KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ARTS AND SOCIAL SCIENCES

DEPARTMENT OF ECONOMICS

THE EFFECT OF CRUDE OIL PRICE ON DOMESTIC INVESTMENT IN GHANA

BY

BENJAMIN AMARTEY

(PG3740215)

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DECLARATION

I hereby declare that this thesis is the result of my original effort towards the Master of Science degree in Economics. To the best of my knowledge, it is independent of materials published by any other person (s) or one that has been accepted for the award of any other degree of the University, except where due acknowledgements have been accorded in the text.

BENJAMIN AMARTEY (PG3740215)	…………………	………………
(STUDENT'S NAME)	SIGNATURE	DATE

CERTIFIED BY:

MR. J.D QUARTEY	…………………..	………………
(SUPERVISOR)	SIGNATURE	DATE

CERTIFIED BY:

DR. YUSIF M. HADRAT	……………………	………………
(INTERNAL EXAMINER)	SIGNATURE	DATE

CERTIFIED BY:

DR. YUSIF M. HADRAT	………………………	………………
(HEAD OF DEPARTMENT)	SIGNATURE	DATE

ABSTRACT

This study investigated the effect of crude oil price level and volatility on domestic investment by applying the Autoregressive Distributed Lag (ARDL) model to the time series from 1970 to 2014. The results indicate that oil price level has a positive and statistically significant impact on domestic investment in the short-term and long-term. Oil price volatility has a negative and significant impact on domestic investment in the short-run and long-run. The Ghana National Petroleum Corporation (GNPC) should employ price hedging techniques in order to reduce the volatility of oil price changes while the deregulation of the downstream petroleum sector should be strengthened to ensure optimal oil price determination. Also, there should be increase in government credible spending on capital projects and Research and Development (R&D) that would encourage the discovery of least cost energy sources and reduce dependence on crude oil.

DEDICATION

To my loving mother, Ms. Vida Abordo for her unflinching support and endurance throughout the course of this academic activity. Also to my late grandmother who was always a strong motivator.

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LIST OF ABBREVIATIONS

ARDL	Autoregressive Distributed Lag
ERP	Economic Recovery Programme
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
IMF	International Monetary Fund
MASD	Mean Average Standard Deviation
MEC	Marginal Efficiency of Capital
MEI	Marginal Efficiency of Investment
R&D	Research and Development
SAP	Structural adjustment Programme
WDI	World Development Indicators

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Investment represents change in physical capital stock including accumulation of factories, goods inventories and houses in a given time period. It is commonly defined in terms of the amount of fixed capital that is accumulated. Various theoretical foundations on growth and productivity support the idea that investment drives economic growth. For instance, The Classical, Neoclassical, Harrod-Dormar, Rostow-Ricardo, Keynesian and McKinnon-Shaw theories all documented that investment is a crucial driver of economic growth. Explaining the significance of investment, Michealides et al. (2005) cited in Wiafe et al. (2014), argued that investment enhances a country's ability to produce higher output, increases the level of employment and enhances the level of real disposable income.

Changes in domestic investment are traditionally assumed to be adequately explained by macroeconomic variables such as inflation rate, interest rate, exchange rate, trade openness, domestic savings, among other factors (Akpalu, 2002; Eshun et al., 2014). However, oil price as a potential determinant of domestic investment has not received the needed attention. Despite the underlining theoretical link between oil price uncertainty and domestic investment, the effect of oil price and oil price uncertainty on domestic investment is not extensively studied. The debate has centered more on magnitude and transmission channels (Antoshin, 2006; Abel & Eberly, 1994; Bloom & Bond, 2007) cited in Wiafe et al. (2014).

Among the macroeconomic factors that influence investment, crude oil prices are the most volatile. The exact effect it will have on a country's economy depends on whether the country is a net importer or exporter of crude oil and the country's ability to find alternative sources of energy. Crude oil or its derivatives is an important energy source for the economy hence fluctuations in the prices create uncertainty and this uncertainty causes delay in investment decisions since investors do not like uncertainty. Ghana has always imported crude oil and crude oil products to meet its energy demands. However, in recent times, due to the inability of the nation's refinery to refine crude oil, refined crude oil products such as gasoline, diesel, aviation fuel and kerosene are mainly imported. Since the discovery of crude oil in commercial quantities in 2007 and the subsequent production in December 2010, Ghana has become not only an importer of crude oil but an exporter as well. Over the years, gross domestic fixed capital formation GDP-ratio rose from 6.10% in 1980 to 9.53% in 1985 which further increased to 20.30% in 1996 and 28.38% in 2004.

Before 2005, regulatory regimes were used in Ghana which resulted in sporadic oil prices. The disproportionate nature of these prices generated a lot of debate among civil society, government, regulators, petroleum traders and association. The rippling effect of oil prices often compels government to introduce fuel subsidies which is perceived as pro-poor policy. Under this regime, consumers buy fuel at prices that are below its global market prices. As a way of ensuring price liberalization and reduction in government debts, Ghana followed Argentina, Australia, New Zealand and Canada and commenced gradual deregulation and strict monitoring of its downstream petroleum sector in 2005. Under this regime, optimal prices are determined by the interplay of market fundamentals. The argument is that it would ensure competition and reduce oil price shocks which could inure to the benefit of the economy. After the deregulation regime, gross domestic fixed capital formation-GDP ratio declined from 29.0% in 2005 to 24.66% in 2010. It increased to 31.13% in 2012 before falling to 26.24 in 2014 (World Development Indicators (WDI) Database, 2015 Edition).

Recent developments in oil markets and the global economy have provoked interest on the impact of oil price shocks on macroeconomic variables. Shocks to international oil prices are persistent as world oil price rose from $22.26 per barrel in 1988 to $36.05 per barrel in 2004. It recorded a further rise to $69.86 in 2007 and again to $77.38 in 2010. In 2012, oil price was markedly high at $109.45 per barrel before easing to $49.49 per barrel in 2015. The concern is that fluctuations in oil price are particularly bad for oil-importing countries (Korhonen and Juurikkala, 2007).

The extent to which oil price shocks affect economies of emerging and developing countries has received little attention, compared with the expanded body of literature in the advanced economies. In an attempt to broaden the debate on the impact of oil prices on domestic investment, this study documents in research the short-run and long-run impact of oil price volatility on domestic investment in Ghana as well as the effect of oil price changes. This will help generate reliable evidence needed to suggest ways of reducing the economy's exposure to oil price shocks.

1.2 Statement of Problem

Liberalization of the financial sector was adopted to enhance domestic saving, investment and economic growth. However, persistent shocks to oil prices since the 1980s seem to be associated with macroeconomic volatility thereby creating uncertainty about investment returns. This has provoked research on the effect of oil price shocks on macroeconomic variables. With regard to the effect of oil price volatility on gross domestic investment, there appears to be no consensus.

Whereas studies such as Bernanke (1983); Triantis and Hodder (1990), find that oil price uncertainty lowers aggregate level of investment, Jin (2008) concludes that oil price shocks have expansionary effect on net oil exporters (Russia) but contractionary effect on net oil importers (China and Japan).

Domestic investment (measured by gross domestic fixed capital formation-GDP ratio) rose from 6.10% in 1980 to 9.53% in 1985 and further increased to 20.30% in 1996. In 2005 it rose to 29.0% but declined to 24.66% in 2010. It later increased to 31.13% in 2012 before falling to 26.24% in 2014 (WDI Database, 2015 Edition).

The trends seem to suggest that crude oil price shocks have a connection with domestic investment. This makes it useful to critically analyze the effect of crude oil price and volatility on domestic investment in Ghana. A study by Wiafe et al. (2014) focused on the long-run dynamics of oil price shocks and domestic investment, neglecting the effect of oil price volatility on domestic investment. However, oil price volatility is an important source of macroeconomic uncertainty, which has serious implications on real aggregate economic activity. Also, the previous study only focused on the post-reform era (ie. from 1983) and did not consider the period before the reform era. Given the literature gap, this study investigates the effect of oil price level and volatility on domestic investment in Ghana.

1.3 Objectives of the Study

The general objective of the study is to investigate the effect of oil price on gross domestic fixed capital formation in Ghana. The specific objectives are;

1. To examine the short-run and long-run impact of oil price on domestic investment in Ghana
2. To examine the short-run and long-run impact of oil price volatility on domestic investment in Ghana

1.4 Hypotheses

The following hypotheses were tested;

1. H_0: Oil price has no significant impact on domestic investment in the short-run and long-run in Ghana

   H_1: Oil price has a significant impact on domestic investment in the short-run and long-run in Ghana
2. H_0: Oil price volatility has no significant impact on domestic investment in the short-run and long-run in Ghana

   H_1: Oil price volatility has a significant impact on domestic investment in the short-run and long-run in Ghana

1.5 Significance of the Study

Since the 1980s, macroeconomic policy in Ghana has exclusively focused on a comprehensive growth agenda through enhanced levels of domestic saving and investment. Oil price shocks are a crucial source of macroeconomic uncertainty, which has serious implications for domestic investment. It is imperative for policy makers to understand the mechanism through which oil price level and volatility affect domestic investment.

This calls for the need to conduct novel econometric investigation into the effect of oil price level and volatility on domestic investment, so as to generate reliable evidence capable of informing macroeconomic policy. Also, the findings of this study will add to the much needed literature on Ghana.

1.6 Scope of the Study

This study was based on the Ghanaian economy over a 45 year period i.e., 1970 to 2014. The sample size was informed by data availability. The choice of 1970 as start observation is because the early 1970s were associated with a highly volatile oil price. Gross domestic fixed capital formation is the dependent variable. The main exogenous variables are oil price level and oil price volatility.

1.7 Organization of the Study

The study consists of five chapters; Chapter One involves background to the study, statement of problem, objectives, hypotheses, scope, significance and organization of the study. Chapter Two constitutes review of theoretical and empirical literature on the effect of oil price on domestic investment. Chapter Three describes the methodology. It involves the data types and sources, the model specification and estimation technique. Chapter Four presents analysis of empirical results and discussion of findings. Finally, Chapter Five encompasses summary of major findings and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of relevant literature that relate to the effect of crude oil price on domestic investment. Crude oil and its derivatives have served as the main source of energy for industries for centuries and their importance have been well documented. Since crude oil plays a major direct or indirect role in the production of goods and services, its price levels and price fluctuations affect the economy. In the case of the Ghanaian economy, however, subsidies were introduced on refined crude oil products and this could have significant effects on the findings.

Fluctuations in oil price became a major concern in the early 1970s and since then oil price shocks have been persistent. Since the 1980s, international oil price fell from an annual average of $35.52 per barrel in 1980 to $13.3 in 1986. It recorded a rise from $22.26 per barrel in 1988 to about $36.05 per barrel in 2002 and further rose to $53 by the second quarter of 2004 (Philip and Akintaye, 2006). From 2000 to 2008, a six fold increase in oil price was observed as it hiked from $23 per barrel at the beginning of 2000 to a record high of $146 by mid-2008 before easing to $42 per barrel by the end of 2008. In 2009, the annual average of crude oil price rose to $60.86 per barrel (Hassan and Zahid, 2011) and it fluctuated between $77.36 and $109.45 per barrel from 2010 to 2012.

This chapter is organized into two sections namely; theoretical and empirical review sections. The theoretical review involves a review of investment theories while the empirical review section examines empirical studies on the effect of crude oil price on domestic investment.

2.1 Theoretical Review

The following are some relevant investment theories which include; The Keynesian theory, Jorgenson neoclassical theory, the accelerator principle, Tobins's q-theory and the financial theory of investment and are discussed below;

2.1.1 The Keynesian Theory of Investment

Keynes (1936) argues that investment decisions hinge on the relationship between the Marginal Efficiency of Capital (MEC) and the real rate of interest (r^{π}). This contrasts the classical paradigm which holds that business investment is determined by three fundamental factors which include; cost of capital, rate of return on capital and expectations. According to the Keynesians, the effect of interest rate on investment is shallow. The MEC is defined as the rate of return on an additional dollar worth of investment which is given by;

$$C_0 = \frac{R_1}{(1+e)} + \frac{R_2}{(1+e)^2} + ...+ \frac{R_n}{(1+e)^n} \qquad 2.1$$

Where C_0 denotes the initial purchase price of a capital good (machine) in the base year, R_i are the prospective rate of return on new investment and $e = MEC$, which serves as the discount or balancing factor.

The criterion for investing in new plant, equipment or machinery is the condition that (MEC greater than r^{π}). With increasing units of capital employed, MEC falls due to diminishing marginal product of capital, and this continues up to the point where $MEC = r^{\pi}$. The reason is that firms focus initial investments on the most productive opportunities and earn high return rates; subsequently, investments become less productive and yield progressively lower returns. At this point, new investment on income-earning assets ceases (Eklund, 2013). However, if there is a change in the supply price of capital equipment, then it becomes relevant to distinguish between MEC and Marginal Efficiency of Investment (MEI).

