foreign exchange market and these are situations where there is an undesired short-term fluctuation. Usually, they accomplish this by either buying or selling of currencies to ensure that the exchange rates reaches or is at the desired level.

iii. *Funding Transaction, Swap Transaction, Spot Transaction*

*Funding transactions* are situations where monetary authorities engages in official resources with loans from international institutions and it must be emphasized that currencies used this way are swapped and not borrowed. “A bank can cover itself by entering into *swap transactions* with another bank by which it will buy, say dollars spot, then sell these dollars spot to another banks, and simultaneously but the dollars back, say three months forward. By that time, it will receive

the dollars which cover its forward sale of dollars to its customer. The cost of such a transaction will reflect largely the relative interest rates of the currencies involved; say the cedi and the dollar." (Inkoom, 1998)

In the foreign exchange market, we have both forward and spot transactions. The *spot transactions* involve the use of current market rates and all transaction settlement should be completed within two business days (*supra cit*.). Whiles the *forward transactions* require that an exchange rate should be booked at which currency will be delivered on a fixed future date or between two future dates, a *fixed forward currency contract* is arranged between the buyer and the seller. For delivery between two future dates, an option forward currency contract is written – the option referring to the choice between the two future dates and not whether or not to deliver. Delivery must be accomplished by the final date of the contract (*op. cit.*).

iv. *Hedging, Arbitrage, Appreciation and Depreciation*

There is a process also known as *hedging exchange rate risk*, where importers and exporters crystallize the domestic currency value of the expected future foreign currency invoice which ensures the profit to be earned in the business (*op. cit.*). Exchange rates between specific currencies are nearly always identical at any given time in different markets around the world. For example, the price of a dollar in terms of yen would be the same in New York, Tokyo, London, Zurich, Istanbul, and other foreign exchange markets. This equalization is ensured by *arbitrage*. *Arbitrageurs* are individuals who take advantage of any temporary difference in exchange rates across markets to buy low and sell high. Their actions tend to equalize exchange rates across markets since arbitrageur buys and sells simultaneously, no risk is involved. The

arbitrageur increases the demand for pounds in New York and increases the supply of pounds in London. So even a tiny difference in exchange rates across markets will prompt arbitrageurs to act, and this action will eliminate discrepancies in exchange rates across markets. Exchange rates may still change because of market forces, but they tend to change in all markets simultaneously.

Since the exchange rate is a price, conventional tools of supply and demand are used to explain its determination. Thus, the equilibrium price of foreign exchange is the one that equates quantity demanded with quantity supplied. For example, let us consider the market for cedi in terms of dollars. The exchange rate or price is specified in terms of the number of dollars required to purchase one Ghanaian cedi. An increase in the number of dollars needed to purchase a cedi indicates a weakening, or a *depreciation* of the dollar. A decrease in the number of dollars needed to purchase a cedi indicates a strengthening or an *appreciation* of the dollar.

v. *Spot Exchange Rate, Real Exchange Rate*

*Spot exchange rate* refers to the current exchange rate while *forward exchange rate* refers to an exchange rate that is quoted and traded today but for delivery and payment on a specific date. *Real exchange rate* (RER) is the purchasing power of two currencies relative to another. It is based on the GDP deflator measurement of the price level in the domestic and foreign countries which are arbitrarily set equal to one (1) in a given base year. Therefore the level of the RER is arbitrarily set, depending on which year is chosen as a base year for the GDP deflator of two countries. The changes in the RER are instead informative on the evolution over time of the relative price of a unit of GDP in the foreign country in terms of GDP unit of the domestic country. If all goods were freely tradable, and foreign and domestic residents purchased identical

baskets of goods, purchasing power parity would hold for the GDP deflator of the two countries, and the RER would be constant (en.wikipedia.org/wiki/exchange rate, 24/01/2011).

vi. *Bilateral, Nominal and Real Effective Exchange Rate*

*Bilateral exchange rate* involves a currency pair, while *effective exchange rate* is weighted average of a basket of foreign currencies and it can be viewed as an overall measure of the country's external competiveness. *A nominal effective exchange rate* (NEER) is weighted with the inverse of the asymptotic trade weight. *A real effective exchange rate* (REER) adjusts NEER by appropriate foreign price level and deflators by home country price level. Compared to NEER, a GDP weighted effective exchange rate might be more appropriate considering the global investment phenomenon (*op. cit.*).

vii. *Volatility*

In the existing literature (most of the time) volatility comes with the exchange rate. *Volatility* is defined as "instability, fickleness or uncertainty" and is a measure of risk, whether in asset pricing, portfolio optimization, option pricing or risk management, and presents a careful example of risk management which could be the input to a variety of economic decisions. *Volatility of exchange rates* describes uncertainty in international transactions both in goods and in financial assets. Exchange rates are modelled as forward- looking relative asset prices that reflect unanticipated change in relative demand and supply of domestic and foreign currencies, so exchange rate volatility reflects agent's expectations of changes in determinants of money supplies, interest rates and incomes. (Azid, T. *et al*, 2005)

## 2.2 Theoretical Review

This section deals with the review of basic theories on the transmission channels of movements of exchange rate on economic growth. It begins with the review of theories of the impact of exchange rate volatility on investment, followed by the impact of exchange rate volatility on trade and the eventual impact of the exchange rate volatility on economic growth.

Exchange rate can affect economic growth through two identified channels:

i. Through investment and
ii. Through international trade.



### 2.2.1 Exchange Rate Volatility and Investment

Exchange rate volatility impacts on growth through investments decisions by all the agents in the economy. The impact of exchange rate volatility on investment and hence on economic growth is not a recent source of concern. It is noted in most literature that uncertainty reduces investment in the presence of adjustment costs and when the investment process includes irreversibilities. Real exchange rate creates 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 negatively on economic performance.

In studying the link exchange rate-investment theoretically, Campa and Goldberg (1999), Nucci and Pozzolo (2001), Harchaoui, Tarkhani and Yuen (2005) with only small differences in their formulations used discrete dynamic optimization problems with a standard adjustment-cost model of a firm which operates in an imperfect uncertain environment. With the assumptions that the firm sells one part of its production in the domestic market and exports the other part

outside. Within these markets the firm possesses a mark-up power, meaning it is able to influence the prices. The firm also imports some part of its inputs from abroad. The common findings of these theoretical works actually could be classified into three (3) categories:

First, exchange rate affects investment through domestic and export sales. With currency depreciation, goods domestically produced become less expensive compared to foreign ones. This results in an increase in demand for domestic goods. In the same vein, exports will increase because they have become cheaper. For a given capital and labour, marginal revenue products of capital and labour increase as a result of convenient demand situations. The firm response by increasing its investment in capital and consequently, labour (Campa and Goldberg, 1999).

Second, exchange rate acts on investment through the price of imported inputs. Depreciation raises total production costs which results in lower marginal profitability. The effect of the exchange rate on the marginal profitability is proportional to the share of imported inputs into production (Nucci and Pozzolo, 2001).

Third, Harchaoui et al. (2005) shows that exchange rate can also affect investment through the price of imported investment via adjustment cost. Depreciation causes an increase of investment price, resulting to higher adjustment costs and lower investment. Overall, it is important to note that the global impact of exchange rate on investment is not obvious because it depends on which of these previous effects prevail and the values of elasticities of demand.

More so, on the theoretical link investment-exchange rate volatility; Campa and Goldberg (1995) applying the same formulation as above and assuming that the exchange rate is log-normally distributed. The model predicts that the effects of exchange rate uncertainty on profits are ambiguous. Increases in exchange rate augment expected profit if the firm exports more than it imports and lower expected profit in the opposite case. Goldberg (1993), using a duality theory, and Darby, Hallet, Ireland and Piscitelli (1999) an adopted model of Dixit and Pindyck (1994), found the same threshold effects of exchange rate uncertainty on investment.



### 2.2.2 Exchange Rate Volatility and International Trade

The effects of exchange rate variability on trade flows are analyzed in terms of risk/uncertainty. Exporters are either very risk-averse or less-averse and therefore would react differently to changes in the real exchange rates. The variability of exchange rates is the source of exchange rates risk and has certain implications on the volume of international trade, consequently on the balance of payments. Hooper and Kohlhagen (1978) and IMF (1984) have analyzed theoretically the relationship between higher exchange rate volatility and international trade transactions. They argued that higher exchange rate volatility leads to higher cost for risk-averse traders and to less foreign trade. This is because the exchange rate is agreed on at the time of the trade contract, but payment is 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. Exchange rate risk for all country is generally not hedged because forward markets are not accessible to all traders. Even if hedging in forward markets were possible, there are limitations and costs. For example, the size of the

contracts is generally large, the maturity is relatively short and it is difficult to plan the magnitude and timing of all international transactions to take advantage of the forward markets.

However, subsequent theoretical studies revealed that this prediction is based on restrictive assumptions about the form of the utility function (De Grauwe, 1988; Dellas and Zilberfard, 1993). Even under the maintained hypothesis of risk aversion, the sign of the effect becomes ambiguous once the restrictions were relaxed. As pointed out by De Grauwe (1988), an increase in risk has both a substitution and an income effect. The substitution effect per se decrease export activities as an increase in exchange rate risk induces agents to shift from risky export activities to less risky ones. The income effect, on the other hand, induces a shift of resources into the export sector when expected utility of export revenues declines as a result of increase in exchange rate risk. Hence, if the income effect dominates the substitution effect, exchange rate volatility will have a positive impact on export activity. In addition, an increase in exchange rate volatility can create profit opportunity for firms if they can protect themselves from negative effects by hedging or if they have the ability to adjust trade volumes to movements in the exchange rate. Franke (1991) and Sercu and Vanhull (1992) demonstrated that an increase in exchange rate volatility can increase the value of exporting firms and thus can promote exporting activities.

De Grauwe (1994) showed that an increase in exchange rate volatility can increase the output and thus the volume of trade if the firm can adjust its output in response to price changes. Broll and Eckwert (1999) demonstrated that an international firm with huge domestic market base has the ability to benefit from exchange rate movements by reallocating their products between

domestic and foreign market. Thus, higher volatility can increase the potential benefits from international trade. Moreover, from the political economy point of view, Brada and Mendez (1988) noted that exchange rate movements facilitate the adjustment of the balance of payments in an event of external shocks and thus reduce the use of trade restrictions and capital controls to achieve the equilibrium, and this in turn encourages international trade.



In brief, 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 becomes an empirical issue.

### 2.3 Empirical Review of Previous Studies

This section deals with the review of empirical literature on the effect of exchange rate volatility on economic growth. Just like the pattern for the theoretical review, this part begins with the review of empirical works on the impact of exchange rate volatility on investment followed by that of exchange rate volatility and international trade and finally that of exchange rate volatility and economic growth.

#### 2.3.1 Exchange Rate Volatility and Investment

A large fraction of studies have examined the relation between exchange rate, its volatility and investment both in developed and developing countries. For developed countries almost all studies are in the industry-level. Campa and Goldberg (1993) studied the linkage between

exchange rates and investment, emphasizing the role of producer exposure through export sales and through inputs into production. Using two estimates of exchange rate volatility that is (i) the ratio of the standard deviation to the mean of the exchange rate index over the previous twelve quarters (ii) the standard deviation of the first differences of the logarithm of the exchange rate over the twelve previous quarters.



With the use of two-stage least squares (2SLS) regressions, Campa and Goldberg discovered 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. In the 1980s, the dollars had significant differentiated impacts on industries. While the dollars had ambiguous effects on non manufacturing industries, its depreciations (appreciations) decreased (increased) investment in manufacturing non durables sector.

Campa and Goldberg (1999) surveyed four countries using annual panel data sets of manufacturing industries and employing the three-stage least square technique. They found that exchange rate appreciation in the USA has a positive effect on investment that decreased with export share and increased with import input share; with a 10% appreciation of the US dollar leading to an overall increase of around 1-2% in investment due to the increasing importance of imported inputs into manufacturing in the USA. Japanese industry generally showed a lower level of response, but with an overall increase in investment also expected following appreciation. For both these countries, groupings of industries classified as “high-mark-up” showed weaker or relatively insufficient effects compared with those classified as “low-mark-up”. However, Campa and Goldberg (1999) were unable to find any statistically significance in

the exchange coefficients for the UK and Canada, which they found surprising in the light of the size and extent of the external orientation of Canadian manufacturing. These authors suggested that the differences between countries were due to cross-country distinctions in industry composition and patterns of external exposure and concluded that further research was needed to identify industry and country- specific factors.



Also Nucci and Pozzolo (2001) investigated the relationship between exchange rate fluctuations and the investment decisions of a sample of Italian manufacturing firms. They used firm-level panel data and employed the generalized method of moments (GMM) estimation procedure developed by Arellano and Band (1999). They came up with the findings that support the view that a depreciation of the exchange rate has a positive effect on investment through the revenue channel, and a negative effect through the cost channel. The magnitude of these effects varies 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. Also this study showed that the effect of exchange rate fluctuations on investment is stronger for firms with low monopoly power, facing a high degree of imported penetration in the domestic market and of a small size and that the degree of substitutability between domestically produced and imported inputs influences the effect through the expenditure side. Nucci and Pozzolo (2001) found that the degree of import penetration in the domestic market was significant when added to the specifications. Dummy variables representing industry classifications of firm were also included in the panel data estimations and were found to be jointly significant, indicating the importance of industry differences in determining the effects of the exchange rate variations.

Harchaoui et al. (2005) used industry-level data for 22 Canadian manufacturing industries to examine the relationship between real exchange rate and investment during the period 1981-1997. The empirical results show that the overall effect of exchange rates on total investment was statistically insignificant. Further investigation revealed the non-uniform investment responses to exchange rate movements in three channels. The result empirically was consistent with earlier results in Campa and Goldberg (1999) that the overall effect of the exchange rate on total investment was statistically insignificant for Canadian manufacturing sector between 1981 and 1997. This notwithstanding, they also found that depreciations (appreciations) tend to have a positive (negative) impact on investment when the exchange rate volatility is relatively low. 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 investigations of the relation between the exchange rate, its volatility and investment in developing countries use, in general, OLS, Two-Stage Least Squares, Fixed effects, GMM and system GMM. Oshikoya (1994) results illustrate that exchange appreciation had a positive impact on private investment for four African middle-income countries (Cameroon, Mauritius, Morocco and Tunisia).

For the effects of real effective exchange rate (REER) volatility, a significant negative impact of exchange rate volatility on investment is reported by the major part of the studies (Serven, 1998), Bleaney and Greenaway (2001), and Serven, 2002). The impact of exchange rate instability on investment is nonlinear. The effect is large when, firstly, volatility is high and secondly, when there is large trade openness combined with low financial development. Contrary, in an

environment with low openness and high financial development, exchange rate volatility tends to act positively on investment, Serven (2002). Furthermore, Guillaumont, Guillaumont Jeanney and Brun (1999) found that "primary" instabilities (climatic, terms of trade and political instabilities) act on Africa growth through the negative effect that "intermediate" instabilities (instability of real exchange rate and instability of the rate of investment) exert on growth.



### 2.3.2 Exchange Rate Volatility and Trade

Given the inconclusive results of the theoretical models on the effect of exchange rate volatility on trade as a channel to economic growth, several studies have attempted to quantify the effects of exchange rate volatility on trade and eventually on growth. Wei (1999) estimated a panel of 63 countries over the years 1975, 1980, 1985 and 1990; a total of over 1000 country pairs were examined. Using switching regressions, the author found that, for country pairs with large potential trade, exchange rate volatility had a negative and significant effect on bilateral trade among the countries considered. Dell' Arricia (1999) examined the effect of exchange-rate volatility on bilateral trade of European Union members plus Switzerland over the period 1975-1994 using several definitions of volatility. In the basic OLS regression, exchange rate volatility had a small but significant negative impact on trade; reducing volatility to zero in 1994 would have increased trade by an amount ranging from ten to thirteen percent, depending on the measure of volatility used. Using both fixed and random effects, the impact of volatility was still negative and significant, but smaller in magnitude. The author found that elimination of exchange rate volatility would have increased trade by about 3.5% in 1994.

Asseery and Peel (1991) examined the impact of volatility on multilateral export volumes of five industrial countries. The novelty in their paper was the use of an error correction framework. It is argued that the non-robust results found in previous empirical work may be due to the fact that the export variable and some of its determinants were potentially non-stationary integrated variables. The volatility measure was based on the residuals from an ARIMA process for the real exchange rate. For all countries except the United Kingdom, they found that volatility has a significant positive effect on exports over 1973 to 1987 periods.



Kroner and Lastrapes (1993) examined the effect of volatility on multilateral export volumes and prices in a particular study utilizing a joint estimation technique in the context of a parameterized model of conditional variance (multivariate GARCH-in-mean model). In contrast with conventional two-step estimation procedures, the model imposes rationality on the variance forecasts. The model restricts the variance that affects trade to be the same as generated by the data. The conditional variance has a statistically significant impact on the reduced- form equations for all countries (based on likelihood ratio tests).

For the individual coefficients, the effect of volatility on volumes was estimated with greater precision for the United States. The sign and magnitude of the effects differ widely across the countries, the magnitude being generally stronger for prices. For the United States, France and Japan, the effect of volatility was found to be only temporary. Volatility had a negative effect on trade volumes only for the United States and the United Kingdom. For the other countries, the coefficient was positive. For export prices, volatility had a negative effect in U.S and German equations, and a positive effect in others. Kroner and Lastrapes showed that the results were not

robust to using the conventional estimation strategy (estimating the export equation separately and substituting the GARCH measure by a six-month rolling sample variance).

Koray and Lastrapes (1989) and Lastrapes and Koray (1990) used VAR models to examine the effect of exchange rate volatility on trade. The major advantage of this approach was that it did not impose exogeneity on the variables in the system. Exchange rate volatility may affect variables other than trade and, at the same time, it may be affected by some macro variables. In their first paper, they examined the link between real exchange rate volatility and U.S. bilateral imports from five countries, including Canada. Estimations were made separately for a fixed (1961-71) and a flexible (1975-85) exchange rate periods. In addition to real exchange rate volatility, each model contained U.S. and foreign money supplies, output, prices and interest rates and the nominal exchange rate (for the fixed rate period).

Koray and Lastrapes (1989) concluded that, although the effect of exchange rate volatility on trade increased from the fixed to the flexible rate regime, the relationship between volatility and trade was weak. This conclusion was based the observation that a fairly small proportion of the variance in U.S. imports is explained by innovations in volatility. For U.S. imports from Canada, the estimated contribution was about 4%. The largest effect was obtained in the Japanese case (about 11%). It is worth noting, however, that although these contributions may appear small, they are often similar or greater than those of the other variables in the system. Except for France, permanent shocks to volatility tend to depress imports. The results also suggested that exchange rate volatility is not a purely exogenous source of instability, as in all cases, at least one macro variable explains a significant proportion of the error variance of volatility.

In their second paper, Lastrapes and Koray (1990) used a similar approach but focused on U.S. multilateral exports and imports during the flexible rate period. They drew the same general conclusions. Compared to the other variables in the system, exchange rate volatility plays a relatively minor role in explaining imports, exports and real output. The responses to volatility shocks were small and statistically insignificant. As well, the state of the economy strongly affects volatility. Innovations in money, interest rates and prices make a particularly large contribution. These results supported the view that exchange rate volatility is a symptom of macroeconomic instability rather than an independent cause.



De Grauwe and Verfaille in 1988 attempted an explanation on the reason that despite the apparent success of the EMS in stabilizing exchange rate over the 1979-85 periods and the evidence suggesting that misalignments among the EMS currencies appeared smaller than those between floating currencies, intra-EMS trade grew at a substantially slower pace than trade among the other industrialized countries. Bilateral export volumes of 15 industrial countries were used. Exports are a function of demand and supply (foreign and domestic income), relative prices, a dummy for customs union (assumed to work through a higher income elasticity on the import side), a measure of long-term real exchange rate volatility (the variance of the annual changes of the exchange rate), and misalignment as an indicator of protectionist pressure.

Both exchange rate variability and misalignment had a negative and significant effect on export growth. In terms of magnitude, De Grauwe and Verfaille found that income and exchange rate variability were the most important factors in explaining export growth. Volatility was estimated to have reduced the growth rate of exports outside the EMS by 8 to 10 percent over the 1979 to

1985 period, while intra-EMS trade was reduced by just 0.7%. There were two reasons for the slower trade growth within the EMS: weaker income growth and a lower income elasticity of export demand, as the trade integration process levelled off. The authors noted that the question remains as to whether low exchange rate variability is correlated with low growth of output. In a comment, Melitz (1988) held that there were a number of serious shortcomings in their approach. In particular, he argued that their measure of volatility (based on consecutive monthly observations of annual changes) was insignificant, as it used overlapping observations and therefore could not measure annual volatility properly.

The study by Brada and Mendez (1988) differs from the previous ones in that it examined the effect of exchange rate regime, rather than volatility per se, on the volume of trade. Its results contradicted those of De Grauwe and Verfaille (1988). The study used a gravity model of bilateral trade flows, which included domestic and foreign incomes, population, distance between countries, and dummy variables for the exchange rate system and trade arrangements. The model was estimated with data on 30 developed and developing countries for each year from 1973 to 1977. With one exception, the coefficients on the exchange rate regime were significant at 5%. In all cases, trade flows were larger between countries with floating rates than between countries with fixed rates.

The reduction in trade under a fixed rate regime ranges from 27 to 61 percent. The authors concluded that even though exchange rate volatility reduces trade among countries, its effects are less than those of the restrictive commercial policies often imposed under fixed rates systems. Instead of relying on exchange rate movements to achieve payments equilibrium, fixed exchange rate countries must rely on changes in domestic incomes and prices, or impose trade restrictions.

As the latter are more acceptable politically than the former, the demand for imports is often controlled by tariff and non-tariff barriers in countries with overvalued currencies.

Frankel and Wei (1993) also used a gravity model of bilateral trade flows to test the effect of nominal and real exchange rate volatility. Regressions were estimated for 1980, 1985 and 1990 using a data set covering 63 countries. Given the likelihood of simultaneity bias in the regressions – governments may deliberately try to stabilize bilateral exchange rates with their major trading partners – the authors report instrumental variable (IV) estimations in addition to ordinary least squares. The bias seems to be confirmed by data, as the magnitude of the estimated effect of exchange rate volatility reduced considerably with the IV method. Frankel and Wei (1993) found that nominal and real volatility had a negative and significant impact on trade flows in 1980.

The effect was positive but insignificant in 1985. It remained positive and became statistically significant in 1990. The change in sign could indicate that the development of exchange risk hedging instruments has diminished the negative effect of volatility over time. In all cases, the magnitude was very small. Their preferred estimate suggested a doubling of exchange rate volatility within Europe, as would happen if variability returned from its 1990 to its 1980 level, would reduce the volume of trade within the region by 0.7 percent. Given that their results did not appear very robust, they concluded that the effect, if it was there at all, was small in magnitude.

Savvides (1992) used a two-step estimation method to test the assumption that only the unanticipated component of exchange rate volatility affects trade. Annual data for 62 industrial and developing countries were used to estimate regressions over the 1973 to 1986 period. The

degree of openness and terms of trade shocks were found to have a significant effect on real exchange rate volatility. The effect of expected and unexpected variability, based on the equation results, was tested on export volumes. Only the latter was negative and significant. Nominal exchange rate variability did not have a significant effect either. The author presented results for industrial countries and lesser-developed countries separately. The same conclusion holds concerning the impact of volatility. Although it was not mentioned in the text, the results for industrial countries were not too convincing, as the income and relative price terms were insignificant (the income term even has the wrong sign.)



And in the study by Kumar (1992), who tested his assumption regarding the differential effect of volatility on intraindustry versus net trade. Equations are estimated for the United Stated, Japan and Germany. The results partly support Kumar's assumptions. Risk increases intraindustry trade and reduces net trade in the United States, as predicted by the model. For Japan, risk reduces net trade but does not affect intraindustry trade, while for Germany; it increases intraindustry trade but does not affect net trade.

In conclusion, most of the empirical works done in this regard gives the evidence that the effect of exchange rate volatility is mixed. Results of the different studies are difficult to compare since the sample period, countries and more importantly the measure of risk vary widely. In several cases, long –run measure are used that may be a better proxy for trend changes in the exchange rate than volatility. But overall, a larger number of studies appear to favour the conventional assumption that exchange rate volatility depresses the level of trade which may impact on growth too in the same direction (De Grauwe and Verfaille 1988, Koray and Lastrapes 1989, Peree and

Steinherr 1989, Bini-Smaghi and Savvides 1992). With the exception of De Grauwe and Verfaille, the magnitude of that effect would be rather small. On the other hand, Asseery and Peel (1991) and Kroner and Lastrapes (1993) find evidence of a positive effect of volatility on export volumes of some industrial countries (the two studies, however, get conflicting signs for the United Kingdom). There is some indication that unanticipated volatility has a more significant impact.