The Monetarists argue that the Keynesian theory is deficient because it does not explain how the MEC is determined. They also argued that the role of interest rate in determining investment is not limited contrary to Keynes (1936). Even small changes in interest rate can have magical impact on investment. So the neo-classical group of economists discarded this theory because it was thought to be unrealistic.

2.1.2 Jorgenson's Neoclassical Theory of Investment

Jorgenson's model is a theory of investment behavior which is framed based on the neoclassical optimal capital accumulation theory. According to Jorgenson (1963), most works on the investment function have ignored substitution parameters such as the relative price of output and capital. He does not dispute that demand for capital stock is determined by output, however, it is also dependent on the relative price of output and capital. What Jorgenson seeks to establish is the price effect in investment, using distinct proxies for the implicit rental or 'shadow price' of a unit of capital service (Eisner and Nadiri, 1968). The theory assumes that variable prices are flexible and factor substitution equals one.

In the original Jorgenson formulation, gross investment is set to be a function of the price of capital goods, rate of interest, rate of depreciation of capital, rental cost of capital, the relative rate of change of prices of capital goods and capital gains (Hickman, 1965). Jorgenson assumes a Cobb-Douglas production function in which he stated that the desired amount of capital stock (K^*) is given by;

$$K^* = a\frac{pQ}{c} \qquad 2.2$$

$$I = a\frac{pQ}{c} = K^*_{(t-\tau)} \qquad 2.3$$

Where a represents output elasticity with respect to capital units, p is the price of output, Q is the amount of output produced and c the rental price of capital (Hickman, 1965). It is expected that period t capital stock will adjust to period t desired stock of capital and if we incorporate a distributed lag structure where actual net investment responds to changes in desired capital stock, the Jorgenson's neoclassical investment function is given by:

$$\lambda(\rho)(I_t - \delta K_t) = \omega(\rho)(K_t^* - K^*_{t-1}) \qquad 2.4$$

Where $\rho =$ lag operator, $I_t =$ gross capital expenditure at period t, $\delta =$ constant depreciation rate of capital stock, and $K_t =$ capital stock at the start of period t. Therefore, the actual net change in the stock of capital over the period t can be derived as:

$$I_t - \delta K_t = K_{t+1} - K_t = v(\rho)(K^*_t - K^*_{t-1}) \qquad 2.5$$

Combining equations 2.3 and 2.4, we obtain what Jorgenson refers to as the "general Pascal distributed lag function" (Eisner, 1968).

A critical review of the Jorgenson's investment theory reveals that if capital is assumed to adjust instantaneously and fully to the optimal capital stock, the investment function essentially disappears, implying that the Jorgenson's theory is indeed a capital theory (Eisner, 1968). Also, following from the derivation, factors such as borrowing cost, fiscal instruments, energy price shocks, exchange rates, among others, can fit in as potential determinants of domestic investment because they influence the relative prices of capital.

2.1.3 Accelerator Theory

Clark (1917) was the first to suggest the accelerator principle, which is merely a special case of the neo-classical theory of investment. In this theory, a priori constraint is set where factor prices are reduced to constants and due to the assumption of fixed prices, it is commonly associated with the Keynesian approach (Eklund, 2013). If it is assumed that output price is constant and the prices of variables s and r in Jorgenson's (1963) user cost of capital function fixed, factor substitution is zero and the desired capital stock reduces to:

$$K^* = aQ \qquad 2.6$$

This is what is popularly referred to as the simplest or rigid version of the accelerator principle where the desired stock of capital is assumed to be proportionally related to output. The rigid accelerator principle implies that investment is a function of output growth only and operates on the assumption that desired capital stock is achieved in each time period:

$$I = a\frac{\delta Q}{\delta t} \qquad 2.7$$

The rigid accelerator principle assumes instantaneous and complete capital stock adjustment, and ignores the role of expectations, profits, financial and other factors in the determination of investment. This makes its empirical application problematic. As a result, it has over the years been reformulated into an alternative theory known as the so-called flexible accelerator principle (see Koyck, 1954; Lucas, 1967). It is flexible because investment is allowed to vary with relevant factors, including those that relate to expectations and market imperfections. A significant feature of the flexible version of the accelerator principle is that adjustment to the desired level of capital stock is not immediate.

Most investment theories incorporate cost of capital as a significant determinant of period t investment. However, it is often argued that the accelerator model does not provide a solid theoretical foundation because it assumes investment to be independent of the cost of capital (Farimani et al., 1998; Mickiewczz et al, 2004). The implication is that macroeconomic factors that directly influence cost of capital can be said to not have any connection with investment.

2.1.4 Tobin's q-Theory of Investment

Critiques of the Neoclassical and accelerator theories raise two issues. First, the two theories share a common assumption that capital stock equals desired capital stock in each period implying that capital stock adjusts instantaneously and fully to desired capital stock. Second, uncertainty plays no role in the neoclassical theory. To address these issues, the q-theory of investment was proposed by Brainard and Tobin (1968) and Tobin (1969) where adjustment cost function is introduced into the optimization problem (Lucas, 1967; Gould, 1968). The Tobin's q-theory is an extension of the neoclassical investment theory which incorporates the assumption that investment is made up to the point where the market value of assets equates replacement cost of capital. Furthermore, the addition of marginal adjustment cost to the profit function makes the neo-classical theory logically equivalent to the q-theory.

Essentially, the addition of adjustment costs is a form of restriction on the speed of adjustment of capital stock. The q theory expresses investment as an implicit function of q_m:

$$I = \theta(q_m) \qquad 2.8$$

Where q_m = the marginal return on capital relative to the opportunity cost of capital. Thus Tobin's q can be espoused to denote ratio of the market value of installed capital to its replacement cost. This means that investment is worthwhile as long as q_m is greater than 1. That is, firms have an incentive to expand the stock of capital because installed capital that produces goods and services is priced higher than its cost. $q_m = 1$ will imply the absence of profitable investment opportunities as period t capital stock equals period t desired capital stock.

The q-theory suggests that firms should finance new investment expenditures through issuance of share capital. The implication is that two major factors influence investment; wealth of the investor and the real return on other financial assets as bonds or real estate. It means that interest rate plays a major role in the determination of investment demand. The relationship between interest rate and share prices is negative and so, a rise in interest rate will depress q and lead to a lower desired capital stock.

2.1.5 The Financial Theory of Investment

Traditional macro models as accelerator and Tobin's q do not emphasize the role of financial factors in investment decisions. Duesenberry (1958) developed the financial theory or cost of capital theory of investment to explain the role of cost of capital in investment decisions by firms. He sought to establish that internal and external funds are important sources of investment financing. The theory strictly assumes that the prevailing market rate of interest represents the cost of capital to the investor which does not vary with the amount of investment. This implies that the firm has access to unlimited funds at the market rate of interest i.e., there exists elastic supply of funds to the firm in the market. There is thus a positive relationship between the cost of funds and the demand for funds. As more funds are demanded to finance investment, the market rate of interest increases.

A major shortfall of this model is the assumption that investment demand is solely influenced by cost of capital. Other factors such as capacity expansion, fiscal policy and depreciation allowance play a significant role in investment decisions. According to Meyer and Kuh (1957), capacity expansion is the most important determinant of investment during periods of boom while lower corporate taxes and changes in depreciation allowance have the tendency of driving investment higher during periods of economic recession.

It is worthy of note that the above theories were formulated with clear focus on the characteristics of advanced industrialized economies. This seems to suggest that the application of these theories to developing economies will be challenging. Particularly, the presence of imperfect competition and repressed financial markets in developing economies make investment unattractive in these countries (Asante, 2000). Also, notable is the difference in institutional and organizational arrangements between the so-called developing and advanced industrialized economies. There is the need to augment the theoretical framework of these theories to make them applicable to developing economies.

In conclusion, the neoclassical theory, acceleratory principle and Tobin's q-theory appear to offer an explanation to the effect that exogenous shocks as oil price uncertainty dampen economic activity. They posit that investment responds negatively to oil price uncertainty under conditions of irreversible investment decisions and the capacity to postpone investment by comparing value of waiting and cost of waiting. In their theoretical expositions, (Bernanke, 1983; Dixit and Pindyck, 1994) established that general uncertainty depresses investment. A contrasting view however, was espoused by Abel (1983) who demonstrated that uncertainty is not necessarily evil as it boosts firms' real investment by raising the marginal efficiency of capital goods. These theoretical contradictions have resulted in a great deal of empirical studies on oil price uncertainty and investment behavior.

2.2 Empirical Review

Questions bordering the effect of energy price shocks on economic activity are fundamental empirical issues in macroeconomics. Specifically, oil price and its volatility cause rising uncertainty levels in the domestic economy, and macroeconomic uncertainty is a robust determinant of investment decisions. This section reviews empirical studies that relate to the effect of oil price on domestic investment.

First and foremost, in examining the effect of oil price shock on real GDP growth in some OECD countries, Jimenez-Rodriguez and Sanchez (2005) cited in Riman et al., (2014) made a distinction between economies which are net oil importers and those that are net oil exporters. They employed the vector auto-regressive (VAR) model with four different specifications (one linear and three leading non-linear specifications) to investigate the relationship between oil prices and GDP growth. They found in their alternative estimations that the effect of oil price on real economic activity is both linear and non-linear in nature. While the results showed that oil price has a contrasting effect for net oil exporters (possibly due to sharper real exchange rate appreciation), they are consistent with the expectation that oil price has a negative impact on real economic growth in oil importing economies. The inference that is made is that oil price hikes lower economic growth in net oil importing countries because of the dampening effect on domestic investment. However, by applying the optimal order of the model (i.e., four lags), the results indicate that oil prices relate positively to real economic activity in oil importing economies.

Secondly, a study by Korhonen and Juurikkala (2007) investigated the asymmetric effects of oil price shocks on economic growth of oil exporting countries. They found that oil price shocks have asymmetric effects on economic growth of net oil exporters, though it was established that the unfavorable effects of higher oil prices are greater than the stimulating effects of lower oil prices. It was further revealed that transmission of the effects of oil price shocks on economic activity is different for net oil exporters and importers. Finally, it was concluded that lower oil prices in oil exporting developing economies would trigger revenue cuts and stagnation in economic activity. This indicates reduced capacity to mobilize domestic funds to expand capital formation. However, rising oil prices and the resultant higher oil revenues in oil exporting developing countries do not translate into enhanced domestic investment and sustained economic growth.

Also, Riman et al., (2014) investigated the asymmetric effect of oil price shocks on exchange rate and domestic investment in a country case study of Nigeria over the period 1970 to 2010. By employing the reduced form unrestricted VAR model, they found that the response of private and public investments to oil price shocks is negative in the short-run, confirming the evidence of "Dutch disease". For a country like Nigeria that exports oil in commercial quantities, persistent crude oil price shocks result in volatile benchmark oil revenues. Thus the negative response of domestic investment to crude oil price was attributed to the country's overdependence on windfalls from oil revenue.

Furthermore, (Henry, 1974; Bernanke, 1983) cited in Elder et al. (2009) estimated the impact of energy price uncertainty on the optimizing behavior of firms. In their estimation, they established that energy price uncertainty would induce optimizing firms to delay irreversible investments, as long as the expected value of extra information exceeds the expected short-run return on current investment.

Bernanke (1983) examined the effect of oil price uncertainty on aggregate investment for selected oil-importing countries. The findings of the study suggest that the effect of a sharp decline in oil prices for oil-importing economies may not necessarily be expansionary in the short-run, given that fluctuations in oil prices are associated with uncertainty about general prices. This indicates that an increase or a decrease in oil price results in macroeconomic uncertainty, thereby causing investment to stagnate. Hence, the total effect of an oil price shock is reduction in aggregate investment as a result of rising macroeconomic volatility in the domestic economy.

Wiafe et al. (2014) examined the effect of oil price shocks on domestic investment in Ghana over the period 1984 to 2012, using quarterly series. By employing the Dynamic Ordinary Least Squares (DOLS) estimation technique, the study found that oil price shocks negatively affect domestic investment in the long-run. This indicates that shocks to oil prices cause decline in domestic investment. The GARCH (1, 1) model was used to predict volatility proxies i.e., conditional variance of non-seasonally adjusted oil price quarterly series.

In examining the effect of oil price shocks on aggregate economic activity in Nigeria, Frankel (2012) applied the VAR model to quarterly time series over the period 1970 to 2003. Their finding showed that oil prices did not have significant impact on inflation and output growth. They however found that oil prices significantly and substantially influenced exchange rate. The conclusion drawn from the study is that positive oil price shocks create wealth effects which results in exchange rate appreciation and increased demand for non-tradable goods. This phenomenon would have a reducing effect on trade balance, domestic investment and hence domestic output.

Jawad (2013) analyzed the impact of oil price volatility on Gross domestic production in Pakistan from 1973 to 2011. By using linear regression analysis, he found that oil price volatility has insignificant effect on domestic production.

In 2010, Elder and Serletis examined the impact of oil price uncertainty on investment, consumer durable and aggregate output in the United States. Their finding suggests that oil price uncertainty has a depressing effect on investment in the U.S. Perhaps, this is so because U.S is a net oil importer making its macroeconomic base highly susceptible to oil price shocks and volatility.