### 2.3.3 Exchange Rate Volatility and Economic Growth

Having indicated the channels through which effects of exchange rate volatility is pass on to growth performance in an economy. What is the eventual effect of exchange rate volatility on growth? Empirical evidences have shown strong effect of short-run and long-run adverse effect of exchange rate swings on economic growth performance through the trade channel likewise the investment channel. In fact, evidence of the link from exchange rate volatility to growth is less than definitive. While Ghosh et al. (1997) found no relationship between observed exchange rate variability and economic growth for a sample of 136 countries over the period 1960-1989, Bailliu et al. (2001) reported a positive association between the degree of exchange rate flexibility and economic growth.

That this association is positive rather than negative leads one to suspect that this result reflects the influence of other factors correlated with exchange rate flexibility and growth: political stability, institutional strength, financial market development, for example. A further problem with much of this literature is that it focuses on the nominal rather than the real exchange rate: Dollar (1992) did report evidence of a negative OLS relationship between real exchange rate

variability and growth in a sample of 95 developing countries covering the period 1976-85. Using different measures and country samples, Bosworth et al. (1995) and Hausmann et al. (1995) report similar results. Belke and Kaas (2004) find the same thing focusing on employment growth, the Central and Eastern European transition economies, and a subsequent period.



But two other studies exploring the relationship between real exchange rate variability and growth in different developing country samples (Ghura and Grenness 1993 and Bleanney and Greenaway 2001) found little evidence of a relationship. Potential explanations include different country samples, different periods, different controls, different ways of measuring the real exchange rate and different degrees of omitted-variables and simultaneity bias. But if contributions this large literatures have something in common, it is that few results are consistent across studies and that the causality issue is rarely addressed systematically, there being few convincing instruments for exchange rate variability.

Using panel estimations for more than 180 countries, Edwards and Levy- Yeyati (2003) found evidence that countries with more flexible exchange rates grow 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 conclude 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 EMU periphery. The evidence according to him is strong for emerging Europe which has moved from an environment of high macroeconomic instability to macroeconomic stability during the observation period.

Most recently, Aghion et al. (2006) have examined the impact of real exchange rate variability not on factor accumulation but on factor productivity. They found that a more variable exchange rate is negatively associated with productivity growth in financially underdeveloped economies, but not in countries with deep financial markets. The implication is that financial development provides hedging instruments and opportunities enabling firms to guard against this 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. Whether this result is robust to alternative definitions of real exchange volatility is yet to be seen. But the larger point, that any effect of real exchange rate volatility on investment and growth is likely to be contingent on circumstances, is strongly valid.

In conclusion, it must be emphasized that empirically the results of the impact of exchange rate volatility on economic growth is mixed and inconclusive. The nature of the effect as indicated by some works is positive (Bacchetta and Van Wincoop, 2000; Schnabl, 2007; Eichengreen and Leblang, 2003) while others indicates a negative direction (Aghion et al. 2006) and yet still others find that there is no relationship (Ghosh *et al*. 1997) making the issue more of an empirical one. Therefore this work seeks to find out the situation with Ghana.

### 2.4 An Overview of Exchange Rate Regimes in Ghana.

Ghana's exchange rate management has undergone a number of regime changes. Initially, with the launch of the economic reform programme, a series of large devaluations of the cedi were implemented between 1983 and 1986. In April 1983, the government adopted many realistic exchange rate policy measures by devaluing the cedi in stages, from C2.75 to the US$1.00 to

C90.00 per $1.00 by the third quarter of 1986. Under the new foreign exchange policy, a scheme of bonuses on exchange receipts and surcharges on exchange payments was introduced.

Moreover, a multiple exchange rate system of two official rates of C23.38/$1.00 and C30.00/$1.00 were applied to specified receipts and payments. This transitory scheme continued until 10 October 1983 when exchange rates were unified at C30.00 to $1.00. After this a real exchange rate rule, in the framework of purchasing power parity (PPP), was adopted. This rule required a quarterly adjustment of the exchange rates in accordance with relative inflation rates of Ghana and its major trading partners for the period 1983–1984. The quarterly adjustment mechanism was replaced in December 1984 by more periodic exchange rate devaluation because the real exchange rate was still considered over-valued. The last discrete exchange rate adjustment before the establishment of an auction system brought the exchange rate to C90.00 per $1.00 by the end of September 1986. In order to accelerate the adjustment of the exchange rate and attain the objective of trade liberalization the auction market was introduced on 16 September 1986.

Now the forces of demand and supply were partially determining the cedi/dollar exchange rate. The new regime established a dual-window exchange rate system. Moreover, the surrender of exchange earnings to the Bank of Ghana was effected at two different rates. The window 1 exchange rate was fixed at C90.00 per $1.00, while the window 2 exchange rate was determined by demand and supply in the weekly auction system conducted by the Bank of Ghana. Transactions such as debt service payments on official debt contracted before 1 January 1986, imports of crude oil, processed petroleum products, essential inputs and drugs were conducted through window 1.

Earnings from exports of cocoa and residual oil products were to be surrendered at the window 1 exchange rate. All other transactions, about 66% of external payments and receipts, were conducted through window 2. The two windows, which coexisted from September 1986, were unified on 19 February 1987. Under the dual-retail auction system, the first auction was based on the marginal pricing mechanism and all the successful bidders were supposed to pay the marginal price. But as from the second auction the Dutch auction system was resorted to and under this system the successful bidders were supposed to pay the bid price.



**Table 2.1: Regime shifts in Ghana's Foreign Exchange Market.**

Episode Date Exchange rate regime

| Sn | Period | Exchange Rate Regime |
|---|---|---|
| 1 | 1983:2–1986:3 | Multiple exchange rate system |
| 2 | 1986:4–1987:2 | Dual retail auction system |
| 3 | 1987:3–1988:1 | Dutch auction system |
| 4 | 1988:2–1989:4 | Foreign exchange bureaus |
| 5 | 1990:1–1992:1 | Wholesale and inter-bank auction system |
| 6 | 1992:2– | Inter-bank market |

Source: Dordunoo (1994).

In order to absorb the parallel market into the legal foreign exchange market, foreign exchange bureaus were allowed to operate as from 1 February 1988, with the first bureau de change becoming operative on 8 April 1988. By the end of June 1988 about 119 bureaus had come into full operation and by early 1990 over 180 were fully licensed. The foreign exchange bureaus

were owned and operated by separate entities: by any individual, group of individuals, bank or institution. With the establishment of the bureaus, the foreign exchange market was characterized by the coexistence of two spot foreign exchange markets, where spot rates were quoted. The auction and the bureau markets were effectively segmented between 8 April 1988 and 29 December 1989. The bureaus were not allowed to bid for foreign exchange in the weekly retail auction. The continued existence of the premium in the parallel market led to the introduction of the wholesale auction system, which replaced the retail system with effect from 23 March 1990 and featured the operation of a composite exchange rate system—an interbank system and a wholesale system.

Under the wholesale auction system, the authorized dealer banks and the eligible forex bureaus were allowed to purchase foreign exchange from the Bank of Ghana for sale to their end-user customers and to meet their own foreign exchange needs. Moreover, the authorized dealers were allowed to determine freely the structure of their own bids at the wholesale auction. They could now sell the foreign exchange obtained in the auction to their customers plus a margin that is determined by each authorized dealer. The wholesale auction was based on the Dutch auction system. Under the inter-bank market, authorized dealers were allowed to trade in foreign exchange among themselves or with their end-user customers. The main provisions of this system were: the foreign exchange traded in the inter-bank auction should not be subject to surrender requirements; the Bank of Ghana may also participate as a buyer or seller in the inter-bank market; authorized dealer banks' working balances should not exceed a given maximum and balances in excess of that after 14 days may be kept with the Bank of Ghana; banks are to provide weekly reports on their gross holding showing the bank's own balances and total

balances in customers' accounts. In order to increase the supply of foreign exchange to the inter-bank market the surrender requirements remained almost the same as under the retail auction and the wholesale auction systems.

However, in the new system all proceeds from exports of non-traditional products must be lodged in a commercial bank in Ghana upon receipt. Other export earnings, apart from electricity earnings, are to be surrendered to the Bank of Ghana. On the demand side, the remaining restrictions on payment for current international transactions involving invisible payments were lifted. This was a step forward towards full liberalization of the exchange system and the cedi was made fully convertible on current account.

The wholesale auction system was abolished in April 1992 and since then; the management of the exchange rate takes place directly in the inter-bank market. Both the commercial banks and forex bureaus operate in a competitive environment. Thus, it is clear from Table 2.1, and the discussion above, that the Bank of Ghana has been following a managed float exchange rate policy since 1986. The Bank of Ghana's intervention in the foreign exchange market is solely at its discretion and is only to smooth wide fluctuations in the foreign exchange market. One of the objectives of this policy has been to reduce the gap between the official rate and the parallel rate. Since major foreign exchange transactions take place at the inter-bank level, the official exchange rate is first determined by the demand and supply conditions. Later on, the forex bureaus add a premium to this official exchange rate and cater for the needs of travellers and traders who trade with the neighbouring countries.

## 2.5 Conclusion

In sum this chapter has reviewed relevant literature on the channels through which exchange rate volatility affects economic growth both theoretical and empirical and finally brought to bear the various exchange rate policies undertaken by Ghana over the years from fixed to flexible and eventually the managed float.

# CHAPTER THREE

# METHODOLOGY

## 3.0 Introduction

In this section we present types of data and sources of data used in this work, the definition of the variables and their measurement are dealt with. Also, we have the specifications of the models used and the estimations technique employed.



## 3.1 Type and sources of data

This research work rely strongly on secondary data coming from the World Bank database, the Ghana Statistical Service, the Bank of Ghana quarterly bulletins and annual reports, the Ministry of Finance and Economic Planning, the Ministry of Trade and Industry. This work employs annual data on the chosen variables from the period 1983 – 2010. Ghana's exchange rate values against the U.S dollar were obtained from both the World Bank database and Ghana Statistical Service. Data on growth rates was equally obtained from both the World Bank and the Statistical Service of Ghana. Population figures were also obtained from these same sources whiles data on gross domestic investment and Human capital index came from the World Bank database.

## 3.2 Data Pass through and Analysis

To determine the impact of exchange rate volatility on Economic Growth in Ghana by asserting whether there is a causal relationship between the exchange rate volatility and growth. Annual data from the years 1983 -2010 are used largely because of the issue of availability of data. The first part of this section is a qualitative analysis to show the pattern and performance of growth

and the pattern of the exchange rate volatility. The second section is the econometric analysis. The use of the qualitative analysis in this part involved:

i. Means and standard deviation analysis of growth trends over the period under consideration.

ii. Correlation analysis between growth and the exchange rate volatility in the whole period under consideration.

iii. Graphical analysis of the patterns of growth and exchange rate volatility in the period under consideration.



### 3.3 Model Specification

Previous studies have used various models to assess the impact of exchange rate volatility on economic growth. Among them Akpan (2008) used GDP as the dependent variable while technology, gross domestic investment, labour force and exchange rate were the independent variables and he employed a simple Ordinary Least Square (OLS) estimation technique. Schnabl (2007) used real growth rate as the dependent variable and the explanatory variables consisting of exchange rate volatility with other control variables as short-term money interest rates as proxy for interest rate, yearly percentage changes of exports in terms of US dollar used as proxy for trade and yearly CPI inflation as proxy for macroeconomic stability.

Schnabl (2007) also included dummies for crises in emerging markets such as for the 1997/98 Asian crises and the 1998 Russian crises and a dummy for inflation targeting regimes which are associated with exchange rate flexibility. Toseef Azid et al. (2005) employed these variables for his model, real money, real exchange rates, real exchange rate volatility, exports, imports and manufacturing production indexes. But this work follows the model by Akpan (2008) for its

simplicity, availability of data of its variables and its straightforwardness. The empirical model specified for this study is as follows:

services as well as government). There is a relationship between all these and exchange rate. Gross domestic product contributes significantly to the growth and sustainable development of economies.

*ii. Exchange Rates*

This equation is also based on the reasons that real exchange rate is associated with a measure of the exchange rate that recognizes the effect of the differences in inflation rates of the countries concerned. Real exchange rate fluctuation is simply the nominal exchange rate for the effect of inflation differential. Real exchange rate fluctuation is presented here as an explanatory variable.

By taking into account the effect of inflation differentials; the real exchange rate provides a measure of price of foreign currency in real terms.