Finally, by employing the SVAR strategy, Ahmed and Wadud (2011) investigated the relationship between oil price volatility and investment in Thailand. They applied a threshold based component generalized autoregressive conditional heteroscedasticity (TGARCH) model to decompose oil price into permanent and transitory volatilities. They found that oil price volatility has dampening effects on both aggregate and sectorial level of investments in Thailand.

To conclude, despite the existence of a significant amount of empirical literature on country case study of the effect of oil price and oil price volatility on economic growth, there is absolute dearth of studies that explored short-run and long-run dynamics of oil price and investment. Most studies in the existing literature applied linear regression, VAR and SVAR models which are only short-run compatible. This study employed the ARDL model because it is efficient in resolving biases of dynamic nature.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter describes the empirical model, types and sources of data used in the analysis, statistical tests conducted and the estimation strategy.

Secondary data were used for the time series analysis. The dataset included annual time series on crude oil price and gross domestic fixed capital formation-GDP ratio over the period 1970 to 2014. Conditional variance series were constructed as proxy for crude oil volatility. Except the crude oil price data which were sourced from the US Federal Reserve website, data on all other variables were sourced from WDI and International Financial statistics (IFS).

By way of estimation technique, the autoregressive distributed lag (ARDL) bounds testing approach to co-integration was used to examine the short-run and long-run impact of oil price level and volatility on gross domestic fixed capital formation. This method was preferred because it resolves the issue of potential endogeneity bias among the regressors. The GARCH (1, 1) model was fitted to non-seasonally adjusted crude oil price series to obtain conditional variance proxies.

3.1 Model Specification

The study anchored its theoretical framework on the Jorgenson's neoclassical theory of investment. According to the Jorgenson's model, the demand for capital stock is determined by the amount of output produced and the relative price of both output and capital. Jorgenson assumes a generalized Cobb-Douglas function where the desired stock of capital (K^*) is given by;

$$K^* = \alpha \frac{PQ}{c} \qquad 3.1$$

Where a represents output elasticity with respect to capital units, p is the price of output, Q is the amount of output produced and c the rental price of capital (Hickman, 1965). Following the above mentioned theory, the study adopts the following model;

$$GDFCF_t = f(D_t, RGDPP_t, INF_t) \qquad 3.2$$

Where GDFCF, RGDPP and INF represent amount of domestic investment or capital stock, domestic output or income and domestic price index respectively. D is a used to denote total factor productivity (TFP) i.e. it captures the proportion of domestic investment that is unaccounted for by changes in domestic income or domestic price level. For the purpose of this study,

$$D_t = f(OP_t, DCPS_t, DR_t) \qquad 3.3$$

Where OP denotes oil price and oil price volatility in turns, DCPS is domestic credit to private sector (% of GDP) and DR is the deposit rate. Since the study sought to investigate the effect of oil price and oil price volatility on domestic investment, two distinct single linear equation models were specified. Following Wiafe et al. (2014), the empirical models are given by;

Model I

$$GDFCF_t = f(OP_t, RGDPP_t, DCPS_t, DR_t, INF_t) \qquad 3.4$$

The specific operational model in semi-log form is given by;

$$\ln GDFCF_t = \alpha_0 + \alpha_1 \ln OP_t + \alpha_2 \ln RGDPP_t + \alpha_3 \ln DCPS_t + \alpha_4 DR_t + \alpha_5 INF_t + \varepsilon_t \qquad 3.4^*$$

Where ε_t is the error term; α_i (for i = 1, 2…6) are parameter estimates; DR is the deposit interest rate; INF_t is Inflation level; $\ln RGDPP$ is log of real GDP per capita; $\ln DCPS_t$ is log of domestic credit to private sector (% of GDP); $\ln OP$ is log of oil price and $\ln GDFCF_t$ is log of gross domestic fixed capital formation (% of GDP).

Model II

$$GDFCF_t = f(OPV_t, RGDPP_t, DCPS_t, DR_t, INF_t) \qquad 3.5$$

The specific operational model in semi-log form is given by;

$$\ln GDFCF_t = b_0 + b_1 \ln OPV_t + b_2 \ln RGDPP_t + b_3 \ln DCPS_t + b_4 DR_t + b_5 INF_t + \eta_t \qquad 3.5^*$$

Where η_t is the error term; b_i (for i = 1, 2…6) are parameter estimates; $\ln OPV$ is log of oil price volatility.

3.2 Sources of Data

The analysis was done using secondary data from 1970 to 2014 which comprises 45 annual observations for each variable. The crude oil price data was sourced from the US Federal Reserve website to capture the world crude oil price. Data on all the other variables except deposit interest rate, were obtained from WDI Database (2015 Edition). Deposit interest rate series were also sourced from International Monetary Fund (IMF), International Financial Statistics (IFS).

3.3 Description of Variables

In this section, the study provides a description of both the dependent and exogenous variables.

3.3.1 Dependent Variable (Domestic Investment)

The study adopts domestic investment as the dependent variable. According to Anyanwu (1997), investment is a flow which connotes either addition to existing capital stock or acquisition of new capital assets. Although domestic investment is a smaller component of aggregate demand than consumption, it is a major source of short time changes in aggregate demand and so very vital in the Keynesian debate. According to the Keynesian, neoclassical and financial theories of investment, investment behavior depends on an array of macroeconomic variables including; output price, the level of income, the cost of capital, interest rate, exogenous shocks, financial sector development, among others. Some empirical studies have also identified a plethora of factors including economic growth rate, exchange rate, inflation, export, interest rate and other macroeconomic variables (Asante, 2000; Akpalu, 2002; Sioum, 2002; Bayai & Nyangara, 2013; Eshun, Adu & Boabeng, 2014; Ayeni, 2014) cited in Wiafe et al. (2014). The study proxy's domestic investment using gross domestic fixed capital formation-GDP ratio. In this study, $GDFCF$ represents domestic investment.

3.3.2 Independent Variables

Two key independent variables used in the study are oil price level and oil price volatility. Other variables such as deposit interest rate, inflation level, real GDP per capita growth and domestic credit to private sector-GDP ratio enter as control variables.

Crude Oil Price Level (OP)

Following Wiafe et al. (2014), this study used crude oil price as an independent variable. Crude oil price affects domestic investment because it is associated with macroeconomic volatility. So, oil price shocks directly influence variables such as inflation, output growth, exchange rate, capital cost, among others. In this study, oil price is measured as the US dollar price of a barrel of benchmark crude oil. Previous studies by Riman et al. (2014); Wiafe et al. (2014) support the existence of a negative relationship between oil price and domestic investment. In this study, oil price is expected to have a negative impact on domestic investment. In the model, the symbol that describes oil price is ‘ OP ’.

Crude Oil Price Volatility (OP_v)

In estimating the effect of crude oil price dynamics on domestic investment in Pakistan, Jawad (2013) used crude oil price volatility as an independent variable. This study also uses crude oil price volatility as a key exogenous variable. Oil price volatility signifies uncertainty about or variability in a certain measure of crude oil price. Volatile oil price affects domestic investment because it creates uncertainty about future return on both short-term and long-term investments. Volatility is commonly measured using moving average standard deviation (MASD) or conditional variance of level. This study measures crude oil price volatility using conditional variance proxies, constructed by fitting the GARCH (1, 1) model to seasonally unadjusted crude oil price series.

Studies such as (Elder and Serletis, 2010; Jawad, 2013) found that oil price uncertainty affects domestic investment negatively. However, there is a theoretical demonstration by Abel (1983) that oil price uncertainty boosts firms’ real investment by raising the marginal efficiency of capital goods. In this study, oil price volatility is expected to have a negative effect on domestic investment. The symbol used to represent oil price volatility is (OP_v).

Deposit Interest Rate (DR)

Following Wiafe et al. (2014), interest rate enters the model as a control variable. The financial theory of investment predicts that interest rates have an effect on the amount of internal and external funds made available, which in turn influences the amount of investment. The interest rate used in this study is the deposit interest rate. It is expected that the deposit rate will relate negatively in the short-run and positively in the long-run to domestic investment. The symbol used for deposit interest rate is (DR).

Inflation Level (INF)

This study follows Wiafe et al. (2014) and includes inflation level as a control variable in evaluating the effect of crude oil prices on domestic investment. Inflation level affects domestic investment through its effect on variables such as interest rates, savings and consumption. This study interprets inflation level as annual percentage change in domestic prices. Based on the neoclassical investment theory, it is expected a priori that inflation level will negatively impact domestic investment. In the empirical model, inflation level is represented by INF.

Real GDP Per Capita Growth ($LnRGDPP$)

Following Frinmpong and Marbuah (2010), real GDP per capita growth was adopted as a control variable. Gross Domestic Product (GDP) is the total output of goods produced by all economic agents in an economy over a given period. A rise in GDP signifies economic growth and translates as increase in productivity. Tobin's q-theory predicts that growth in domestic output or income is proportionally related to domestic investment. In estimating the effect of output growth on domestic investment, the study measured output growth as percentage change in real per capita GDP overtime. Real GDP is nominal GDP adjusted for effects of inflation. The former was preferred because the latter is susceptible to significant variations. The proxy used for real GDP per capita growth is natural log of real GDP per capita. This study expects real GDP per capita growth to have a positive relationship with domestic investment. The symbol used to represent real GDP per capita growth in the model is (*RGDPP*).

Financial Development (***DCPS*** **)**

Financial deepening was also incorporated as a control variable. Financial deepening connotes marked reduction in liquidity constraints in the economy. One crucial indicator of financial deepening is the amount of financial resources made available by financial institutions to domestic and foreign investors. In this study, financial sector development was proxied by domestic credit to private sector-GDP ratio. Following the financial theory of investment, domestic credit to private sector is expected to have a positive impact on domestic investment. In the model, DCPS is the variable used to represent domestic credit to private sector-GDP ratio.

Table 3.1: Description of Variables

Variable	Description	A Priori Sign
Dependent		
GDFCF	Represents domestic investment which was measured as gross fixed capital formation-GDP ratio	
Independent		
OP	Represents oil price which was measured as the price of a barrel of benchmark crude oil	Negative (-)
OP_v	Represents oil price volatility which was measured as conditional variance of oil price	Negative (-)
DR	Represents domestic interest rate measured as real deposit rate	Negative (-/+)
INF	Represents inflation level which is measured as annual percentage change in CPI	Negative (-)
RGDPP	Represents real GDP per capita growth which is proxied by natural log of real GDP per capita	Positive (+)
DCPS	Represents financial sector development which is measured as domestic credit to private sector-GDP ratio	Positive (+)

Source: Author's Construct

Measurement of Oil Price Volatility

A crucial issue in investigating the effect of oil price volatility on domestic investment is the choice of suitable proxy for oil price volatility. Volatility is commonly estimated using mean average standard deviation (MASD), however, few other studies used conditional variance as proxy. In this study, volatility was measured by fitting the GARCH (1, 1) model to seasonally unadjusted oil price series to construct conditional variance series. The unrestricted specification GARCH (p, q) model captures lag variables with higher order up to (p, q). The commonly used GARCH (1, 1) model is specified as:

$$H_t = \beta_0 + \beta_1 \varepsilon^2_{t-1} + \beta_2 H_{t-1}$$

3.3

The equation states that conditional variance is a union of squared lag residuals and the lag conditional variance itself (Kumo, 2006; Bollerslev and Mikkelsen, 1996) cited in Kumo (2015). In the formulation, ε_t is the stochastic disturbance term and H_t is the conditional variance of the disturbance term. The GARCH (1, 1) model was adopted because; (i) it aids to deal with the problem of endogeneity as conditional variance is allowed to depend on previous own lag; (ii) it produces consistent and reliable estimates with few parameters; and (iii) it is suitable for finite-sized samples as higher order ARCH leads to possible loss of degree of freedom.

3.4 Statistical Tests

Preliminary statistical tests that were conducted include unit root, model diagnostic and model stability tests.

3.4.1 Unit Root Tests

In undertaking time series estimations, the stationarity or otherwise of the data is very crucial. The reason is that estimation of models with non-stationary data could result in spurious regression (Hendry et al., 1988). To establish the order of integration of the dependent and independent variables, the DF-GLS and Philip Peron unit root tests were employed. The unit root tests were applied to test the null hypothesis of the existence of unit roots against the alternative hypothesis of no unit roots. Series that are stationary at levels are said to be integrated of order zero while those that are stationary at first difference are integrated of order one.

According to Taylor (2005), Wald test is appropriate for testing unit root in volatility process. This study used the Wald test to examine the stationarity of conditional variance by testing the null hypothesis of existence of unit root against its alternative of stationary volatility process. For GARCH (1, 1) model, the null hypothesis is stated as $H_0 : \beta_1 + \beta_2 = \theta = 1$, where θ is the persistence parameter. If the restriction $H_0 : \beta_1 + \beta_2 = \theta = 1$ holds, then the GARCH (1, 1) model is said to be strictly covariance stationary.