In sum real exchange rate (RER) refers to the price of foreign goods in terms of domestic goods. Exchange rate fluctuation then refers to the volatility and/or movements in real exchange rate. Fluctuation is the short- term variation (volatility/instability) of real exchange rate in relation to long – term trends. Thus changes in world price or fluctuations in nominal exchange rate gives rise to instability in international commodity trade. Thus, there exist a relationship between the exchange rate fluctuation and the macroeconomic environment of Ghana vis-à-vis terms of trade, government consumption expenditure, tradable, investment, macroeconomic imbalances and nominal exchange rate.

### 3.5 Real Exchange Rates

One frequently asked question in the literature on the impact of exchange rate volatility on macroeconomic variables is whether nominal or real exchange rate volatility enters the decision making of economic agents. Some argue that risk regard nominal rather than real exchange rate risk as the latter depends in effect not only on the variance of the nominal exchange rate, but also on that of relative prices which constitute a different type of risk for economic agents. Volatility measures that partly reflect fluctuations in price levels thus do not distinguish between the risk associated with nominal exchange rate changes independent of price movements and the risk associated with all other factors which may affect domestic and foreign prices. Others argue that volatility based on the real exchange rate is the more relevant measure because the effects of uncertainty on firm's profit that arise from fluctuations in the nominal exchange rate are likely to be offset in large part by movements in costs and prices, at least in the long run.

With all the above issues considered, works such as Thursby and Thursby (1987), Qian and Varangis (1994) and Bong and Fagereng (2002) have provided the evidence that suggest that the distinction between nominal and real exchange rate volatility makes no difference to the result obtained. Yet this study in following Kyereboah-Coleman *et al.*(2008) employ the use of real exchange rate which is defined as nominal bilateral exchange rate deflated by relative price level (CPI) of respective countries.

Real exchange rate (RER) is defined as

Where S is the nominal exchange rate of the Ghana's currency against the U.S dollar and P* is the consumer price index (CPI) of the rest of the world proxied by that of the USA.

*Estimation of the Real Exchange Rate*

In calculating the real exchange rate indices of the cedi with that of the U.S dollar, taking the price differential of Ghana with the U.S.A in order to arrive at a single measure of the exchange rate index. The method used by Kyereboah-Coleman *et al.* (2008) was used. That is the real exchange rate is calculated by using the purchasing power parity (PPP) approach with the definition of real exchange rate as the nominal exchange rate (NER) of the cedi/dollar multiplied by the ratio of price level in the U.S.A to price levels in Ghana. The NER index is the amount of local currency that can purchase a unit US dollar. Therefore, a rise in the index will indicate a depreciation of the local currency nominally while a fall will show a nominal appreciation of the local currency.

While calculating the real exchange rate, NER is adjusted for the price differential by keeping the US prices

### 3.6 Measurement of Exchange rate Volatility

The major issue in estimating the effects of exchange rate volatility on the various macroeconomic variables is the choice of an appropriate proxy to measure the exchange rate volatility. A variety of measures have been employed in numerous empirical studies to represent exchange rate volatility like the Standard deviation of the first difference of the log real exchange rate (VOL), the moving average standard deviation (MASD) of the quarterly log of bilateral real exchange rate and the conditional volatility of the exchange rates estimated using GARCH (General Autoregressive Conditional Heteroscedasticity Model) but there is no consensus on the appropriate measure.

For the purposes of this research, the Standard deviation of the first difference of the log real exchange rate (VOL) will be used as a proxy measure of real exchange rate volatility or risk. A key characteristic of VOL as a measure is that it gives large weight to extreme volatility. Since the countries being considered focus on export promotion and their domestic markets cannot absorb the entire production, their exports might not be affected by relatively small volatility. In addition, this measure will equal zero when the exchange rate follows a constant trend. If the exchange rate follows a constant trend it could be a source of exchange risk. This measure is as a benchmark proxy for exchange rate volatility.

Therefore, by following Gujarati (2004) the standard deviation of the first difference of the log real exchange rate will be modelled as

Let

*iv. Labour Force*

Labour force is presented here as an explanatory variable. It represents the economically active group of society. The labour force is classified into the age bracket of 21 and 65 years. This group has a lot of significance and consequences on a nation's unemployment ceteris paribus. If a country's labour force is high then it is very likely that employment level will also be high. Less output is bound to occur if the dependency ratio is more than the working force. The converse of this holds. If available job opportunities are not adequate for the labour force, then unemployment will result. There is a positive relationship between gross domestic product, real exchange rate fluctuation, gross domestic investment and technology.

*v. Population*

It must be emphasized however that data on the active employed labour force are not readily available (Ramirez, 2006), so many empirical studies (e.g. Li and Liu, 2005; Vamvakidis, 2002; Pattillo *et al*, 2002) use population as a proxy for labour. Hence Model 3 is formulated where labour *LLAB* is dropped from and replaced with population *LPOP*. Aside these reasons population was used just to test the effect of such proxy on economic growth.

agricultural, manufacturing and services sectors is a sine qua non so as to aid greater productivity. This subsequently impacts positively on gross domestic product (GDP) of Ghana. Technology is represented here as an independent variable having a functional relationship with real exchange rate fluctuation, gross domestic investment (GDI), labour force vis-à-vis exchange rate.



*vii. Human Development Index*

Unlike population of a nation and the labour force, human development index looks at the educational levels, the health status and the income levels of the population. Therefore instead of looking at the quantity of labour or people as in population and labour force, human development index goes further to talk about the quality of such a population and labour force. To also assist in finding out what the relationship between human development index and growth will be. Therefore population is proxied by human development index to see what the sign and effect will be as in Model 4.

and Hendry (1986) have shown, the results of econometric estimation on non-stationary variables are not statistically valid because the conventional tests, student's t and F are biased. Such results actually lead to spurious regression and not to a real correlation between a dependent variable and explanatory variables. When a series is stationary or otherwise of the time series variables thus when a series is stationary at level it is said to be integrated of order zero and when it is integrated of a higher order (2) then it is differenced in order to become stationary.



The characteristics of the variables are analyzed using non stationary tests – the augmented version of the Dickey – Fuller (ADF) test (1981) and the Phillips – Perron (PP) test (1988) in order to detect the presence of a unit root in the series and to determine the order of the integration of the variables.

### 3.8 Estimation Technique

#### 3.8.1 Engle – Granger Co-integration Test

Two or more variables are said to be co-integrated if individually each is non-stationary (has one or more unit roots), but there exist a linear combination of the variables that is stationary. This means that non – stationary economic time series may produce stationary relationships if they are co-integrated. For this, unit root tests are applied for residuals obtained from the regression results. If residuals do not contain unit roots, economic relationship among variables could be co-integrating. The procedure used is the Engle – Granger co-integration regression technique. For

example, if there are two variables, Y (consumption expenditure) and X (disposable income), the following equation can be considered for co-integration test.

### 3.9 Conclusion

This chapter has given a detailed description of the variables used and model specifications. It also dealt with the estimation technique for exchange rate volatility, the calculation of the real exchange rate and the estimation technique used.

# CHAPTER FOUR

## EMPIRICAL RESULTS, DISCUSSION AND ANALYSIS

### 4.0 Introduction

This section is in two parts, part 1 is the descriptive analysis of the data in tables and graphs while part 2 is the analysis of the regression results.



### 4.1 Analysis of Growth and Exchange Rate Movements

Just for the beginning, Table 4.1 shows the trend of annual growth rates (%) and movements in exchange rates for the Ghanaian economy during the period under consideration while Figure 4.1 shows the graph of growth rates.

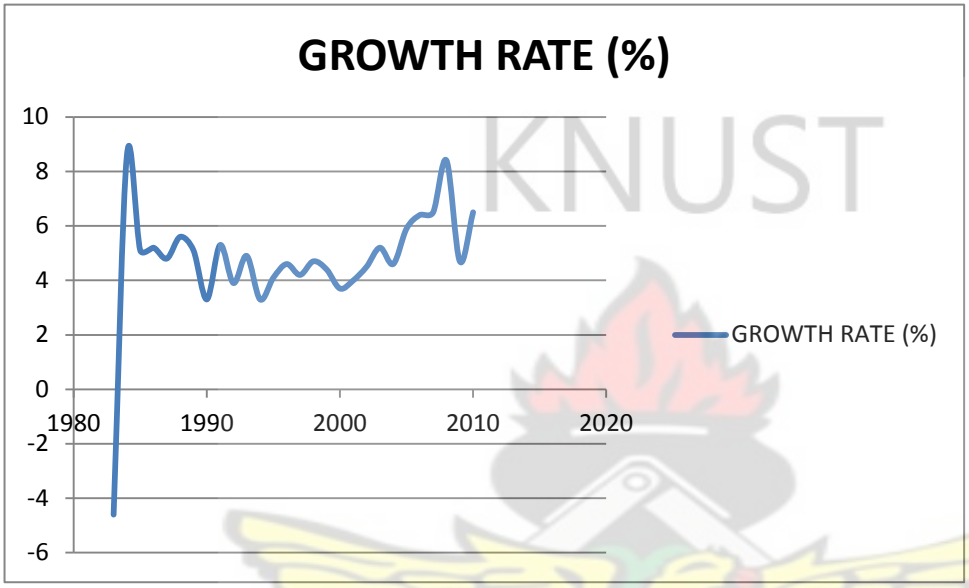
**Table 4.1a Output Growth Rate (annual rate) from 1983 – 2010**

| YEAR | GROWTH RATE (%) | YEAR | GROWTH RATE (%) | YEAR | GROWTH RATE (%) |
|---|---|---|---|---|---|
| 1983 | -4.6 | 1993 | 4.9 | 2003 | 5.2 |
| 1984 | 8.6 | 1994 | 3.3 | 2004 | 4.6 |
| 1985 | 5.1 | 1995 | 4.1 | 2005 | 5.9 |
| 1986 | 5.2 | 1996 | 4.6 | 2006 | 6.4 |
| 1987 | 4.8 | 1997 | 4.2 | 2007 | 6.5 |
| 1988 | 5.6 | 1998 | 4.7 | 2008 | 8.4 |
| 1989 | 5.1 | 1999 | 4.4 | 2009 | 4.7 |
| 1990 | 3.3 | 2000 | 3.7 | 2010 | 6.5 |
| 1991 | 5.3 | 2001 | 4.0 | | |

| | | | | | |
|---|---|---|---|---|---|
| 1992 | 3.9 | 2002 | 4.5 | | |

Source: World Bank database

**Figure 4.1a – Output Growth Rate (annual rate) 1983 - 2010**




Source: Author's own

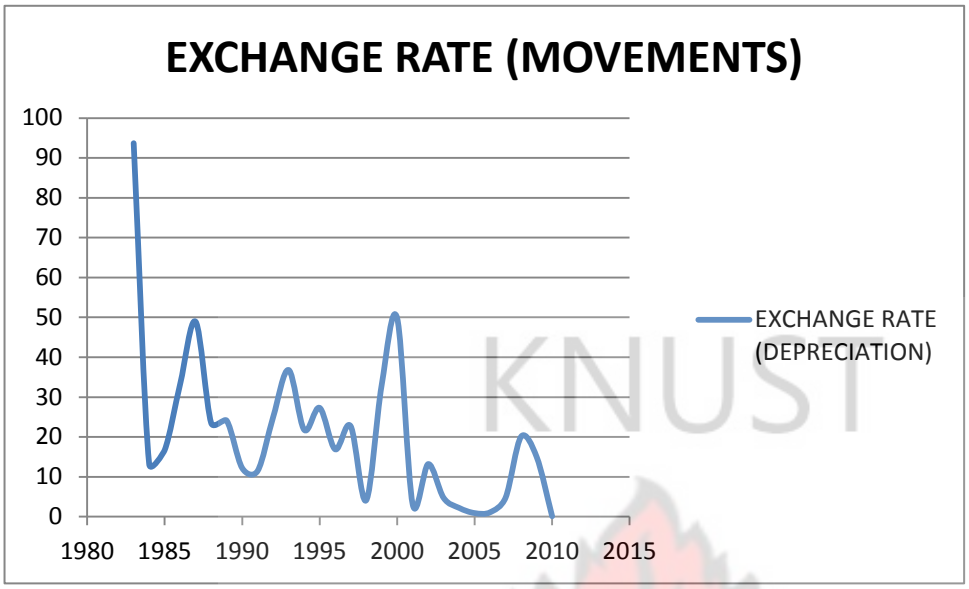
Figure 4.1 shows the growth rate of the years under consideration. It averaged 474.64% over the entire period with a standard deviation of 223.60%. The inference sheds light on the high average growth during the period under consideration and at the same time on the high volatility, which could be seen from the graph. It can clearly be seen from the graph that the growth rate has not been stable over the years and shows signs of a high volatility.