3.4.2 Model Diagnostic and Stability Tests

Diagnostic tests that were undertaken to check model reliability include multivariate normality, LM White (Heteroskedasticity) and Breusch-Godfrey (Serial Correlation). A model is said to be reliable if the residual diagnostic tests have statistically insignificant F-statistic. The stability of the model was also examined using recursive estimates such as CUSUM and CUSUM of square tests. To ensure a correctly specified model the Ramsey reset test was used to test the functional form of the model.

3.5 Estimation Technique

Previous studies have employed varied approaches to examine the effect of crude oil prices on domestic investment. Riman et al. (2014) used the unrestricted VAR model to examine the asymmetric effect of oil price shocks on exchange rate and domestic investment in a country case study of Nigeria over the period 1970 to 2010. Also, Wiafe et al. (2014) examined the effect of oil price shocks on domestic investment in Ghana over the period 1984 to 2012 by using the Dynamic Ordinary Least Squares (DOLS) technique.

This study employs the use of ARDL framework to explore the short-run and long-run dynamics of oil price and domestic investment in Ghana. ARDL model was preferred because; (i) it is capable of estimating time series regardless of whether the underlying series are purely I (0) or purely I (1) or both and (ii) it yields robust estimates for finite-sized samples and resolves the problem of regressor endogeneity (Lawson and Pesaran, 2009).

In the estimation of time series using ARDL, three key steps are observed, namely, test for unit root, test for co-integration and estimation of short-run and long-run relationships.

3.5.1 The Error-Correction Model (ECM)

According to Engel and Granger (2001), if there is co-integration among time series, it means that forces exist that tend to ensure convergence to long-run equilibrium from past period's disequilibrium. The process of restoring equilibrium entails a short-run dynamic adjustment process which is simplified by an error – correction specification. Equations 3.7 and 3.8 represent the ECM for I and II respectively;

$$\Delta GDFCF_t = \eta_0 + \sum_{i=0}^{q} \tau \Delta GDFCF_{t-i} + \sum_{i=1}^{q} \delta \Delta OP_{t-i} + \sum_{i=1}^{q} \rho \Delta Q_{t-i} + \alpha_1 GDFCF_{t-1} + \alpha_2 OP_{t-1} + \alpha_3 Q_{t-1} + \varepsilon_t \qquad 3.7$$

$$\Delta GDFCF_t = \tau_0 + \sum_{i=0}^{q} A \Delta GDFCF_{t-i} + \sum_{i=1}^{q} B \Delta OPV_{t-i} + \sum_{i=1}^{q} C \Delta Q_{t-i} + d_1 GDFCF_{t-1} + d_2 OPV_{t-1} + d_3 Q_{t-1} + \lambda_t \qquad 3.8$$

Where Δ is first difference operator, *GDFCF* denotes the dependent variable, *OP* and *Q* are the regressors as defined in models I and II. *OP* and *OPV* represent oil price and oil price volatility respectively while Q is a vector of control variables. η_0 and τ_0 are drift components; α_i and d_i (for i = 1, 2 and 3) are coefficients of the lag level variables; ε_t is the error term which is white noise and q is the optimal lag.

3.5.2 Bounds Test (Co-integration)

The ARDL bounds approach to co-integration involves estimating the short-run conditional ECM for domestic investment and its determinants. The bounds test requires the use of the F-statistic as a benchmark for establishing the existence of co-integration. In testing the null hypothesis that there exists no co-integration, the coefficients of the lag level variables in equations 3.7 and 3.8 are set to zero i.e., $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = 0$ against $H_1 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0$ and $H_0 : d_1 = d_2 = d_3 = 0$ against $H_1 : d_1 \neq d_2 \neq d_3 \neq 0$, after estimating equations 3.7 and 3.8 using Ordinary Least Squares (OLS).

Two asymptotic critical points referred to as the lower and upper bound values are compared with the computed F-statistic. If the F-statistic is greater than the upper bound, we reject the null hypothesis and this suggests the presence of co-integration and the existence of long-run relationship. Conversely, if the F-statistic falls below the lower bound, we fail to reject the null hypothesis implying the absence of co-integrating and long-run relationship. We obtain inconclusive results if the F-statistic falls between the two critical values (Sakyi et al., 2012).

After establishing the existence of co-integration, the final stage of the ARDL involves estimating short-run and long-run dynamics of the model. The ARDL specification of the short-run dynamics is derived based on the following ECM:

Model I

$$\Delta \ln GDFCF_t = \eta_0 + \sum_{i=0}^{q} a_1 \Delta \ln GDFCF_{t-i} + \sum_{i=1}^{q} a_2 \Delta \ln OP_{t-i} + \sum_{i=1}^{q} a_3 \Delta \ln DCPS_{t-i} + \sum_{i=1}^{q} a_4 DR_{t-i} + \sum_{i=1}^{q} a_5 INF_{t-i} + a_6 ecm(-1) + v_t \quad (3.8)$$

Model II

$$\Delta \ln GDFCF_t = \chi_0 + \sum_{i=0}^{q} b_1 \Delta \ln GDFCF_{t-i} + \sum_{i=1}^{q} b_2 \Delta \ln OPV_{t-i} + \sum_{i=1}^{q} b_3 \Delta \ln DCPS_{t-i} + \sum_{i=1}^{q} b_4 DR_{t-i} + \sum_{i=1}^{q} b_5 INF_{t-i} + b_6 ecm(-1) + \varepsilon_t \quad (3.9)$$

Where $ecm(-1)$ is the error correction term and a_4 or b_4 (for $0 \le a_4, b_4 \le 1$).

The following long-run models were estimated;

Model I

$$\Delta \ln GDFCF_t = \alpha_0 + \sum_{i=0}^{q} c_1 \Delta \ln GDFCF_{t-i} + \sum_{i=1}^{q} c_2 \Delta \ln OP_{t-i} + \sum_{i=1}^{q} c_3 \Delta \ln DCPS_{t-i} + \sum_{i=1}^{q} c_4 DR_{t-i} + \sum_{i=1}^{q} c_5 INF_{t-i} + \mu_t \quad (3.8^*)$$

Model II

$$\Delta \ln GDFCF_t = \beta_0 + \sum_{i=0}^{q} d_1 \Delta \ln GDFCF_{t-i} + \sum_{i=1}^{q} d_2 \Delta \ln OPV_{t-i} + \sum_{i=1}^{q} d_3 \Delta \ln DCPS_{t-i} + \sum_{i=1}^{q} d_4 DR_{t-i} + \sum_{i=1}^{q} d_5 INF_{t-i} + \upsilon_t \quad (3.9^*)$$

CHAPTER FOUR

EMPIRICAL RESULTS, DISCUSSION AND ANALYSIS

4.0 Introduction

The analysis and discussion of results is organized as follows; graphical exploration of time series, unit root and co-integration test results, model diagnostic and stability test results, as well as, analysis and discussion of ARDL long-run and short-run estimates.

4.1 Graphical Exploration of Time Series

In this section, graphs were used to describe the behavioral pattern of the time-series. This was a tool used for exploring the data in order to develop first-hand understanding of the nature of the series. Indeed, graphical exploration of time series gives an insight into the stationary nature of data employed. The application of natural log to some of the series was meant to linearize the relationship among the study variables. The reason is that after visualizing the raw data, observed fluctuations in the series seemed to suggest the existence of a nonlinear type of relationship.

Figures 1 and 2 (see appendix 1) present level and first difference graphs of inflation rate, real deposit rate, log of gross domestic fixed capital formation-GDP ratio, log of real GDP per capita, log of crude oil price and log of domestic credit to private sector-GDP ratio, over the period 1970 to 2014. The level graphs revealed that with the exception of inflation rate which seemed to fluctuate around its mean, the other series did not. This suggests that while inflation rate appeared to exhibit stationarity at levels, all the other variables tended to exhibit stationarity at first difference. The trends in the time series were useful in providing preliminary information on the existence of stationarity.

4.2 Statistical Tests Conducted

Some preliminary tests that were conducted to determine model reliability and stability include unit root, model diagnostic and stability tests.

4.2.1 Unit Root Test Results

Time series estimations are usually preceded by unit root testing so as to avoid the emergence of spurious regressions. Thus, the time series properties of gross domestic fixed capital formation-GDP ratio, crude oil price, crude oil price volatility, domestic credit to private sector-GDP ratio, real GDP per capita, inflation level and deposit rate; were examined using the Philip Peron and DF-GLS unit root tests. For inflation, the null-hypothesis of the existence of unit root was rejected at level and for the other variables, it was rejected at first difference.

As shown in Table 4.1, with the exception of inflation which is stationary at levels, the DF-GLS and Philip Peron test statistics show that all the other variables are non-stationary at levels. This means that the other variables became stationary after first difference. With this, inflation level can be said to be integrated of order zero – I (0), while all other variables are integrated of order one – I (1).

It is also shown in Table 4.1 that crude oil price series are covariance stationary. In other words, they exhibit a stationary volatility process. The implication is that oil price series tended to fluctuate around its mean or exhibit a unique behavioral pattern. This justifies the use of the constructed covariance series to estimate the investment model.

The Philip Peron and DF-GLS unit root test results are shown in Table 4.1 below.

Table 4.1: Stationarity Test Results

		Philip Peron		DF-GLS	
	Variable	Intercept	Intercept + Trend	Intercept	Intercept + Trend
Levels	LnGDFCF	-1.009045 (0.7420)	-2.581276 (0.2903)	-1.131262 (0.2642)	-2.215397 (0.2321)
	LnOP	-2.630927 (0.0946)	-2.735705 (0.2281)	-0.252896 (0.8016)	-1.841297 (0.0725)
	OPV	-4.063594*** (0.0028)	-3.289437* (0.0816)	-1.380785 (0.1746)	-2.411894 (0.3203)
	LnDCPS	-0.585040 (0.8635)	-2.081732 (0.5413)	-0.670891 (0.5059)	-1.49885 (0.1412)
	LnRGDPP	-1.535368 (0.5066)	-2.097382 (0.5329)	-1.475463 (0.1474)	-1.79628 (0.0795)
	INF	-4.382983*** (0.0011)	-4.986620*** (0.0011)	-2.155745** (0.0370)	-2.649444 (0.1114)
	DR	-2.015510 (0.2794)	-1.755974 (0.7088)	-1.564220 (0.1251)	-1.784134 (0.0815)
First Difference	LnGDFCF	-6.826436*** (0.0000)	-6.799252*** (0.0000)	-6.66260*** (0.0000)	-6.876424*** (0.0000)
	LnOP	-6.277932*** (0.0000)	-6.343245*** (0.0000)	-5.923038*** (0.0000)	-6.411838*** (0.0000)
	LnDCPS	-6.013449*** (0.0000)	-6.505646*** (0.0000)	-4.119311*** (0.0002)	-5.320532*** (0.0000)
	LnRGDPP	-2.19873 (0.2097)	-1.434218 (0.8363)	-2.775143** (0.0082)	-2.511830 (0.1159)
	INF	-13.88720*** (0.0000)	-15.33251*** (0.0000)	-11.61426*** (0.0000)	-11.88140*** (0.0000)
	DR	7.456966*** (0.0000)	-7.449837*** (0.0000)	-6.315820*** (0.0000)	-7.376598*** (0.0000)

Note: indicated in parenthesis are p-values. *** (**) * denotes rejection of the null hypothesis at 1% (5%) 10% levels of significance

Source: Author's Construct (2016)

4.2.2 Model Diagnostic and Stability Test Results

This section presents results of diagnostic and stability tests that were conducted for models I and II. They include the multivariate normality, Breusch-Godfrey (Serial Correlation), LM White (Heteroskedasticity), CUSUM and CUSUM of square tests. Table 4.2 presents the diagnostic and stability test results.

Table 4.2: Model Diagnostic and Stability Test Results

	Dependent Variable is LnGDFCF	
Test Statistic	I	II
Normality $\chi 2$ (1)	0.261042 (0.877638)	0.336511 (0.845138)
Heteroscedasticity $\chi 2$ (1)	1.552064 (0.1653)	1.405042 (0.2259)
Serial Correlation $\chi 2$ (1)	0.201753 (0.8184)	0.039964 (0.9609)
Functional Form $\chi 2$ (1)	4.893830 (0.3042)	0.839491 (0.4074)
CUSUM	Stable	Stable
CUSUMQ	Stable	Stable

Note: Shown in parenthesis are p – values.

Source: Author's estimation

The results in Table 4.2 indicate that all the diagnostic tests were statistically insignificant and this suggests that models I and II passed the tests against serial correlation, normality and heteroscedasticity. The Ramsey Reset test result also show that models I and II were stable and correctly specified.

4.3 Results of the GARCH (1, 1) Model

Table 4.3 presents results of the estimated GARCH (1, 1) model. It can be shown in Table 4.3 that the parameter estimates for squared lag residual – ARCH (1) and lag conditional variance – GARCH (1), are statistically significant at 1% level. This demonstrates the existence of strong GARCH effect in the oil price series. In other words, crude oil price series can be said to exhibit a high volatility process over the period 1970 to 2014.