**Table 4.1b Exchange Rate Movements from 1983 – 2010**

| YEAR | EXCHANGE RATE MOVEMENTS (%) | YEAR | EXCHANGE RATE MOVEMENTS (%) | YEAR | EXCHANGE RATE MOVEMENTS (%) |
|---|---|---|---|---|---|
| 1983 | 93.67 | 1993 | 36.76 | 2003 | 4.7 |
| 1984 | 13.16 | 1994 | 21.76 | 2004 | 2.2 |
| 1985 | 16.67 | 1995 | 27.33 | 2005 | 0.9 |
| 1986 | 33.33 | 1996 | 16.91 | 2006 | 1.1 |
| 1987 | 48.86 | 1997 | 22.66 | 2007 | 4.8 |
| 1988 | 23.48 | 1998 | 4.07 | 2008 | 20.1 |
| 1989 | 24.09 | 1999 | 33.00 | 2009 | 15.0 |
| 1990 | 12.17 | 2000 | 49.8 | 2010 | 0.1 |
| 1991 | 11.54 | 2001 | 3.1 | | |
| 1992 | 25.00 | 2002 | 13.2 | | |

Source: World Bank data bank.

**Figure 4.2 Exchange Rate Depreciation (%) using inter-Bank Rate**




Source: Author's Own

Figure 4.2, shows the movements in exchange rate of the years under consideration. It averaged 2070.36% over the entire period with a standard deviation of 1918.08%. The graph shows that the Ghanaian cedi has been volatile over the years and it has also been depreciating consistently over the years.

**Figure 4.3 Growth Rate and Exchange Rate Depreciation**

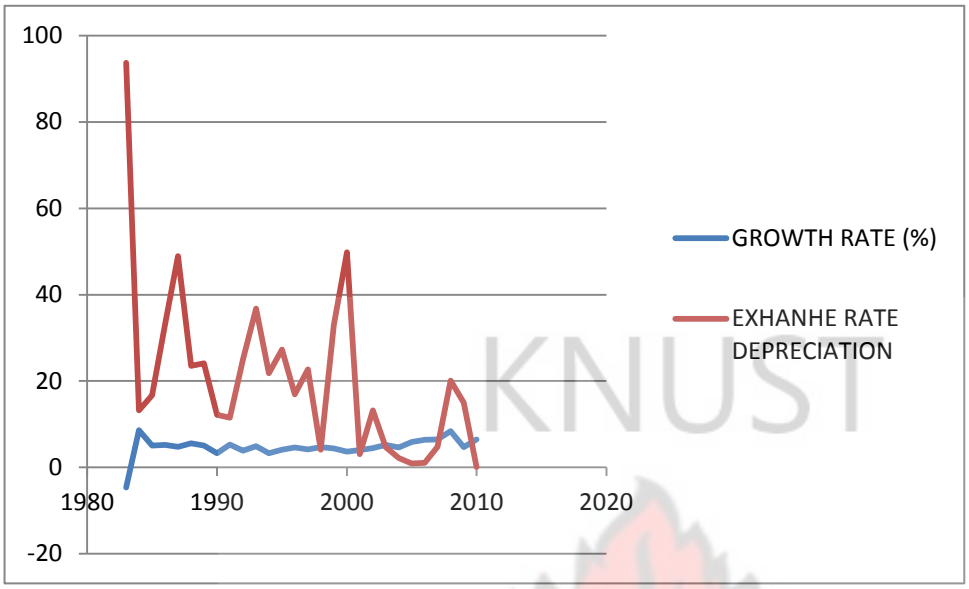



Figure 4.3 reveals that there seems to be some sort of correlation between the movements in exchange rate and economic growth. But the econometric testing ahead will establish more convincingly the relationship between exchange rate volatility and economic growth.

### 4.2 The Unit Root Test Results

The application of the ADF and the PP root test to the variables in equations (2) with labour force, (4) with population and (5) with human development and the results are summarized in Table 4.2. The two tests are complementary as the PP test is less restrictive than the ADF test and its results are valid even when the requirements of absence of autocorrelation and heteroscedasticity of errors are not met. The results of the two tests show that all the variables used, except *LTECH* and *LVEXCHR*, which are stationary, display characteristics of level non-stationarity. But all used variables became stationary at first difference: it thus follows that the variables in equation (2) with labour force are integrated to the order of 2, i.e. I (2). In equation (4) where labour force was proxied by population, the variables were integrated to the order 1.

And for equation 5, where population was proxied by human development index, all the variables were stationary at levels excerpt *LTECH, LVEXCHR* and *LHDI*. But all became stationary at first difference therefore the variables in equation 4 are integrated to the order of 1 i.e. I (1).

**Table 4.2: Unit root tests**

| Variables in level | ADF test | | PP test | |
|---|---|---|---|---|
| | With constant | with constant and trend | with constant | with constant and trend |
| *LGDP* | -2.090623 | -10.67805 | -8.087890 | -8.220384 |
| *LPOP* | -0.461229 | -5.473666 | 3.355315 | -2.204970 |
| *LGDI (LCU)* | 2.607183 | -0.035470 | 4.041298 | 0.647763 |
| *LVEXCHR* | -8.703295 | -4.991503 | -4.896307 | -5.048532 |
| *LTECH* | -14.0514 | -20.0346 | | |
| *LLAB* | -1.0150 | -3.461128 | | |
| *LHDI* | -0.273223 | -3.271534 | -0.214656 | -2.702646 |
| Variables at 1st Difference | | | | |
| *LGDP* | -17.73348*** | -16.93929*** | -26.24848 | -39.30788 |
| *LPOP* | -5.924601*** | -3.420996* | -1.349686 | -0.760199 |

| | | | | |
|---|---|---|---|---|
| *LGDI (LCU)* | -3.933228*** | -5.361614*** | -3.935372 | -5.654504 |
| *LVEXCH* | -8.298557*** | -8.668967*** | -12.11323 | -13.811442 |
| *LTECH* | -17.1149*** | -24.0808*** | | |
| *LLAB* | -1.654065 | -0.286894 | | |
| *LHDI* | -4.592857*** | -4.494546*** | -4.987471 | -4.819365 |

Notes: *significant at 10% level; **significant at 5% level; ***significant at 1% level

Source: Estimation 2011



### 4.3 Co – integration Test Results

The results of the Engle – Granger cointegration residual test for models 2, 3 and 4 are shown in Table 4.2 and the test results show that all the variables are co-integrated for all the models.

**Table 4.3 ADF test for the Residuals of Models 2, 3 and 4**

| | |
|---|---|
| ADF test statistic (Model 2) | -5.975* |
| ADF test statistic (Model 4) | -6.762* |
| ADF test statistic (Model 5) | -5.898* |

* Series are stationary

From Table 4.3, the Mackinnon critical values for the cointegrating equation of five (5) variables without trend at 1%, 5% and 10% level of significance are -4.9587, -4.4185 and -4.1327 respectively. Since the ADF test statistic for models 2, 3 and 4 are (-5.975), (-6.762) and (-5.898) are all higher than the Mackinnon critical value at 1% level in absolute terms, it shows that the

residuals are stationary and that the variables are cointegrated therefore there is both a long – run and a short – run relationship among the variables. Since the Engle – Granger two-step estimation procedure was applied and thus requiring a two-step estimation method for dynamic specifications, both the long – run and short – run models required only OLS regression.

### 4.3.1 Regression Results for Long-term Relationship for Models 2, 4 and 5

| VARIABLES | MODEL 2 | MODEL 4 | MODEL 5 |
|---|---|---|---|
| | Coefficients | Coefficients | Coefficients |
| Constant | - 46.76308** | -27.8319** | 14.3434*** |
| *LPOP* | 2.987703** | - | |
| *LGDI* | 0.056593 | 0.0981225 | -0.0019646 |
| *LVEXCHR* | - 0.015180 | -0.020230 | -0.0303041 |
| *LTECH* | - 0.906016 | - 0.803706*** | -1.0152*** |
| *LLAB* | _ | 1.9062* | |
| *LHDI* | _ | _ | 12.0152*** |

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Source: Estimation 2011

The central goal of this thesis is to examine the relationship between economic growth and exchange rate volatility. The coefficient of exchange rate volatility was -0.015180 for Model 2(long term relationship) which indicates a negative relationship between exchange rate and economic growth. This is contrary to the research work by Akpan (2008) who found a positive relationship between exchange rate volatility and economic growth in Nigeria but confirms

works by Dollar (1992), Hausmann *et al* (1995) and Ghosh *et al* (1997) who all found a negative relationship between exchange rate volatility and economic growth. Thus the negative relationship between exchange rate volatility and economic growth supports the assertion that uncertainties surrounding the foreign exchange market adversely affect the growth performance of the economy. And it must be emphasized however that the t statistic was statistically not significant. The same was the situation in Model 4 for the long term relationship between exchange rate volatility and economic growth. The coefficient of exchange rate volatility was -0.020230 but the t statistic was equally not significant in the long term as in Model 2. In Model 5, the sign of the coefficient was still negative and not significant as well.

The negative relationship between gross domestic product and instability of exchange rate in the foreign exchange market shows that economic growth is affected negatively by exchange rate movements in the economy. Increase in volatility of exchange rate leads to a reduction in economic growth. Put simply, it leads to the reduction in the amount of goods and services produced in the economy which may lower the standard of living in the economy.

As indicated in the growth Models (2, 4 and 5) on pages 42, 49 and 50, economic growth (GDP) is regressed on technology, exchange rate volatility, population/labour force/human development index and gross domestic investment. The regression coefficient constant term is negative for Model 2 and Model 4 but positive for Model 5, implying that in the long-run and at zero performance of all the independent variables Ghana's economic growth will contract by 46.76 and 27.83 respectively for Models 2 and 4 but for Model 5, at zero performance of all the independent variables Ghana's economy will expand by 14.3434 units. These constant terms were both statistically significant at 5% for Models 2 and 4 but that of Model 5 was significant at

1%. The regression results show a positive relationship between population/labour force/human development index, gross domestic investments and economic growth which were the predicted signs by theory. But surprisingly the coefficients of technology showed a negative sign for Model 2, 4 and 5 indicating a negative relationship between gross domestic product and technology in Ghana.

The empirical results for Model 2 indicates that in the long – run when population increases by one unit, GDP increases by 2.988 units, a result which was statistically significant. The positive relationship between population and gross domestic product shows that the human resource base and the labour force of the country are efficient. This may be due to adequate training given them which is evidenced by the establishment of a lot technical and vocational institutions and the increase in graduates from both Polytechnics and Universities every year. So also in Model 4, where Labour force was employed instead of population. There was a positive relationship between GDP and the labour force of Ghana with the same reasons as the relation population – GDP. The coefficient of labour force of 0.9062 was equally significant at 10%. Also, using human development index as a proxy for labour force we find that there is a positive relationship and equally significant at 1%.

Gross domestic investment when increased by one unit will result in a 0.057 and 0.098units for Models 2 and 4 respectively increase in GDP but this was statistically not significant for both Models. The importance of investment to the growth of the Ghanaian economy is evidenced by the constant cry for increase in foreign direct investment and the creation of an enabling environment to facilitate domestic investment. In Model 4 there was a negative relationship

between gross domestic investment and economic growth contrary to Models 2 and 4 but this was equally not significant.

The coefficient of technology in Model 2 was -0.906 and this was statistically significant. The negative relationship between GDP growth and technology might be that the assumption of technology improving with time which was proxied by time in this work may not be applicable probably in the African and especially the Ghanaian context. A different result might have occurred if technology was proxied by other variables other than time. This negative relationship between growth and technology also shows that there are more vital elements that affect growth more in Ghana than technology. This relationship may result since the largest contributor to the GDP of Ghana's economy – agriculture and services has failed to employ the highest form of technology. Mechanized farming is still not a reality and the services sector to is dominated by petty trading (distribution of goods which hardly employs technology) even though recently the telecommunication sector employs some modern technology. The same situation happened in model 3, where the coefficient of Technology was also negative and statistically significant at 1%. Also, in Model 5, there was a negative relationship between technology and economic growth and the t-statistic was also significant at 1%.

The $R^2$ of 0.543059 for Model 2 indicates that all the dependent variables as population, technology, gross domestic investment and exchange rate volatility explains about 54% of the variations in GDP in Ghana. This is an indication that the variables fairly fit the Model. The $R^2$ of Model 4 was 0.53684 which shows that when population is proxied by labour force; all the dependent variables explain about 53% of the variations Model 4 an improvement from Model 2.

Also, the $R^2$ for Model 5 was 0.61996 which shows when labour force was proxied by human development index. All the dependent variables explain about 61% of the variations in Model 5 an improvement from Model 4. Various diagnostic tests on the properties of the residuals were applied to examine the validity of the Models. The conventional tests of serial correlation, heteroscedasticity, normality of the residual and functional form misspecification revealed no problem. These are shown in the Tables 4.4, 4.5 and 4.6.



**Table 4.4 Diagnostic Tests for Model 2**

| Test Statistic | LM Version | F Version |
|---|---|---|
| A: Serial Correlation | CHSQ (1) = 0.62605[0.429] | F(1,21) = 0.49849[0.488] |
| B: Functional Form | CHSQ (1) = 1.3755[0.241] | F (1,21) = 1.1273[0.300] |
| C: Normality | CHSQ (2) = 1.5126[0.469] | Not applicable |
| D: Heteroscedasticity | CHSQ (1) = 1.0889[0.297] | F (1,25) = 1.0507[0.315] |

Source: Estimation 2011

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on the regression of squared residuals on squared fitted values.

From Table 4.4 the probability values of (0.429), (0.241), (0.469) and (0.297) proved that the null hypothesis of serial correlation, functional misspecification, normality assumption of the residuals and Heteroscedasticity were all rejected. This shows that the quality of Model 2 is satisfactory.

**Table 4.5 Diagnostic Tests for Model 4**

| Test Statistic | LM Version | F Version |
|---|---|---|
| A: Serial Correlation | CHSQ(1) = 0.91973[.338] | F (1,21) = 0.74057[.399] |
| B: Functional Form | CHSQ (1) = 1.1860[.276] | F (1,21) = 0.96484[.337] |
| C: Normality | CHSQ (2) = 1.3998[.497] | Not Applicable |
| D: Heteroscedasticity | CHSQ (1) = .50531[.477] | F (1,25) = 0.47680[0.496] |

Source: Estimation 2011

A: Lagrange multiplier test of residual serial correlation.

B: Ramsey's RESET test using the square of fitted values.

C: Based on a test of skewness and kurtosis of residuals.

D: Based on the regression of squared residuals on squared fitted values.

From Table 4.5 the probability values of (0.338), (0.276), (0.497) and (0.477) proved that the null hypothesis of serial correlation, functional misspecification, normality assumption of the residuals and Heteroscedasticity were all rejected. This shows that the quality of Model 4 is satisfactory.

**Table 4.6 Diagnostic Tests for Model 5**

| Test Statistic | LM Version | F Version |
|---|---|---|
| A: Serial Correlation | CHSQ (1) = 2.5430[0.111] | F(1,2) = 2.1835[0.154] |
| B: Functional | CHSQ (1) = 0.7186[1.00] | F(1,21) = 0.5589E-7[1.00] |
| C: Normality | CHSQ (2) = 0.77738[0.678] | Not Applicable |
| D: Heteroscedasticity | CHSQ (1) = 0.9719[0.324] | F(1,25) = 0.93352[0.343] |

Source: Estimation 2011

A: Lagrange multiplier test of residual serial correlation.

B: Ramsey's RESET test using the square of fitted values.

C: Based on a test of skewness and kurtosis of residuals.

D: Based on the regression of squared residuals on squared fitted values.

From Table 4.6 the probability values of (0.111), (1.00), (0.678) and (0.324) proved that the null hypothesis of serial correlation, functional misspecification, normality assumption of the residuals and Heteroscedasticity were all rejected. This shows that the quality of Model 5 is satisfactory.

### 4.3.2 The Estimation of the Error – Correction Model

The short- run Models 2, 4 and 5 provide information relating to the adjustments that occur between the different variables to restore the long – run equilibrium in response to the short – run disturbances of the growth Models 2, 4 and 5. For these error correction Models, the elements of which are second difference (for model 2) first difference (for model 4) values of the long – run Model's variables and the error correction term (ECM-1) whose role is to ensure that the short – run deviations in relation to the long – run relationship are corrected; it was constructed on the basis of the long – run Models of equations 2, 4 and 5.

**Table 4.6: the short – run parsimonious model for Models 6a, 6b and 6c**

| VARIABLES | MODEL 6a | MODEL 6b | MODEL 6c |
|---|---|---|---|
| | Coefficients | Coefficients | Coefficients |
| *Constants* | 0.14056 | 0.025085 | 0.032323 |
| *D(DPOP)* | -1.3435 | - | - |
| *D(DGDI)* | -0.10466 | 0.13229 | 0.0066031 |
| *D(DVEXCHR)* | -0.026192* | -0.29462* | -0.034485** |
| *D(DTECH)* | -1.1103* | -1.2396 | -1.2755*** |
| *D(DLAB)* | - | 35.4444 | - |
| *D(DHDI)* | - | - | 10.5807* |
| *ECM(-1)* | -1.2016*** | -2.3747*** | -1.3085*** |

Note: ***significant at 1% level; **significant at 5% level; *significant at 10% level

Source: Estimation 2011.

**Table 4.7 Diagnostic Test for ECM 6a**

| Test Statistics | LM Version | F Version |
|---|---|---|
| A: Serial correlation | CHSQ(1)= 0.005498[0.941] | F(1,19) = 0.0040191[0.950] |
| B: Functional Form | CHSQ (1) = 2.6115[0.106] | F(1,19) = 2.1215[0.162] |
| C: Normality | CHSQ (2) = 1.7749[0.412] | Not applicable |
| D: Heteroscedasticity | CHSQ (1) = 0.36181[0.548] | F (1,24) = 0.33870[0.566] |

Source: Estimation 2011

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of fitted values

C: Bases on a test of skewness and Kurtosis of residual

D: Based on the regression of squared residuals on squared fitted values

**Table 4.8 Diagnostic Test for ECM 6b**

| Test Statistic | LM Version | F Version |
|---|---|---|
| A: Serial Correlation | CHSQ (1) = 2.3097[0.129] | F (1,18) = 1.8323[0.193] |
| B: Functional Form | CHSQ (1) = 0.81868[0.775] | F (1,18) = 0.59139[0.811] |
| C: Normality | CHSQ (2) = 0.59842[0.741] | Not Applicable |
| D: Heteroscedasticity | CHSQ(1) = 0.075289[0.784] | F (1,23) = 0.069475[0.794] |

Source: Estimation 2011.

A: Lagrange multiplier test of residual serial correlation.

B: Ramsey's RESET test using the square of fitted values.

C: Based on a test of Skewness and Kurtosis of residuals.

D: Based on the regression of squared residuals on squared fitted values.

**Table 4.9 Diagnostic Tests for ECM 6c**

| Test Statistic | LM Version | F Version |
|---|---|---|
| A: Serial Correlation | CHSQ (1) = 1.9825[0.159] | F (1,19) = 1.5683 [0.226] |
| B: Functional Form | CHSQ (1) = 3.8379[0.050] | F (1,19) = 3.2903 [0.086] |
| C: Normality | CHSQ (2) = 0.60105[0.740] | Not Applicable |
| D: Heteroscedasticity | CHSQ (1) = 1.8496[0.174] | F (1,24) = 1.838 [0.188] |

Source: Estimation 2011

A: Lagrange multiplier test of residual serial correlation.

B: Ramsey's RESET test using the square of fitted values.

C: Based on a test of Skewness and Kurtosis of residuals.

D: Based on the regression of squared residuals on squared fitted values.

From Table 4.9 the probability values of (0.159), (0.050), (0.740) and (0.174) proved that the model passed the tests of no heteroscedasticity, normality assumption, no serial correlation but failed the test of functional misspecification.



ECM 6a, 6b and 6c seems to be satisfactory in terms of its quality as indicated by the results from the diagnostic tests shown in Table 4.7, Table 4.8 and Table 4.9.The coefficients of technology, exchange rate volatility and that of the error-correction term were all significant while that of the constant term, gross domestic investment and population were not significant for ECM 6a. But in ECM 6b, the coefficients of gross domestic investment, technology, the constant term and labour force used as a proxy for population were all insignificant statistically. Only the coefficients of the exchange rate volatility and the error correction term were statistically significant. In ECM 6c, the coefficients of human development index, a proxy for labour force, technology, exchange rate volatility and the coefficient of the error correction term were significant.

The coefficient of gross domestic investment was -0.10456 indicating a negative relationship between investment and GDP for ECM 6a. This was contrary to the relationship between the two in the long –run Model and the t – statistic was however not significant for ECM 6a. But for ECM 6b and 6c, there was a positive relationship between investment and GDP with a coefficient of 0.13229 and 0.0066031 respectively. Population had a coefficient of -1.3435 which

also shows a negative relationship between GDP and population, a different relationship as compared to what happens in the long – run. The t – statistic was however not significant. In ECM 6b, labour force (proxy for population) had a positive relationship with GDP. It was statistically insignificant. For ECM 6c, human development index, a proxy for labour force had a coefficient of 10.5807; a significant positive relationship between economic growth and human development index. The coefficient of technology maintained its negative relationship with GDP. Technology had a coefficient of -1.1103 and its t- statistic was significant at 10% for ECM 6a. The same was the situation with ECM 6b. There was a negative relationship between technology and GDP with a coefficient of -1.2396 for ECM 6b. It was however not significant. The same negative relationship was found in ECM 6c, a coefficient of -1.2755 and this was significant at 5%.

The coefficient of exchange rate volatility was -0.026 confirming the negative relationship between GDP and uncertainties around the foreign exchange market as was the situation in the long –run. The t – statistic was this time statistically significant at 10% for ECM 6a. The error correction term, ECM (-1), was highly significant with a probability value approaching almost zero. A result required to ensure the stability of the error – correction model. The negative coefficient of the error correction term (-1.2016) confirms the existence of long – term equilibrium relationship of the model. This also confirms the existence of a cointegration relationship among the variables of the ECM 6a. The coefficient of the exchange rate volatility for ECM 6b was -0.29462 affirming the negative relation between exchange rate volatility and GDP. This was equally significant statistically. The sign of the coefficient of the error correction term was negative (-2.3747) and significant confirming the existence of a long –term equilibrium

relationship of the model. For ECM 6c, the coefficient of the exchange rate volatility was still negative (-0.034485) which was significant at 5%. The sign of the error correction term was also negative (-1.3085) and significant at 1% thus confirming the existence of a long – term equilibrium relationship of the Model.

The coefficient of multiple determination ($R^2$) for ECM 6a had a value of 0.67, which is reasonable with first difference estimations (Randa, 1999). For ECM 6b, the $R^2$ was 0.74801 indicating that the data fits the Model quite well as population was proxied by labour force even with second difference of the variables. This is an improvement from ECM 6a. Also, $R^2$ for ECM 6c was 0.72913 showing the model fits the data quite well even though marginally it was lower than that of ECM 6b. Finally, none of the other diagnostic tests presented any particular problem concerning the properties of residuals for ECM 6a, ECM 6b and ECM 6c. The hypothesis of normality, absence of autocorrelation and no heteroscedasticity were accepted, while the hypothesis of functional form misspecification was rejected.

**4.4 Conclusion**

This chapter has analysed the regression results for the various models where labour force was proxied by both population and human development index and the error correction Models that resulted from each. It also looked at the graphical analysis of the data in both table and line graph formats.

# CHAPTER FIVE

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 5.0 Introduction

This chapter gives the major finding of the research and its policy implications, limitations to the work and recommendations.



### 5.1 Summary of Major Finding

The aim of this study was to assess the impact of exchange rate volatility on economic growth in the short and long – term in the Ghanaian economy during the 1983 – 2010 periods. The study also sorts to examine the trends in both exchange rate and economic growth performance for the years considered. After a careful analysis of the acquired data using Engle – Granger cointegration test, the following were the findings:

The study found that there is a link between instabilities in the foreign exchange market and economic growth vis-à-vis population/labour force/human development index, technology and gross domestic investment in both the short and long term. The study revealed a negative relationship between uncertainties in the exchange rate market and economic growth in long – term but this relationship was found to be insignificant. This confirms the insignificant role uncertainties in the exchange rate market plays in the economy since a volatile exchange rate is usually characterized by huge agitations from the public and with the political advantage likely to be gained by political opponents of the Government. The government does all it can to ensure stability in the exchange rate market as it happened in the early periods of 2009.

However, it was observed that in the short – term there exist a negative relationship between economic growth and uncertainties in the exchange rate market. Thus fluctuations in the exchange rate market significantly influence the behaviour of investors, firms and businesses in their investment decisions. This means that the behaviour of this variable must be taken into consideration while setting up and running monetary policy in the short - term. In such a context, an intervention policy intended to stabilize the exchange rate and reduce the level of risk of investing in the economy in various forms.