Table 4.3: Results of Estimated GARCH (1, 1) Model

Independent Variable	Dependent variable is $OILP_v$	
	Coefficient	Standard error
Constant	0.004011**	(0.001905)
ARCH(1)	-0.183400***	(0.003543)
GARCH(1)	1.138586***	(0.001272)

Note: (***) indicates that the null hypothesis is rejected at 1% level of significance

After establishing the presence of strong GARCH (1, 1) effect in the oil price series, the conditional variance series were then constructed within the GARCH (1, 1) framework. This was done by fitting the GARCH (1, 1) model to seasonally unadjusted oil price series. The constructed conditional variances were used to estimate the model.

4.4 ARDL Bounds Co-integration Test Results

After examining stationarity properties of the time series, ARDL bounds co-integration technique was applied to the data set to test for the existence of long-run stochastic trend. The natural log of gross domestic fixed capital formation-GDP ratio is the dependent variable for models I and II. The results in Table 4.4 indicate that long-run relationship exists among the study variables.

As shown in Table 4.4, the computed F-statistic is larger than the upper bound critical value at 5% level of significance. This implies rejection of the null hypothesis of no co-integration. This means that it is statistically feasible to proceed and corroborate the existence of non-spurious unique short-run and long run relationship between the independent and regressor variables.

Table 4.4: Co- integration Test Results

F-Statistic I	F-Statistic II	Significance Level	Critical Value Bound I		Critical Value Bound II	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound
4.306047**	3.954669**	10%	2.26	3.35	2.26	3.35
		5%	2.62	3.79	2.62	3.79
		1%	3.41	4.68	3.41	4.68

Note: ** indicates rejection of the null hypothesis at 5% level of significance.

Source: Author's Analysis

The natural log of gross domestic fixed capital formation-GDP ratio is the dependent variable for models I and II.

4.5 Analysis of Regression Results

This part of the study presents and discusses the long-run and short-run regression results.

4.5.1 Analysis of Long-run Regression Results

The long-run regression results for models I and II are reported in Table 4.5.

For model I, the results in Table 4.5 indicate that the coefficient of oil price level is positive and statistically significant at 1% level. A rise in crude oil price by 1% is likely to trigger a corresponding increase in domestic investment by 0.253047%. This suggests that fluctuations in crude oil prices lead to sustained significant positive responses from domestic investment in the long-run. This finding is inconsistent with a priori expectation that oil price has a dampening effect on domestic investment.

Table 4.5: Long-run Regression Results

Variable	Dependent (LnGDFCF)	
Independent	I	II
$LnOP_v$		-2.201087***
LnOP	0.253047***	
LnRGDPP	-1.13361	-0.231568
LnDCPS	0.55189***	0.473779***
DR	0.025380***	0.016334***
INF	-0.011581***	-0.008474***
Constant	8.227403*	3.434841

Note: Standard errors of the long run parameter estimates are indicated in parenthesis.

*** (**) and * indicates rejection of the null hypothesis at 1% (5%) and 10% significance level.

Source: Author's Analysis

With regard to model II, the coefficient of oil price volatility is negative and statistically significant at 1% level. This means that a 1% rise in crude oil price volatility is likely to trigger a negative increase in domestic investment by 2.201087%. By implication, uncertainty about crude oil price induces significant negative responses from domestic investment in the long-run. This finding is consistent with a priori expectation that volatile oil price causes uncertainty about general prices (including rental rate of capital), raises the opportunity cost of irreversible investments and induces decline in total investment. It is consistent with empirical studies by Elder and Serletis (2010), Ahmed and Wadud (2010). However, it contrasts to the findings of Jawad (2013), who concluded that oil price volatility has no significant effect on domestic investment. Perhaps, the possible reason is that a highly volatile oil price causes general macroeconomic uncertainty thereby reducing investor confidence. This leads to reduction in the stock of physical capital.

Again, for both models I and II, the coefficient of LnRGDPP ratio is negative and statistically insignificant at 1%. This means that real GDP per capita has no significant impact domestic investment in the long-run. This contrasts the central posit of Tobin's q that income growth and domestic investment are proportionately related.

The coefficient of LnDCPS is positive and statistically significant at 1% for models I and II. As shown in Table 4.5, an increase in domestic credit to private sector-GDP ratio by 1% is likely to trigger a rise in gross domestic fixed capital formation-GDP ratio by about 0.55189% and 0.473779% respectively, in the long-run. A significant positive relationship between domestic credit to private sector-GDP ratio and domestic investment implies minimal financial market distortions. This makes it possible for domestic investors to leverage domestic financing channels as means of financing their investments.

Additionally, for both models I and II, the coefficient for deposit rate is positive and statistically significant at 1%. The result in Table 4.5 is interpreted to mean that in the long-run, a unit increase in deposit rate is likely to cause gross domestic fixed capital formation-GDP ratio to grow at the rate of 0.025380 and 0.016334 respectively. Saving is a crucial driver of capital accumulation. Perhaps, liberalization of Ghana's financial sector has created an environment where real interest rates are driven higher and this induces increased domestic savings mobilization thereby raising physical capital stock levels.

Finally, the results show that the coefficient for inflation is -0.011581 for model I and -0.008474 for model II. Table 4.5 indicates that inflation has a negative and statistically significant impact on domestic investment. In the long-run, a unit increase in inflation triggers a fall in the growth rate of gross domestic fixed capital formation-GDP ratio by 0.011581 and 0.008474 respectively. Though the coefficients are statistically and economically significant, the size effect is rather weak. The economic sense is that higher inflation rates lower real interest rates which reduce real savings mobilization and hence the amount of financial resources made available for investment financing.

4.5.2 Analysis of Short-run Regression Results

The short-run regression results for models I and II are reported in table 4.6. The selection of optimal lag lengths, ARDL (1, 1, 1, 0, 1, 1) and ARDL (1, 1, 0, 1, 1, 0) respectively for models I and II, was done using the Akaike Information Criterion (AIC). According to Stock and Watson (2007), the AIC permits the inclusion of more parameters to obtain a parsimonious model.

Table 4.6: Short-run Regression Results

Variable	Dependent (LnGDFCF)	
Independent	I	II
D($LnOP_v$)		-1.377591***
D(LnOP)	0.321975***	
D(LnRGDPP)	0.041395	1.389405**
D(LnDCPS)	0.266750**	0.296523***
D(DR)	0.028838***	0.024251***
D(INF)	-0.002257*	-0.002030*
ecm (-1)	-0.483336***	-0.625868***

Note: Standard errors of the long run parameter estimates are indicated in parenthesis.

*** (**) and * indicates rejection of the null hypothesis at 1% (5%) and 10% significance level.

Source: Author's Analysis

The statistical adequacy and fit of the ARDL model crucially depends on the ecm (-1) estimate**.** The results in Table 4.6 indicate that the ecm (-1) coefficients for models I and II are negative and statistically significant. This confirms the bounds co-integration test results that a long-run stochastic trend exists between the dependent and independent variables. The error correction coefficients give an indication of an approximate average speed of adjustment from past period's disequilibria. For model I, the ecm (-1) coefficient is 0.483336 while it is 0.625868 for model II. The coefficients are interpreted to imply that approximately 48% to 63% of past period's disequilibria converges back to long-run equilibrium.

Considering the short-run estimates in Table 4.6, oil price level has a positive and statistically significant impact on gross domestic fixed capital formation-GDP ratio in the short-run. That is, a rise in crude oil price by 1% is likely to cause domestic investment to increase by 0.321975%. This implies that changes in crude oil prices evoke significant positive responses from domestic investment in the short-run. This is in sharp contrast with a priori expectation that oil price has a reducing impact on domestic investment but consistent with the long-run results. Perhaps, domestic consumers did not pay competitive prices for oil products due to the presence of regulatory regimes such as subsidies. Therefore, a jump in international oil price does not necessarily signify a rise in domestic oil price and subsequent decline in domestic investment. Again, it could stem from the fact that with increase in oil price, domestic firms continue to invest more in research and development (R&D) and physical projects that could minimize energy costs. This raises investment expenditure.

Table 4.6 again indicates that the coefficient of oil price volatility is negative and statistically significant at 1% level. The coefficient can be interpreted to mean that a 1% rise in crude oil price volatility would trigger a fall in domestic investment by 1.377591%. This implies that oil price uncertainty induces significant negative responses from domestic investment in the short-run. This finding is consistent with a priori expectation that volatile oil price causes general macroeconomic uncertainty and induces decline in investment. The short-run result is consistent with that of the long-run and empirical studies by Elder and Serletis (2010), Ahmed and Wadud (2010). Perhaps, the logic is that a highly volatile oil price raises the opportunity cost of irreversible investments and creates uncertainty about return on current and future investments.

Under these situations, there is no incentive to invest in long-term projects and accumulate physical capital over a longer horizon.

Again, the coefficient of LnRGDPP ratio is positive in both models but statistically significant only for model II. It means that a rise in LnRGDPP is likely to induce an increase in domestic investment by 1.389405%. This finding is consistent with the proposition of Tobin's q theory that income growth drives investment upward. However, it is in contrast with the long-run regression results.

The coefficient of LnDCPS is positive and statistically significant at 5% for model I and 1% for model II. As shown in Table 4.6, an increase in domestic credit to private sector-GDP ratio by 1% would prompt an expansion in gross domestic fixed capital formation-GDP ratio by about 0.266750% and 0.296523% respectively, in the short-run. The significant impact of domestic credit to private sector-GDP ratio on domestic investment implies a deepened financial market which makes it possible for domestic investors to leverage domestic sources of finance as a channel of raising financial resources to finance investment activities.

The results show that the deposit rate has a positive and statistically significant effect on gross domestic fixed capital formation-GDP ratio. The short-run result show that a unit increase in deposit rate is likely to induce growth in gross domestic fixed capital formation-GDP ratio by 0.028838% and 0.024251% respectively. This is consistent with the long-run regression result. The intuition is that financial liberalization in Ghana has removed financial market distortions and has driven real interest rates positive. Perhaps, this has induced the mobilization of financial resources required to promote investment in physical capital.

In a nutshell, the coefficients of inflation rate are -0.002257 and -0.002030 for models I and II. It can be shown in Table 4.6 that inflation has a negative and statistically significant impact on domestic investment, albeit at 10%. In the short-run, a unit increase in inflation triggers growth of gross domestic fixed capital formation-GDP ratio to fall by 0.002257 and 0.002030 respectively. Unlike the long-run where the coefficients are statistically and economically strong, they are statistically and economically weak in the short-run. Perhaps, inflation rates affect expectation formation in the long-run but investors soon realize that real interest rate has fallen and cost of investment reduces. This becomes an incentive for increased acquisition of capital assets.

CHAPTER FIVE

SUMMARY OF MAJOR FINDINGS, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.0 Introduction

This chapter presents the following; summary of major findings, concluding remarks and policy recommendations.

5.1 Summary

The general objective of the study was to evaluate the effect of crude oil price level and volatility on domestic investment in Ghana using annual time series from 1970 to 2014. The specific objectives are to explore the short-run and long-run dynamics of crude oil price level/volatility and domestic investment. GARCH (1, 1) was fitted to seasonally unadjusted crude oil price series to construct conditional variance proxies and ARDL was applied to the data set to generate the long-run and short-run estimates. The major findings of the study are reported as follows;

First and foremost, the results indicate that a rise in crude oil price by 1% is likely to cause domestic investment to increase by 0.32197%. This means that international oil price significantly prompts changes in domestic investment in the short-run.

Secondly, it was found that a 1% rise in crude oil price volatility induces a fall in domestic investment by 1.377591%. This suggests that oil price uncertainty induces significant negative responses from domestic investment in the short-run. Crude oil price level has a greater impact on domestic investment in the long-run than in the short-run.

Thirdly, crude oil price volatility induces a negative effect on domestic investment in the long run. Based on the size effect, the study established that a 1% rise in crude oil price volatility is likely to evoke decline in domestic investment by about 2.201087%. The study found that investment is more sensitive to crude oil price volatility than crude oil price level itself.

Other variables such as deposit rate, inflation rate and domestic credit to private sector-GDP ratio were all found to have significant impact on domestic investment in the short-run and long-run. Among the control variables, only domestic credit to private sector-GDP ratio had a substantial influence on domestic investment.

5.2 Conclusions

The principal objective of this study was to examine the effect of crude oil price level and volatility on domestic investment in Ghana, using the ARDL model. Theoretical and empirical foundations were evaluated to ensure that the study results could be interpreted within conventional research requirements. The conclusions that emerged from the study are;

First, crude oil price level has a positive and statistically significant impact on domestic investment in both short-term and long-term.

Second, crude oil price volatility has a strong economic and statistically significant impact on domestic investment in the short-run and long-run.

The effect of crude oil price volatility on domestic investment is greater than that of crude oil price level. Thus the study concludes that investment is more sensitive to crude oil price volatility than crude oil price level.

Finally, deposit rate, inflation rate and domestic credit to private sector-GDP ratio have statistically significant impact on gross domestic fixed capital formation-GDP ratio in both short-term and long-term, though inflation has an economically weak effect in the long-run. Domestic credit to private sector-GDP ratio was found to influence domestic investment more strongly than both deposit rate and inflation rate.

5.3 Policy Recommendations

The findings and conclusions of the study suggest the following policy recommendations;

The Ghana National Petroleum Corporation (GNPC), which is the main regulatory body in charge of crude oil trade, should implement hedging techniques in order to ensure more oil price stability hence decrease the oil price volatility shocks.

Also, mechanisms should be put in place to strengthen the downstream petroleum deregulation policy which seeks to ensure price liberalization and open up the market for competition. An explanation for the findings is that Ghana enjoyed subsidies on refined petroleum products even though crude oil was imported into the country to be refined by Tema Oil Refinery (TOR) at market prices. The effect of these subsidies is that consumers did not experience the full impact of price hikes in crude oil thereby keeping the cost of production of goods and services relatively cheaper as compared to other countries which did not have such subsidies in place hence had to feel the full impact of these price hikes. This led to relatively cheaper exports from the country and lower costs of production hence attracting more investors and generating more income some of which are then invested. Since this deregulation is important in order to free up revenue for the government for other developmental projects, its efficiency will be vital and successfully doing this could lead to reduction in domestic oil prices and hence encourage investment.

There should be increase in government credible spending on capital projects and R&D that would encourage the discovery of least cost energy sources and reduce dependence on crude oil. This could help minimize exposure of the economy to oil price volatility and shocks and hence costs associated with macroeconomic volatility. Again, strengthening economic ties with major oil exporters could serve as a natural shock absorber.

Finally, policy makers should adopt a comprehensive mix of macroeconomic policies. The study recommends that monetary authorities should continue to implement financial reforms that have the capacity to ensure further deepening of the financial sector. In other words, positive real interest rates should be maintained so as to raise domestic investment.

5.4 Suggestions for Future Research

Further empirical investigations could be conducted on a relatively longer horizon time scale given the availability of supportive data. Also, if high frequency series are accessible, they could be employed to capture large variations in the series which is more suitable for co-integration and error correction frameworks.

5.5 Limitation of the Study

High frequency data are useful in constructing volatility proxies. However, annual time series were used for the analysis because high frequency monthly or quarterly data were not available for some of the study variables.

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APPENDIX

APPENDIX 1: (Raw Data)

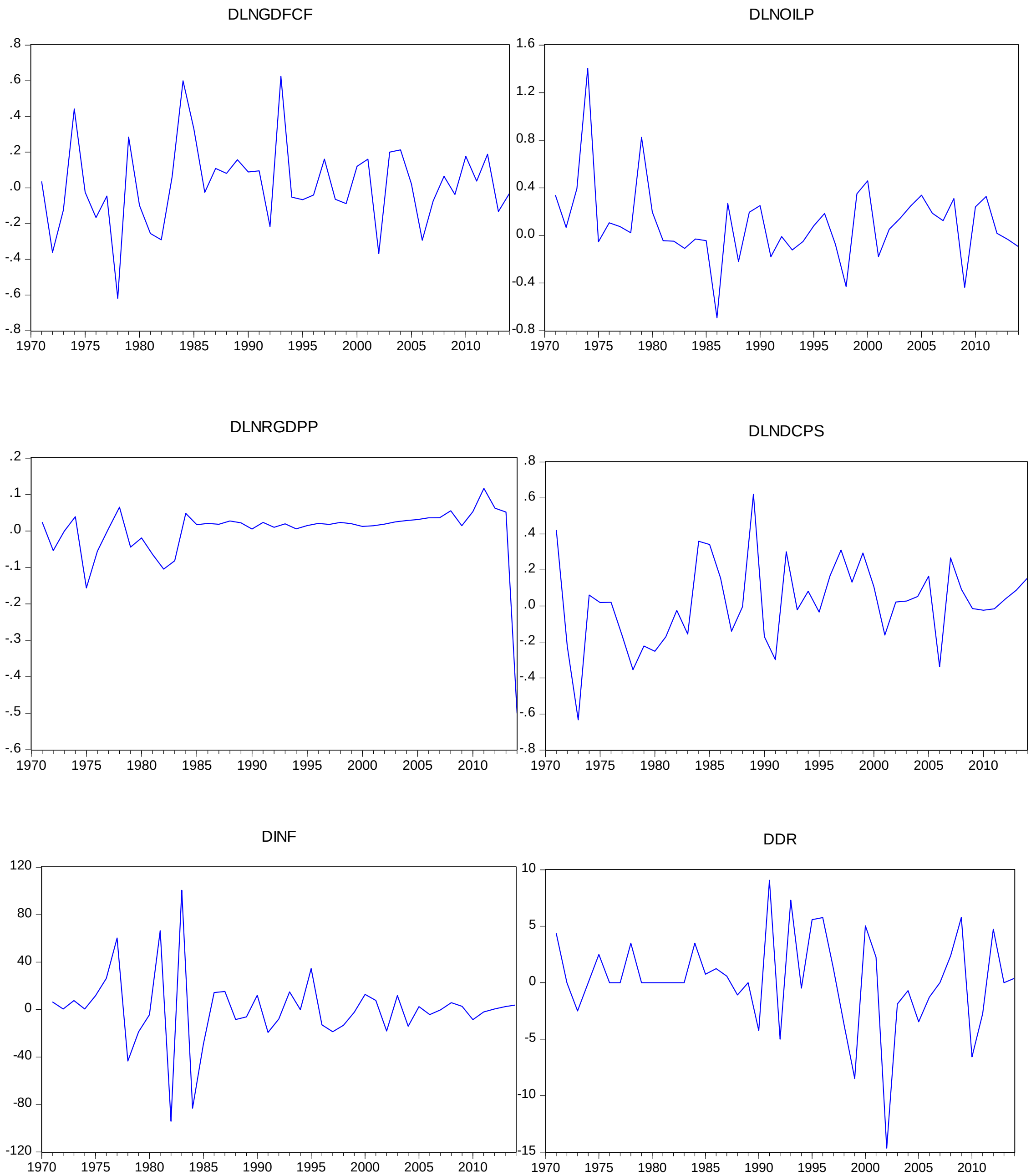
Year	gdfcf-gdp	DR	INF	rGDPP	dcps-gdp	oilp$
1970	12.00	3.62	3.03	819.25	8.25	1.21
1971	12.44	8.00	9.56	839.49	12.58	1.70
1972	8.67	8.00	10.07	795.51	10.06	1.82
1973	7.65	5.50	17.68	795.12	5.34	2.70
1974	11.91	5.50	18.13	827.13	5.68	11
1975	11.62	8.00	29.82	707.57	5.78	10.43
1976	9.84	8.00	56.08	669.51	5.90	11.6
1977	9.40	8.00	116.45	673.55	5.02	12.5
1978	5.06	11.50	73.09	719.02	3.52	12.79
1979	6.73	11.50	54.44	687.89	2.82	29.19
1980	6.10	11.50	50.07	675.06	2.19	35.52
1981	4.72	11.50	116.50	632.92	1.85	34
1982	3.53	11.50	22.30	570.09	1.80	32.38
1983	3.76	11.50	122.87	525.46	1.54	29.04
1984	6.85	15.00	39.67	551.61	2.21	28.2
1985	9.53	15.75	10.31	561.23	3.11	27.01
1986	9.30	17.00	24.57	572.94	3.63	13.53
1987	10.36	17.58	39.82	583.65	3.15	17.73
1988	11.24	16.50	31.36	599.93	3.14	14.24
1989	13.16	16.5	25.22	613.62	5.84	17.31
1990	14.39	12.25	37.26	616.90	4.93	22.26
1991	15.82	21.32	18.03	631.59	3.66	18.62
1992	12.74	16.32	10.06	637.91	4.94	18.44
1993	23.79	23.63	24.96	650.54	4.84	16.33

1994	22.57	23.15	24.87	654.24	5.25	15.53
1995	21.13	28.73	59.46	664.01	5.07	16.86
1996	20.30	34.50	46.56	678.05	6.01	20.29
1997	23.84	35.76	27.89	690.45	8.20	18.86
1998	22.36	32.05	14.62	706.80	9.36	12.28
1999	20.47	23.56	12.41	721.22	12.56	17.44
2000	23.10	28.60	25.19	730.39	13.97	27.6
2001	27.12	30.85	32.91	741.17	11.88	23.12
2002	18.77	16.21	14.82	755.23	12.15	24.36
2003	22.94	14.32	26.67	774.33	12.49	28.1
2004	28.38	13.63	12.62	796.74	13.17	36.05
2005	29.00	10.16	15.12	822.11	15.54	50.59
2006	21.64	8.89	10.92	852.25	11.09	61
2007	20.11	8.90	10.73	884.03	14.49	69.04
2008	21.45	11.29	16.52	934.32	15.88	94.1
2009	20.67	17.06	19.25	947.77	15.66	60.86
2010	24.66	10.5	10.71	999.56	15.29	77.38
2011	25.61	7.75	8.73	1123.75	15.05	107.46
2012	30.93	12.5	9.16	1196.17	15.64	109.45
2013	27.10	12.5	11.61	1260.17	17.07	105.87
2014	26.24	12.9	15.49	763.94	19.91	96.29
	WDI 2015	IFS 2015	WDI 2015	WDI 2015	IFS 2015	FED RES

(Time Series Graphs and Stationarity Test results)

Figure 1: Level Graphs of Time Series

Figure 2: Graphs of Difference Series



Source: Author's Construct (2016)

APPENDIX 2: (Unit Root Test Results)

Stationarity Test Results

		Philip Peron		DF-GLS	
	Variable	Intercept	Intercept + Trend	Intercept	Intercept + Trend
Levels	LnGDFCF	-1.009045 (0.7420)	-2.581276 (0.2903)	-1.131262 (0.2642)	-2.215397 (0.2321)
	LnOP	-2.630927 (0.0946)	-2.735705 (0.2281)	-0.252896 (0.8016)	-1.841297 (0.0725)
	OPV	-4.063594*** (0.0028)	-3.289437* (0.0816)	-1.380785 (0.1746)	-2.411894 (0.3203)
	LnDCPS	-0.585040 (0.8635)	-2.081732 (0.5413)	-0.670891 (0.5059)	-1.49885 (0.1412)
	LnRGDPP	-1.535368 (0.5066)	-2.097382 (0.5329)	-1.475463 (0.1474)	-1.79628 (0.0795)
	INF	-4.382983*** (0.0011)	-4.986620*** (0.0011)	-2.155745** (0.0370)	-2.649444 (0.1114)
	DR	-2.015510 (0.2794)	-1.755974 (0.7088)	-1.564220 (0.1251)	-1.784134 (0.0815)
First Difference	LnGDFCF	-6.826436*** (0.0000)	-6.799252*** (0.0000)	-6.66260*** (0.0000)	-6.876424*** (0.0000)
	LnOP	-6.277932*** (0.0000)	-6.343245*** (0.0000)	-5.923038*** (0.0000)	-6.411838*** (0.0000)
	LnDCPS	-6.013449*** (0.0000)	-6.505646*** (0.0000)	-4.119311*** (0.0002)	-5.320532*** (0.0000)
	LnRGDPP	-2.19873 (0.2097)	-1.434218 (0.8363)	-2.775143** (0.0082)	-2.511830 (0.1159)
	INF	-13.88720*** (0.0000)	-15.33251*** (0.0000)	-11.61426*** (0.0000)	-11.88140*** (0.0000)
	DR	7.456966*** (0.0000)	-7.449837*** (0.0000)	-6.315820*** (0.0000)	-7.376598*** (0.0000)

Note: indicated in parenthesis are p-values.