The study also revealed a positive relationship between population and economic growth and labour force and economic growth when labour force was used as a proxy for population. But in the error correction models with the second difference labour force still maintained it positive relationship with economic growth while population on first difference had an inverse relationship with economic growth.

### 5.2 Recommendations of the Study

Based on our findings, it is recommended that for a better growth performance, policy makers should put in place measures that will ensure stable macroeconomic environment since any disturbances in the macroeconomic environment may affect the growth performance of the economy. Therefore to attract investors (especially foreign direct investment) means that we should have stable exchange rate system.

A volatile exchange rate could raise strategic and managerial issues because it could lead to losses or gains. This may create uncertainty in investors as to invest or not to invest in the

market. Hence to boost investor confidence, there would be the need for policy maker's intervention in times of abnormal volatility. The volatile nature of the exchange rate market in the country also means that firms that import raw materials or market their product internationally need to make use of forward contracts in other to hedge their payables and receipts. This will enable them to lock in so as to go round the problem of exchange rate volatility.

It is also recommended that investors could take into consideration the nature of volatility in the exchange rate market and other macroeconomic variables in the economy to make an informed decision as to where to direct their investments so as to maximize their returns.

One major problem this research encountered was the availability of data from local sources like the Statistical Service and the Bank of Ghana. The lack of proper storage of data on common macroeconomic variables such as growth rates, exchange rate values, and labour force among others created a lot of problems and as such most of the data used had to come from international sources such as the World Bank and the International Monetary Fund (IMF). Also the issue of going to Accra for almost everything especially statistical data is problematic looking at the decentralization polices pursued over the years. Therefore this study recommends that to assist and encourage better research in the country there should be proper storage and availability of secondary data on all macroeconomic variables even in the district offices of the Statistical Service of Ghana.

## 5.3 Conclusion

The objective of the study was to measure the impact of exchange rate volatility on economic growth in Ghana both in short and long run. It was established that there is a link between exchange rate volatility and economic growth in Ghana both in the short and long term. The study established that there is a negative relationship between growth and exchange rate volatility and the result was significant in the short run but insignificant in the long run due government interventions.

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## APPENDIX A

Regression Results for Models 1, 2 and 3

**APPENDIX A1 Regression and Diagnostic Test for Model 1**

**Dependent Variable: LOG(GROWTH)**
Method: Least Squares
Date: 05/17/11 Time: 10:30
Sample (adjusted): 1984 2010
Included observations: 27 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -46.76308 | 20.70042 | -2.259040 | 0.0341 |
| LOG(POPULATION) | 2.987703 | 1.358830 | 2.198733 | 0.0387 |
| LOG(GDI) | 0.056593 | 0.144501 | 0.391643 | 0.6991 |
| LOG(TECH) | -0.906016 | 0.274259 | -3.303499 | 0.0032 |
| LOG(VEXCHR) | -0.015180 | 0.020704 | -0.733192 | 0.4712 |

| | | | |
|---|---|---|---|
| R-squared | 0.543059 | Mean dependent var | 1.599312 |
| Adjusted R-squared | 0.459978 | S.D. dependent var | 0.238179 |
| S.E. of regression | 0.175028 | Akaike info criterion | -0.482161 |
| Sum squared resid | 0.673968 | Schwarz criterion | -0.242192 |
| Log likelihood | 11.50918 | F-statistic | 6.536553 |
| Durbin-Watson stat | 2.407065 | Prob(F-statistic) | 0.001265 |

**APPENDIX A 2 Regression for Model 2**

**Dependent variable is LGDP**
**27 observations used for estimation from 1984 to 2010**

**********

| Regressor | Coefficient | Standard Error | T-Ratio [Prob.] |
|---|---|---|---|
| C | -27.8319 | 12.7615 | -2.1809 [0.040] |
| LTECH | -0.80371 | 0.23221 | -3.4612 [0.002] |
| LLAB | 1.9062 | 0.92010 | 2.0717 [0.050] |
| LGDI | 0.098122 | 0.13863 | 0.70782 [0.486] |
| LVEXCHR | -0.020230 | 0.019226 | -1.0522 [0.304] |

**********

| | | | |
|---|---|---|---|
| R-Squared | 0.53684 | R-Bar-Squared | 0.45263 |
| S.E. of Regression | 0.17622 | F-stat. | F (4, 22) 6.3749[.001] |
| Mean of Dependent Variable | 1.5993 | S.D. of Dependent Variable | 0.23818 |
| Residual Sum of Squares | 0.68314 | Equation Log-likelihood | 11.3267 |
| Akaike Info. Criterion | 6.3267 | Schwarz Bayesian Criterion | 3.0871 |

DW-statistic 2.3270

**********

## APPENDIX B

Regression and Diagnostic results for error correction Models for Models 1, 2 and 3

### APPENDIX B 1 Regression Results for ECM 1

**Dependent variable is DGDP**
**26 observations used for estimation from 1985 to 2010**

**********

| Regressor | Coefficient | Standard Error | T-Ratio | [Prob.] |
|---|---|---|---|---|
| C | 0 .14056 | 0.33957 | 0.41394 | [0.683] |
| DGDI | -0.10466 | 0.19335 | -0.54128 | [0.594] |
| DPOP | -1.3435 | 14.9587 | -0.089812 | [0.929] |
| DTECH | -1.1103 | 0.60427 | -1.8373 | [0.081] |
| DVEXCHR | -0.026192 | 0.014656 | -1.7871 | [0.089] |
| ECM | -1.2016 | 0.21600 | -5.5628 | [0.000] |

**********

| | | | |
|---|---|---|---|
| R-Squared | 0.67330 | R-Bar-Squared | 0 .59162 |
| S.E. of Regression | 0.17024 | F-stat. F (5, 20) | 8.2435[0.000] |
| Mean of Dependent Variable | -0.010768 | S.D. of Dependent Variable | 0.26639 |
| Residual Sum of Squares | 0.57962 | Equation Log-likelihood | 12.5528 |
| Akaike Info. Criterion | 6.5528 | Schwarz Bayesian Criterion | 2.7785 |
| DW-statistic | 1.9622 | | |

**********

### APPENDIX B 3 Regression Results for ECM 2

**Dependent variable is DDGDP**
**25 observations used for estimation from 1986 to 2010**

**********

| Regressor | Coefficient | Standard Error | T-Ratio | [Prob.] |
|---|---|---|---|---|
| C | 0.025985 | 0.061261 | 0.42418 | [0.676] |
| DDLAB | 35.4444 | 25.1752 | 1.4079 | [0.175] |
| DDGDI | 0.13229 | 0.21523 | 0.61463 | [0.546] |
| DDVEXCHR | -0.029462 | 0.016130 | -1.8265 | [0.084] |
| DDTECH | -1.2396 | 2.1168 | -0.58559 | [0.565] |
| ECM | -2.3747 | 0.33333 | -7.1242 | [0.000] |

**********

| | | | |
|---|---|---|---|
| R-Squared | 0.74801 | R-Bar-Squared | 0.68170 |
| S.E. of Regression | 0.25793 | F-stat. F (5, 19) | 11.2801[0.000] |

| | | | |
|---|---|---|---|
| Mean of Dependent Variable | 0.033870 | S.D. of Dependent Variable | 0.45717 |
| Residual Sum of Squares | 1.2640 | Equation Log-likelihood | 1.8339 |
| Akaike Info. Criterion | -4.1661 | Schwarz Bayesian Criterion | -7.8227 |
| DW-statistic | 1.4279 | | |

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## APPENDIX C

Augmented Dickey – Fuller and Phillips – Perron Unit Root Testing results for the variables (with only a constant and with both constant and trend)



**ADF Tests of Unit Roots at levels**

**1. Null Hypothesis: POPULATION has a unit root**

Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -0.461229 | 0.8838 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**2. Null Hypothesis: GROWTH has a unit root**

Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -2.090623 | 0.2497 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**3. Null Hypothesis: GDI has a unit root**

Exogenous: Constant

Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | 2.608150 | 1.0000 |
| Test critical values: | 1% level | -3.699871 | |
| | 5% level | -2.976263 | |
| | 10% level | -2.627420 | |

*MacKinnon (1996) one-sided p-values.



**4. Null Hypothesis: VEXCHR has a unit root**

Exogenous: Constant

Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -8.703295 | 0.0000 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**5. Null Hypothesis: LAB has a unit root**

Exogenous: Constant

Lag Length: 1 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -1.015098 | 0.7324 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**6. Unit root tests for variable LTECH**

The Dickey-Fuller regressions include an intercept but not a trend

**********

25 observations used in the estimation of all ADF regressions.

Sample period from 1986 to 2010

**********

| | Test Statistic | LL | AIC | SBC | HQC |
|---|---|---|---|---|---|
| DF | -16.9411 | 66.4308 | 64.4308 | 63.2119 | 64.0927 |
| ADF (1) | -14.0514 | 122.3294 | 119.3294 | 117.5010 | 118.8223 |
| ADF (2) | -13.5942 | 162.5787 | 158.5787 | 156.1410 | 157.9026 |

**********

95% critical value for the augmented Dickey-Fuller statistic = -2.9850
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

**With constant and trend**



**7. Null Hypothesis: GROWTH has a unit root**
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -10.67805 | 0.0000 |
| Test critical values: | 1% level | -4.339330 | |
| | 5% level | -3.587527 | |
| | 10% level | -3.229230 | |

*MacKinnon (1996) one-sided p-values.

**8. Null Hypothesis: POPULATION has a unit root**
Exogenous: Constant, Linear Trend
Lag Length: 6 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.473666 | 0.0013 |
| Test critical values: | 1% level | -4.467895 | |
| | 5% level | -3.644963 | |
| | 10% level | -3.261452 | |

*MacKinnon (1996) one-sided p-values.

**9. Null Hypothesis: GDI has a unit root**
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | t-Statistic | Prob.* |
|---|---|---|

| | | | |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -0.035390 | 0.9934 |
| Test critical values: | 1% level | -4.339330 | |
| | 5% level | -3.587527 | |
| | 10% level | -3.229230 | |

*MacKinnon (1996) one-sided p-values.

**10. Null Hypothesis: VEXCHR has a unit root**

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -7.689423 | 0.0000 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.

**11. Null Hypothesis: LAB has a unit root**

Exogenous: Constant, Linear Trend

Lag Length: 3 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.461128 | 0.0668 |
| Test critical values: | 1% level | -4.394309 | |
| | 5% level | -3.612199 | |
| | 10% level | -3.243079 | |

*MacKinnon (1996) one-sided p-values.

**12. Unit root tests for variable LTECH**

The Dickey-Fuller regressions include an intercept and a linear trend

**********

25 observations used in the estimation of all ADF regressions.

Sample period from 1986 to 2010

**********

| | Test Statistic | LL | AIC | SBC | HQC |
|---|---|---|---|---|---|
| DF | -26.7194 | 94.1488 | 91.1488 | 89.3205 | 90.6417 |
| ADF (1) | -20.0346 | 148.8560 | 144.8560 | 142.4182 | 144.1799 |

ADF (2) -18.6257 189.7441 184.7441 181.6969 183.8989

**********

95% critical value for the augmented Dickey-Fuller statistic = -3.6027
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

**FIRST DIFFERENCE OF ADF TESTS**

**With constant only**

**13. Null Hypothesis: D(POPULATION) has a unit root**
Exogenous: Constant
Lag Length: 6 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.924601 | 0.0001 |
| Test critical values: | 1% level | -3.808546 | |
| | 5% level | -3.020686 | |
| | 10% level | -2.650413 | |

*MacKinnon (1996) one-sided p-values.

**14. Null Hypothesis: D(GDI) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.933228 | 0.0059 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**15. Null Hypothesis: D(GROWTH) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -17.73348 | 0.0001 |
| Test critical values: | 1% level | -3.711457 | |

| | | |
|---|---|---|
| | 5% level | -2.981038 |
| | 10% level | -2.629906 |

*MacKinnon (1996) one-sided p-values.

**16. Null Hypothesis: D(VEXCHR) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -8.298557 | 0.0000 |
| Test critical values: | 1% level | -3.724070 | |
| | 5% level | -2.986225 | |
| | 10% level | -2.632604 | |

*MacKinnon (1996) one-sided p-values.