Source: Author’s Construct

APPENDIX 3: (Stability and Diagnostic Tests Results)

Appendix 2A: Stability and Diagnostic Tests Results for Model I

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.201753	Prob. F(2,31)	0.8184
Obs*R-squared	0.565360	Prob. Chi-Square(2)	0.7538

Test Equation:

Dependent Variable: RESID

Method: ARDL

Date: 09/19/16 Time: 13:13

Sample: 1971 2014

Included observations: 44

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDFCF(-1)	-0.004703	0.164374	-0.028610	0.9774
LNOILP	0.005622	0.103230	0.054463	0.9569
LNOILP(-1)	-0.004930	0.095286	-0.051738	0.9591
LNRGDPP	-0.037742	0.365410	-0.103286	0.9184
LNRGDPP(-1)	0.030161	0.349645	0.086261	0.9318
LNDCPS	0.006096	0.123086	0.049526	0.9608
DR	0.001338	0.007506	0.178213	0.8597
DR(-1)	-0.001012	0.007776	-0.130180	0.8973
INF	0.000250	0.001273	0.196372	0.8456
INF(-1)	-0.000218	0.001324	-0.164872	0.8701

C	0.041658	1.969232	0.021154	0.9833
RESID(-1)	0.072894	0.230633	0.316060	0.7541
RESID(-2)	-0.111456	0.211316	-0.527439	0.6016

R-squared	0.012849	Mean dependent var	2.66E-16
Adjusted R-squared	-0.369274	S.D. dependent var	0.151515
S.E. of regression	0.177296	Akaike info criterion	-0.381280
Sum squared resid	0.974455	Schwarz criterion	0.145867
Log likelihood	21.38817	Hannan-Quinn criter.	-0.185789
F-statistic	0.033626	Durbin-Watson stat	2.040350
Prob(F-statistic)	1.000000		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.552064	Prob. F(10,33)	0.1653
Obs*R-squared	14.07459	Prob. Chi-Square(10)	0.1696
Scaled explained SS	7.201439	Prob. Chi-Square(10)	0.7063

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 09/19/16 Time: 13:14

Sample: 1971 2014

Included observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.565969	0.316396	1.788799	0.0828

LNGDFCF(-1)	-0.026126	0.020431	-1.278783	0.2099
LNOILP	0.001998	0.016678	0.119786	0.9054
LNOILP(-1)	0.003604	0.015267	0.236086	0.8148
LNRGDPP	-0.006919	0.057418	-0.120504	0.9048
LNRGDPP(-1)	-0.080713	0.056281	-1.434112	0.1609
LNDCPS	0.042059	0.018230	2.307072	0.0275
DR	0.001987	0.001164	1.707106	0.0972
DR(-1)	-0.002398	0.001191	-2.012888	0.0523
INF	-1.09E-05	0.000196	-0.055653	0.9560
INF(-1)	0.000403	0.000206	1.956793	0.0589

R-squared	0.319877	Mean dependent var	0.022435
Adjusted R-squared	0.113779	S.D. dependent var	0.030610
S.E. of regression	0.028816	Akaike info criterion	-4.043452
Sum squared resid	0.027402	Schwarz criterion	-3.597405
Log likelihood	99.95594	Hannan-Quinn criter.	-3.878036
F-statistic	1.552064	Durbin-Watson stat	1.979261
Prob(F-statistic)	0.165309		

Ramsey RESET Test

Equation: UNTITLED

Specification: LNGDFCF LNGDFCF(-1) LNOILP LNOILP(-1) LNRGDPP

LNRGDPP(-1) LNDCPS DR DR(-1) INF INF(-1) C

Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	2.212200	32	0.3042
F-statistic	4.893830	(1, 32)	0.3042

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.130940	1	0.130940
Restricted SSR	0.987139	33	0.029913
Unrestricted SSR	0.856199	32	0.026756

Unrestricted Test Equation:

Dependent Variable: LNGDFCF

Method: ARDL

Date: 09/19/16   Time: 13:16

Sample: 1971 2014

Included observations: 44

Maximum dependent lags: 1 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

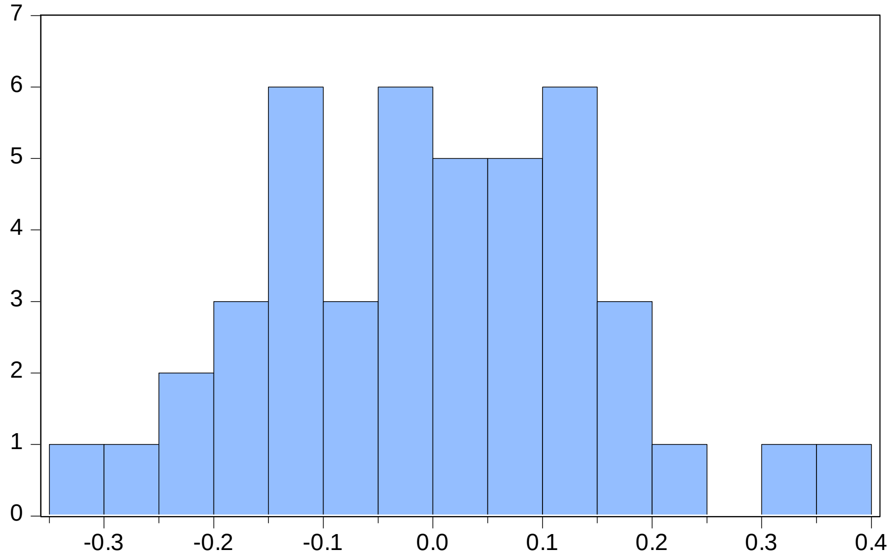
Dynamic regressors (1 lag, automatic):

Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNGDFCF(-1)	1.132011	0.301369	3.756230	0.0007
LNOILP	0.807744	0.239126	3.377900	0.0019
LNOILP(-1)	-0.468476	0.149248	-3.138908	0.0036
LNRGDPP	0.158460	0.330201	0.479888	0.6346
LNRGDPP(-1)	-1.348122	0.468745	-2.876023	0.0071
LNDCPS	0.709369	0.225259	3.149131	0.0035
DR	0.072257	0.020709	3.489208	0.0014
DR(-1)	-0.038889	0.012145	-3.202185	0.0031
INF	-0.004483	0.001502	-2.984257	0.0054
INF(-1)	-0.007411	0.002179	-3.400784	0.0018
C	6.969694	2.248611	3.099555	0.0040
FITTED^2	-0.280406	0.126755	-2.212200	0.0342

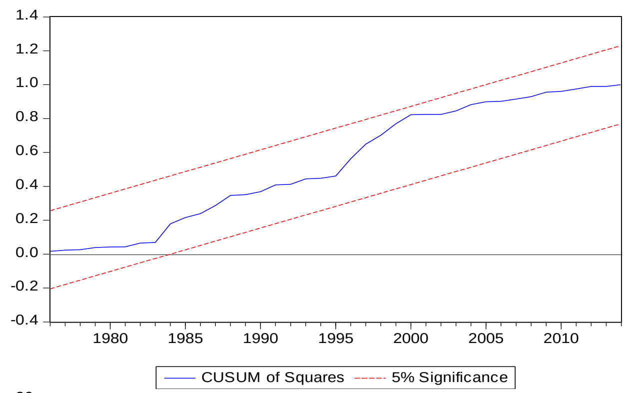
R-squared	0.944084	Mean dependent var	2.655501
Adjusted R-squared	0.924863	S.D. dependent var	0.596739
S.E. of regression	0.163573	Akaike info criterion	-0.556111
Sum squared resid	0.856199	Schwarz criterion	-0.069514
Log likelihood	24.23444	Hannan-Quinn criter.	-0.375657
F-statistic	49.11690	Durbin-Watson stat	1.927151
Prob(F-statistic)	0.000000		

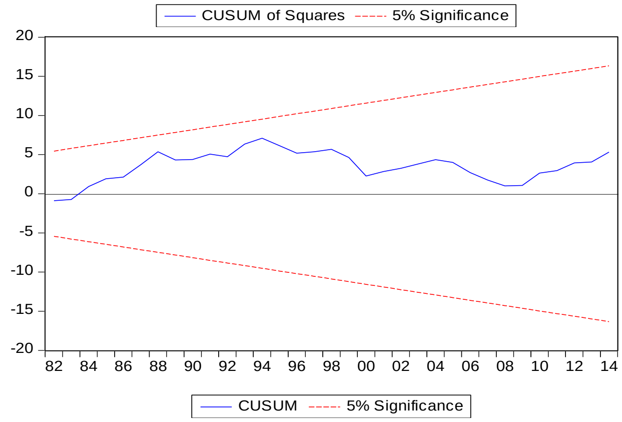
*Note: p-values and any subsequent tests do not account for model selection.



Series: Residuals
Sample 1971 2014
Observations 44

Mean	2.66e-16
Median	-0.001301
Maximum	0.356714
Minimum	-0.328293
Std. Dev.	0.151515
Skewness	0.165615
Kurtosis	2.819244
Jarque-Bera	0.261042
Probability	0.877638





Appendix 3B: **Stability and Diagnostic Tests Results for Model II**

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.039964	Prob. F(2,31)	0.9609
Obs*R-squared	0.110584	Prob. Chi-Square(2)	0.9462

Test Equation:

Dependent Variable: RESID

Method: ARDL

Date: 09/19/16   Time: 14:06

Sample: 1971 2013

Included observations: 43

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDFCF(-1)	0.013447	0.154501	0.087035	0.9312
LNRGDPP	-0.044445	0.711033	-0.062508	0.9506
LNRGDPP(-1)	0.029910	0.706562	0.042332	0.9665
LNDCPS	-0.001793	0.119770	-0.014972	0.9882
INF	8.38E-05	0.001247	0.067173	0.9469
INF(-1)	-7.71E-06	0.001264	-0.006098	0.9952
DR	0.000234	0.006986	0.033449	0.9735
DR(-1)	-0.000509	0.007478	-0.068053	0.9462
OILPVOL	0.014215	0.394775	0.036009	0.9715
C	0.064928	1.829496	0.035490	0.9719
RESID(-1)	-0.013784	0.224424	-0.061418	0.9514

RESID(-2)	-0.057127	0.203482	-0.280745	0.7808

R-squared	0.002572	Mean dependent var	-1.91E-15
Adjusted R-squared	-0.351354	S.D. dependent var	0.149400
S.E. of regression	0.173674	Akaike info criterion	-0.432351
Sum squared resid	0.935039	Schwarz criterion	0.059147
Log likelihood	21.29554	Hannan-Quinn criter.	-0.251102
F-statistic	0.007266	Durbin-Watson stat	2.014902
Prob(F-statistic)	1.000000		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.405042	Prob. F(9,33)	0.2259
Obs*R-squared	11.91252	Prob. Chi-Square(9)	0.2183
Scaled explained SS	6.158000	Prob. Chi-Square(9)	0.7240

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Date: 09/19/16 Time: 14:06

Sample: 1971 2013

Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.511516	0.291581	1.754283	0.0887
LNGDFCF(-1)	-0.005439	0.019843	-0.274087	0.7857
LNRGDPP	0.070968	0.111832	0.634598	0.5301

LNRGDPP(-1)	-0.148643	0.112148	-1.325420	0.1941
LNDCPS	0.021777	0.018004	1.209538	0.2351
INF	-1.39E-05	0.000193	-0.072021	0.9430
INF(-1)	0.000376	0.000200	1.885293	0.0682
DR	0.001344	0.001113	1.207620	0.2358
DR(-1)	-0.002310	0.001154	-2.001577	0.0536
OILPVOL	-0.033625	0.061766	-0.544396	0.5898

R-squared	0.277035	Mean dependent var	0.021801
Adjusted R-squared	0.079863	S.D. dependent var	0.029226
S.E. of regression	0.028035	Akaike info criterion	-4.110292
Sum squared resid	0.025937	Schwarz criterion	-3.700710
Log likelihood	98.37127	Hannan-Quinn criter.	-3.959251
F-statistic	1.405042	Durbin-Watson stat	2.163047
Prob(F-statistic)	0.225929		

Ramsey RESET Test

Equation: UNTITLED

Specification: LNGDFCF LNGDFCF(-1) LNRGDPP LNRGDPP(-1)

LNDCPS INF INF(-1) DR DR(-1) OILPVOL C

Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.839491	32	0.4074
F-statistic	0.704746	(1, 32)	0.4074

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.020201	1	0.020201
Restricted SSR	0.937450	33	0.028408
Unrestricted SSR	0.917249	32	0.028664

Unrestricted Test Equation:

Dependent Variable: LNGDFCF

Method: ARDL

Date: 09/19/16   Time: 14:05

Sample: 1971 2013

Included observations: 43

Maximum dependent lags: 1 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

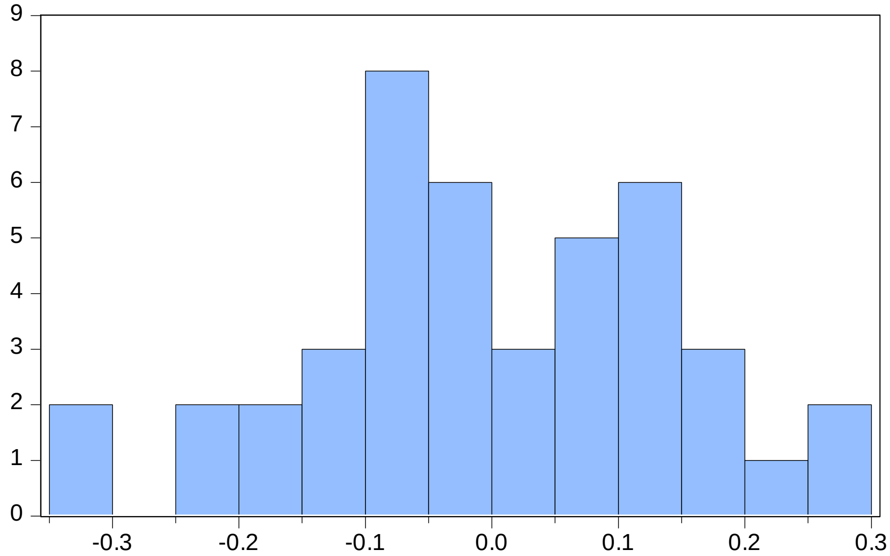
Dynamic regressors (1 lag, automatic):

Fixed regressors: C

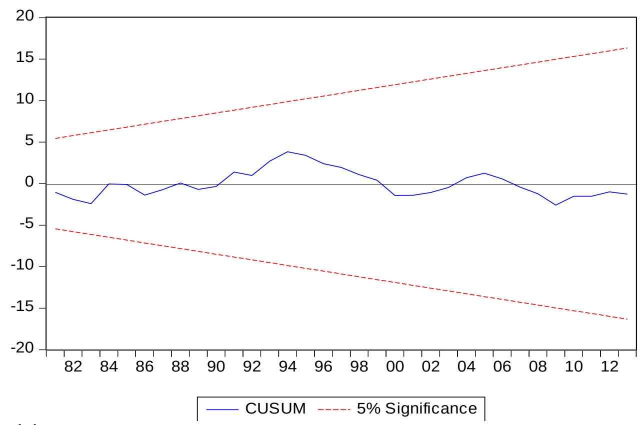
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNGDFCF(-1)	0.515049	0.206246	2.497263	0.0179
LNRGDPP	2.018299	1.008616	2.001057	0.0539
LNRGDPP(-1)	-2.097620	0.953364	-2.200230	0.0351
LNDCPS	0.454961	0.217810	2.088796	0.0448
INF	-0.002787	0.001472	-1.893574	0.0674
INF(-1)	-0.004605	0.001992	-2.311259	0.0274
DR	0.036998	0.016605	2.228185	0.0330
DR(-1)	-0.019940	0.009906	-2.012791	0.0526
OILPVOL	-2.151850	0.994869	-2.162948	0.0381
C	1.774592	1.816686	0.976829	0.3360
FITTED^2	-0.097980	0.116714	-0.839491	0.4074

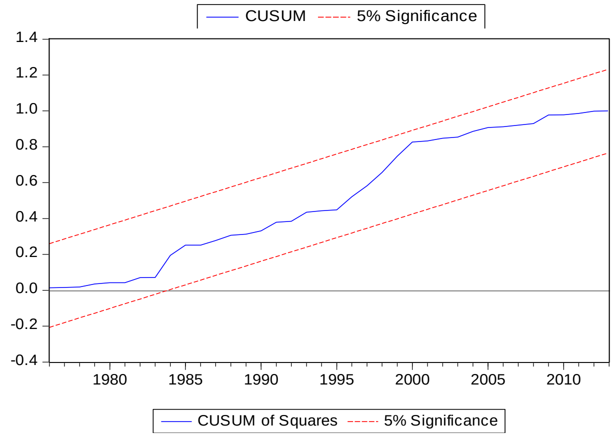
R-squared	0.938560	Mean dependent var	2.641274
Adjusted R-squared	0.919360	S.D. dependent var	0.596203
S.E. of regression	0.169305	Akaike info criterion	-0.498072
Sum squared resid	0.917249	Schwarz criterion	-0.047532
Log likelihood	21.70854	Hannan-Quinn criter.	-0.331927
F-statistic	48.88347	Durbin-Watson stat	1.980737
Prob(F-statistic)	0.000000		

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



Series: Residuals	
Sample 1971 2013	
Observations 43	
Mean	-1.91e-15
Median	-0.023920
Maximum	0.298364
Minimum	-0.349546
Std. Dev.	0.149400
Skewness	-0.178878
Kurtosis	2.755396
Jarque-Bera	0.336511
Probability	0.845138





APPENDIX 4: (Estimated GARCH (1, 1) Results)

Dependent Variable: LNOILP(-1)

Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)

Date: 09/19/16 Time: 22:43

Sample (adjusted): 1971 2014

Included observations: 44 after adjustments

Failure to improve likelihood (non-zero gradients) after 101 iterations

Coefficient covariance computed using outer product of gradients

Presample variance: backcast (parameter = 0.7)

GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.161380	0.124218	1.299163	0.1939
LNOILP	0.932830	0.037857	24.64098	0.0000
		Variance Equation		
C	0.004011	0.001905	2.105880	0.0352
RESID(-1)^2	-0.183400	0.003543	-51.77134	0.0000
GARCH(-1)	1.138586	0.001272	895.1504	0.0000

R-squared	0.889260	Mean dependent var	3.045794
Adjusted R-squared	0.886624	S.D. dependent var	1.027199
S.E. of regression	0.345872	Akaike info criterion	0.304546
Sum squared resid	5.024364	Schwarz criterion	0.507295
Log likelihood	-1.700005	Hannan-Quinn criter.	0.379735
Durbin-Watson stat	1.670053		

APPENDIX 5: (Regression Results)

APPENDIX 5A: Regression Results for Model I

Dependent Variable: LNGDFCF

Method: ARDL

Date: 09/19/16   Time: 13:11

Sample (adjusted): 1971 2014

Included observations: 44 after adjustments

Maximum dependent lags: 1 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (1 lag, automatic): LNOILP LNRGDPP LNDCPS DR

INF

Fixed regressors: C

Number of models evalulated: 32

Selected Model: ARDL(1, 1, 1, 0, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNGDFCF(-1)	0.516664	0.122625	4.213354	0.0002
LNOILP	0.321975	0.100103	3.216420	0.0029
LNOILP(-1)	-0.199668	0.091630	-2.179069	0.0366
LNRGDPP	0.041395	0.344626	0.120116	0.9051
LNRGDPP(-1)	-0.589311	0.337798	-1.744562	0.0904
LNDCPS	0.266750	0.109420	2.437858	0.0203
DR	0.028838	0.006984	4.128956	0.0002
DR(-1)	-0.016571	0.007149	-2.318046	0.0268
INF	-0.002257	0.001179	-1.913668	0.0644
INF(-1)	-0.003341	0.001235	-2.705150	0.0107
C	3.976597	1.899017	2.094029	0.0440

R-squared	0.935533	Mean dependent var	2.655501
Adjusted R-squared	0.915997	S.D. dependent var	0.596739
S.E. of regression	0.172955	Akaike info criterion	-0.459257
Sum squared resid	0.987139	Schwarz criterion	-0.013210
Log likelihood	21.10366	Hannan-Quinn criter.	-0.293841
F-statistic	47.88860	Durbin-Watson stat	1.893741
Prob(F-statistic)	0.000000		

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

ARDL Cointegrating And Long Run Form

Dependent Variable: LNGDFCF

Selected Model: ARDL(1, 1, 1, 0, 1, 1)

Date: 09/19/16 Time: 13:06

Sample: 1970 2014

Included observations: 44

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNOILP)	0.321975	0.100103	3.216420	0.0029
D(LNRGDPP)	0.041395	0.344626	0.120116	0.9051
D(LNDCPS)	0.266750	0.109420	2.437858	0.0203
D(DR)	0.028838	0.006984	4.128956	0.0002
D(INF)	-0.002257	0.001179	-1.913668	0.0644
CointEq(-1)	-0.483336	0.122625	-3.941561	0.0004

Cointeq = LNGDFCF - (0.2530*LNOILP -1.1336*LNRGDPP + 0.5519

*LNDCPS + 0.0254*DR -0.0116*INF + 8.2274)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNOILP	0.253047	0.083845	3.018023	0.0049
LNRGDPP	-1.133613	0.737183	-1.537762	0.1336
LNDCPS	0.551894	0.182828	3.018643	0.0049
DR	0.025380	0.009342	2.716820	0.0104
INF	-0.011581	0.004118	-2.812681	0.0082
C	8.227403	4.584300	1.794691	0.0819

ARDL Bounds Test Results

Date: 09/19/16   Time: 13:08

Sample: 1971 2014

Included observations: 44

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	4.306047	5

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18

1%	3.41	4.68

Test Equation:

Dependent Variable: D(LNGDFCF)

Method: Least Squares

Date: 09/19/16 Time: 13:08

Sample: 1971 2014

Included observations: 44

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNOILP)	0.341945	0.106760	3.202936	0.0030
D(LNRGDPP)	0.083083	0.375439	0.221296	0.8262
D(DR)	0.028794	0.007542	3.817852	0.0006
D(INF)	0.003693	0.001311	2.816993	0.0081
C	2.839778	2.181289	1.301880	0.2020
LNOILP(-1)	0.120864	0.036714	3.292080	0.0024
LNRGDPP(-1)	-0.366625	0.353073	-1.038383	0.3066
LNDCPS(-1)	0.120263	0.119847	1.003476	0.3229
DR(-1)	0.013202	0.005776	2.285777	0.0288
INF	-0.006773	0.001722	-3.933213	0.0004
LNGDFCF(-1)	-0.389933	0.134440	-2.900423	0.0066

R-squared	0.537720	Mean dependent var	0.017788
Adjusted R-squared	0.397636	S.D. dependent var	0.238470
S.E. of regression	0.185082	Akaike info criterion	-0.323720
Sum squared resid	1.130424	Schwarz criterion	0.122328
Log likelihood	18.12183	Hannan-Quinn criter.	-0.158304

F-statistic	3.838537	Durbin-Watson stat	1.949771
Prob(F-statistic)	0.001635		

APPENDIX 5B: Regression Results for Model II

Dependent Variable: LNGDFCF

Method: ARDL

Date: 09/19/16 Time: 14:03

Sample (adjusted): 1971 2013

Included observations: 43 after adjustments

Maximum dependent lags: 1 (Automatic selection)

Model selection method: Akaike info criterion (AIC)

Dynamic regressors (1 lag, automatic): LNRGDPP LNDCPS INF DR

OILPVOL

Fixed regressors: C

Number of models evalulated: 32

Selected Model: ARDL(1, 1, 0, 1, 1, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNGDFCF(-1)	0.374132	0.119296	3.136161	0.0036
LNRGDPP	1.389405	0.672326	2.066566	0.0467
LNRGDPP(-1)	-1.534336	0.674227	-2.275697	0.0295
LNDCPS	0.296523	0.108241	2.739469	0.0098
INF	-0.002030	0.001158	-1.752761	0.0889
INF(-1)	-0.003274	0.001200	-2.726867	0.0102
DR	0.024251	0.006690	3.624932	0.0010
DR(-1)	-0.014029	0.006938	-2.022170	0.0513

OILPVOL	-1.377591	0.371336	-3.709823	0.0008
C	2.149758	1.752966	1.226355	0.2287

R-squared	0.937207	Mean dependent var	2.641274
Adjusted R-squared	0.920082	S.D. dependent var	0.596203
S.E. of regression	0.168545	Akaike info criterion	-0.522799
Sum squared resid	0.937450	Schwarz criterion	-0.113218
Log likelihood	21.24018	Hannan-Quinn criter.	-0.371758
F-statistic	54.72630	Durbin-Watson stat	2.005892
Prob(F-statistic)	0.000000		

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

ARDL Cointegrating And Long Run Form

Dependent Variable: LNGDFCF

Selected Model: ARDL(1, 1, 0, 1, 1, 0)

Date: 09/19/16 Time: 13:52

Sample: 1970 2014

Included observations: 43

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRGDPP)	1.389405	0.672326	2.066566	0.0467
D(LNDCPS)	0.296523	0.108241	2.739469	0.0098
D(INF)	-0.002030	0.001158	-1.752761	0.0889
D(DR)	0.024251	0.006690	3.624932	0.0010
D(OILPVOL)	-1.377591	0.371336	-3.709823	0.0008
CointEq(-1)	-0.625868	0.119296	-5.246343	0.0000

Cointeq = LNGDFCF - (-0.2316*LNRGDPP + 0.4738*LNDCPS - 0.0085*INF

+ 0.0163*DR -2.2011*OILPVOL + 3.4348)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRGDPP	-0.231568	0.461204	-0.502093	0.6189
LNDCPS	0.473779	0.142614	3.322113	0.0022
INF	-0.008474	0.002784	-3.043631	0.0046
DR	0.016334	0.007272	2.246001	0.0315
OILPVOL	-2.201087	0.612058	-3.596207	0.0010
C	3.434841	2.936130	1.169853	0.2504

ARDL Bounds Test

Date: 09/19/16 Time: 13:54

Sample: 1971 2013

Included observations: 43

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	3.954669	5

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.26	3.35

5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Test Equation:

Dependent Variable: D(LNGDFCF)

Method: Least Squares

Date: 09/19/16 Time: 13:54

Sample: 1971 2013

Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRGDPP)	2.058274	0.747846	2.752269	0.0095
D(INF)	0.004198	0.001394	3.011777	0.0050
D(DR)	0.024358	0.007746	3.144684	0.0035
C	0.606343	2.089279	0.290216	0.7735
LNRGDPP(-1)	0.121824	0.333963	0.364782	0.7176
LNDCPS(-1)	0.136642	0.125979	1.084645	0.2859
INF	-0.007201	0.001859	-3.874247	0.0005
DR(-1)	0.013580	0.006025	2.254158	0.0309
OILPVOL(-1)	-1.040038	0.450434	-2.308966	0.0273
LNGDFCF(-1)	-0.598078	0.158609	-3.770775	0.0006

R-squared	0.497861	Mean dependent var	0.018952
Adjusted R-squared	0.360914	S.D. dependent var	0.241166
S.E. of regression	0.192795	Akaike info criterion	-0.253954
Sum squared resid	1.226608	Schwarz criterion	0.155627

Log likelihood	15.46002	Hannan-Quinn criter.	-0.102913
F-statistic	3.635424	Durbin-Watson stat	2.027669
Prob(F-statistic)	0.003032		