**17. Null Hypothesis: D(LAB) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -1.654065 | 0.4418 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**18. Unit root tests for variable DTECH**

The Dickey-Fuller regressions include an intercept but not a trend

**********

24 observations used in the estimation of all ADF regressions.
Sample period from 1987 to 2010

**********

| | Test Statistic | LL | AIC | SBC | HQC |
|---|---|---|---|---|---|
| DF | -21.9280 | 104.7551 | 102.7551 | 101.5771 | 102.4426 |
| ADF (1) | -17.1149 | 152.7454 | 149.7454 | 147.9783 | 149.2765 |
| ADF (2) | -16.1265 | 189.7049 | 185.7049 | 183.3488 | 185.0798 |

**********

95% critical value for the augmented Dickey-Fuller statistic = -2.9907
LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC= Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

**With constant and trend**

**19. Null Hypothesis: D(VEXCHR) has a unit root**

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -8.668967 | 0.0000 |
| Test critical values: | 1% level | -4.374307 | |
| | 5% level | -3.603202 | |
| | 10% level | -3.238054 | |

*MacKinnon (1996) one-sided p-values.

**20. Null Hypothesis: D(GDI) has a unit root**

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -5.361614 | 0.0010 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.

**21. Null Hypothesis: D(POPULATION) has a unit root**

Exogenous: Constant, Linear Trend

Lag Length: 6 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.420996 | 0.0768 |
| Test critical values: | 1% level | -4.498307 | |
| | 5% level | -3.658446 | |
| | 10% level | -3.268973 | |

*MacKinnon (1996) one-sided p-values.

**22. Null Hypothesis: D(GROWTH) has a unit root**

Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -16.93929 | 0.0000 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.



**23. Null Hypothesis: D(LAB) has a unit root**
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -0.286894 | 0.9866 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.

**24. Unit root tests for variable DTECH**

The Dickey-Fuller regressions include an intercept and a linear trend

**********

24 observations used in the estimation of all ADF regressions.
Sample period from 1987 to 2010

**********

| | Test Statistic | LL | AIC | SBC | HQC |
|---|---|---|---|---|---|
| DF | -32.8223 | 124.3431 | 121.3431 | 119.5760 | 120.8742 |
| ADF (1) | -24.0808 | 173.4745 | 169.4745 | 167.1184 | 168.8494 |
| ADF (2) | -21.9541 | 211.9352 | 206.9352 | 203.9900 | 206.1538 |

**********

95% critical value for the augmented Dickey-Fuller statistic = -3.6119
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

**SECOND DIFFERENCE ADF TEST FOR LABOUR FORCE**

**With constant**

**25. Null Hypothesis: D(LAB,2) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -3.800111 | 0.0084 |
| Test critical values: | 1% level | -3.724070 | |
| | 5% level | -2.986225 | |
| | 10% level | -2.632604 | |

*MacKinnon (1996) one-sided p-values.

**With constant and trend**

**26. Null Hypothesis: D(LAB,2) has a unit root**
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=6)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -4.229049 | 0.0137 |
| Test critical values: | 1% level | -4.374307 | |
| | 5% level | -3.603202 | |
| | 10% level | -3.238054 | |

*MacKinnon (1996) one-sided p-values.

**Phillips - Perron tests for unit roots in variables**

**With constant only**

**27. Null Hypothesis: POPULATION has a unit root**
Exogenous: Constant
Bandwidth: 2 (Newey-West using Bartlett kernel)

| | Adj. t-Stat | Prob.* |
|---|---|---|

| | | | |
|---|---|---|---|
| Phillips-Perron test statistic | | 3.355315 | 1.0000 |
| Test critical values: | 1% level | -3.699871 | |
| | 5% level | -2.976263 | |
| | 10% level | -2.627420 | |

*MacKinnon (1996) one-sided p-values.

**28. Null Hypothesis: VEXCHR has a unit root**
Exogenous: Constant
Bandwidth: 1 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -4.896307 | 0.0005 |
| Test critical values: | 1% level | -3.699871 | |
| | 5% level | -2.976263 | |
| | 10% level | -2.627420 | |

*MacKinnon (1996) one-sided p-values.

**29. Null Hypothesis: GDI__LCU_ has a unit root**
Exogenous: Constant
Bandwidth: 6 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | 4.041298 | 1.0000 |
| Test critical values: | 1% level | -3.699871 | |
| | 5% level | -2.976263 | |
| | 10% level | -2.627420 | |

*MacKinnon (1996) one-sided p-values.

**with constant and Trend**

**30. Null Hypothesis: GDP has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -8.220384 | 0.0000 |
| Test critical values: | 1% level | -4.339330 | |

| | | |
|---|---|---|
| | 5% level | -3.587527 |
| | 10% level | -3.229230 |

*MacKinnon (1996) one-sided p-values.

**31. Null Hypothesis: VEXCHR has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.048532 | 0.0020 |
| Test critical values: | 1% level | -4.339330 | |
| | 5% level | -3.587527 | |
| | 10% level | -3.229230 | |

*MacKinnon (1996) one-sided p-values.

**32. Null Hypothesis: GDI__LCU_ has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | 0.647763 | 0.9992 |
| Test critical values: | 1% level | -4.339330 | |
| | 5% level | -3.587527 | |
| | 10% level | -3.229230 | |

*MacKinnon (1996) one-sided p-values.

**33. Null Hypothesis: POPULATION has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -2.204970 | 0.4681 |
| Test critical values: | 1% level | -4.339330 | |
| | 5% level | -3.587527 | |
| | 10% level | -3.229230 | |

*MacKinnon (1996) one-sided p-values.

**FIRST DIFFERENCE PHILLIPS-PERRON UNIT ROOT TEST OF VARIABLES**

**34. Null Hypothesis: D(POPULATION) has a unit root**
Exogenous: Constant
Bandwidth: 1 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -1.349686 | 0.5907 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**35. Null Hypothesis: D(GDP) has a unit root**
Exogenous: Constant
Bandwidth: 4 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -26.24848 | 0.0001 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**36. Null Hypothesis: D(GDI__LCU_) has a unit root**
Exogenous: Constant
Bandwidth: 0 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -3.935372 | 0.0059 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.

**37. Null Hypothesis: D(VEXCHR) has a unit root**
Exogenous: Constant
Bandwidth: 0 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -12.11323 | 0.0000 |
| Test critical values: | 1% level | -3.711457 | |
| | 5% level | -2.981038 | |
| | 10% level | -2.629906 | |

*MacKinnon (1996) one-sided p-values.



**With constant and trend**

**38. Null Hypothesis: D(VEXCHR) has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 0 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -13.81442 | 0.0000 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.

**39. Null Hypothesis: D(GDI__LCU_) has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 5 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -5.654504 | 0.0005 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.

**40. Null Hypothesis: D(GDP) has a unit root**

Exogenous: Constant, Linear Trend
Bandwidth: 8 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -39.30788 | 0.0000 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.



**41. Null Hypothesis: D(POPULATION) has a unit root**
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West using Bartlett kernel)

| | | Adj. t-Stat | Prob.* |
|---|---|---|---|
| Phillips-Perron test statistic | | -0.760199 | 0.9568 |
| Test critical values: | 1% level | -4.356068 | |
| | 5% level | -3.595026 | |
| | 10% level | -3.233456 | |

*MacKinnon (1996) one-sided p-values.

**RESIDUAL BASED A (DF) TEST FOR MODEL 1**

**42. Unit root tests for variable RESIDUALS**

The Dickey-Fuller regressions include an intercept but not a trend

**********

24 observations used in the estimation of all ADF regressions.
Sample period from 1987 to 2010

**********

| | Test Statistic | LL | AIC | SBC | HQC |
|---|---|---|---|---|---|
| DF | -5.3127 | 9.4280 | 7.4280 | 6.2499 | 7.1154 |
| ADF (1) | -2.9606 | 9.7811 | 6.7811 | 5.0140 | 6.3123 |
| ADF (2) | -2.8696 | 10.1067 | 6.1067 | 3.7506 | 5.4816 |

**********

95% critical value for the augmented Dickey-Fuller statistic = -2.9907
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

**43. Unit root tests for variable RESIDUALS**

The Dickey-Fuller regressions include an intercept and a linear trend

**********

24 observations used in the estimation of all ADF regressions.
Sample period from 1987 to 2010

**********

| | Test Statistic | LL | AIC | SBC | HQC |
|---|---|---|---|---|---|
| DF | -5.1925 | 9.4393 | 6.4393 | 4.6722 | 5.9705 |
| ADF(1) | -2.8647 | 9.8231 | 5.8231 | 3.4670 | 5.1980 |
| ADF(2) | -2.7838 | 10.1558 | 5.1558 | 2.2107 | 4.3745 |

**********

95% critical value for the augmented Dickey-Fuller statistic = -3.6119
LL = Maximized log-likelihood AIC = Akaike Information Criterion
SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion



## APPENDIX D

Table 1: Real GDP equation: GDP = f(VEXCHR,GDI, LAB/POP, TECH, REXR)

| YEAR | GDI (LCU) | LAB | VEXCHR | GDP | TECH | POPULATION | REXR |
|---|---|---|---|---|---|---|---|
| 1983 | 34,300 | 4,744,183.7 | - | -4.6 | 1 | 12160724 | 0.003 |
| 1984 | 39,250 | 4,912,141.9 | 0.2132 | 8.6 | 2 | 12580615 | 0.0012 |
| 1985 | 48,166 | 5,090,616.5 | 0.0126 | 5.1 | 3 | 13005766 | 0.0018 |
| 1986 | 40,900 | 5,256,436.7 | 0.0205 | 5.2 | 4 | 13402394 | 0.0029 |
| 1987 | 40,273 | 5,426,755.7 | 0.0299 | 4.8 | 5 | 13786185 | 0.0050 |
| 1988 | 47,855 | 5,597,883.9 | 0.0032 | 5.6 | 6 | 14166109 | 0.0066 |
| 1989 | 57,970 | 5,775,325.9 | 0.0037 | 5.1 | 7 | 14556541 | 0.0088 |
| 1990 | 61,784 | 5,962,958.0 | 0.0003 | 3.3 | 8 | 14967509 | 0.0106 |
| 1991 | 74,019 | 6,170,246.5 | 0.0001 | 5.3 | 9 | 15401291 | 0.0120 |
| 1992 | 57,000 | 6,378,379.5 | 0.0002 | 3.9 | 10 | 15852831 | 0.0143 |
| 1993 | 58,140 | 6,630,761.9 | 0.0115 | 4.9 | 11 | 16316159 | 0.0212 |
| 1994 | 65,785 | 6,890,063.2 | 0.0108 | 3.3 | 12 | 16782487 | 0.0312 |
| 1995 | 54,030 | 7,154,239.2 | 0.0012 | 4.1 | 13 | 17245464 | 0.0391 |
| 1996 | 63,490 | 7,422,616.2 | 0.0051 | 4.6 | 14 | 17702991 | 0.0534 |
| 1997 | 74,779 | 7,695,830.5 | 0.0012 | 4.2 | 15 | 18157031 | 0.0669 |
| 1998 | 77,877 | 7,974,689.1 | 0.0001 | 4.7 | 16 | 18610166 | 0.0755 |
| 1999 | 75,705 | 8,260,518.0 | 0.0001 | 4.4 | 17 | 19066601 | 0.0871 |
| 2000 | 114,826 | 8,554,239.5 | 0.0564 | 3.7 | 18 | 19529305 | 0.1779 |
| 2001 | 197,480 | 8,808,936.4 | 0.0030 | 4.0 | 19 | 19999194 | 0.2339 |
| 2002 | 242,967 | 9,068,519.2 | 0.0004 | 4.5 | 20 | 20474921 | 0.2587 |
| 2003 | 193,152 | 9,331,979.4 | 0.0006 | 5.2 | 21 | 20954557 | 0.2830 |
| 2004 | 245,246 | 9,585,052.6 | 0.0023 | 4.6 | 22 | 21435257 | 0.2937 |
| 2005 | 273,898 | 9,852,131.1 | 0.0037 | 5.9 | 23 | 21915168 | 0.2959 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2006 | 314,834 | 10,120,319.9 | 0.0035 | 6.4 | 24 | 22393338 | 0.2992 |
| 2007 | 381,525 | 10,376,026.8 | 0.0030 | 6.5 | 25 | 22870966 | 0.3053 |
| 2008 | 409,401 | 10,647,454.2 | 0.00010 | 8.4 | 26 | 23350927 | 0.3454 |
| 2009 | 486,620 | 10,921,024.4 | 0.0049 | 4.7 | 27 | 23837261 | 0.3407 |
| 2010 | 510,505 | 11,130,230.6 | 0.1104 | 6.5 | 28 | 24233431 | 0.1836 |



Source: Ghana Statistical Service Statistical Report (various issues), Bank of Ghana Annual Report (various issues), World Bank data bank.

Definition of variables: GDP = Gross Domestic Product, REXR = Real Exchange Rate, GDI = Gross Domestic Investment, TECH = Technology, VEXCHR = Volatility of Exchange rate and POP = Population.