Economic Growth, Investment and Asset Pricing: Empirical Evidence

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To my parents, beloved husband and my two angels Ahmed and Majeed

Abstract

Drawing upon economic development under uncertainty, this thesis investigates some channels of nations' prosperity in three different but related topics.

First, in chapter 2, panel data for 130 countries from 1981 to 2009 are employed to scrutinize the impact of multiple forms of human capital and energy consumption on per capita GDP growth. With the application of an expanded neoclassical growth model, the individual effects of primary, secondary and tertiary education enrolment ratios as well as average years of schooling is studied. In addition, the effect of health variables (such as life expectancy and the infant mortality rate) on GDP per capita growth is examined. The education and health variables have a significant effect on economic growth with the secondary enrolment ratio being the most effective. Energy has long been argued as an essential factor for the development of the economy and it should be in line with other production factors of neoclassical economics, capital (K) and labour (L). Energy consumption is found to support higher growth. Exploring the differential effect for the developed and oil-exporting countries, the education variables are found to have no differential impact in the oil exporting countries nor the developed countries, however, health human capital affects the growth of the developed countries differently. Energy consumption per capita has a significant positive effect in both types of countries.

Second, crude oil price behaviour has become more volatile since 1973 which has a significant impact on major macroeconomic variables such as GDP, inflation and productivity. Studies considering the effects of oil price changes on decisions at the firm level are comparatively few. Oil price volatility represents a source of uncertainty affecting the cost of an important input, oil, which creates uncertainty regarding firm profitability, valuations and investment decisions. Chapter 3 builds on related strands in the literature that focus on investment decisions by firms. Investment theory is combined with modern econometric approaches to examine the effects of industry uncertainty and market instability on total investment expenditures in the UK firms. Generalized method of moments estimation techniques are applied to a panel data set that covers 2694 non-financial firms and 416 financial firms from Worldscope DataStream over the period 1986-2011. Tobins Q theory which connects investment to the ratio Q is applied to estimate the investment model that is augmented with measures for both macroeconomic and industry spe-

cific uncertainty; specifically this is done by including stock market and oil price volatility in the model. Stock price uncertainty seems to be positively related to investment among the companies in both samples. On the other hand, empirical results are presented to show that there is a U shaped relationship between oil price volatility and firm investment. The results should be useful to decision makers, investors, managers and policy makers who need to make investment decisions in an uncertain world.

Third, recent empirical research has found evidence of a relationship between changes in oil price and stock prices. Most published papers investigate the relationship between oil price movements and stock prices using either economy-wide measures of stock prices or industry sector measures of stock prices. The aim of Chapter 4 is to scrutinize the responses of some of the UK transportation, travel and leisure, and oil and gas firms to oil price changes. Fama-French-Carhart's (1997) four-factor asset pricing model is augmented with the oil price risk factor to study the association of oil and stock prices of 25 firms over the period from January 1998 to December 2012. The extent of the exposure of UK transportation and travel and leisure firms is generally negative but it is particularly significant for a number of firms including delivery services, travel and tourism, and airlines. Oil price risk exposures of UK oil and gas companies are generally positive and significant. With the aid of asymmetric and scaled specifications, some firms show strong evidence of asymmetry in the reaction of stock returns to changes in the price of oil comprising travel and tourism, airlines, and integrated oil and gas. Moreover, the results document that oil price risk exposures vary over time. In particular, the global recession of 2008 has significantly contributed to the oil price risk exposure of travel and tourism and integrated oil and gas firms. These results should be of interest to financial analysts, corporate executives, regulators and policy makers.

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Chapter 1

Introduction

The fundamental goal of each country is building a robust and sustainable economy and subsequently applying appropriate economic measures that are compatible with a given country at a particular point in time. Due to the disagreement on such a distinctive economic concept in the world, there is also no single program that can be implemented in the cases of all countries in the world at any point of time. Over the last three decades, the determinants of economic growth have attracted researchers' concern in both theoretical and empirical fields. To date there is no unified theory but instead there are a number of theories that explore the function of several factors in determining economic growth. Two leading theories can be characterized: the neoclassical, that is built on the Solow (1956) growth model, who asserts the weight of investment, and endogenous growth theory developed by Romer (1986) and Lucas (1988), who focus on the role of human capital and innovation power.

An abundance of cross-country and panel empirical studies have been done to reveal the determinants of economic growth. One of the most important and examined sources of growth is human capital. Lucas (1988) argues that human capital can be treated as a factor in the production function just like physical capital, where there are various investments in physical capital, there should also be investments in human capital. With the realization of the importance of human capital, many countries have attempted to effectively evaluate their human capital to perceive their actual economic condition. Although, the number of empirical studies that utilize human capital variables in their regressions is large and growing, these studies have concentrated narrowly on measuring human capital with the use of education variables (Barro, 1991, Mankiw et al., 1992, Benhabib and Spiegel, 1994). More recently, it has been realized that human capital is also accumulated through improvements in health but with less empirical literature compared to education capital. Most of these studies propose a positive relationship between health capital and growth (Barro, 1996, Bloom et al., 2004, Gyimah-Brempong and Wilson, 2004, Baldacci et al., 2008).

The effect of human capital on growth is investigated empirically with the implication of a large number of countries, either cross sectionally or in a panel format. The majority of these studies employ a sample of countries that share comparable specifications such as the level of development that leads to a variation in the impact of human capital on growth (for example Gyimah-Brempong and Wilson, 2004, Keller, 2006). Furthermore, the majority of the countries that are rich in natural resources tend to have a slower rate of economic growth compared to other less endowed countries. In the case of oil rich countries, although the abundance of oil reserves may provide jobs for the people, it is rarely used in improving the lives of the bulk of residents or having stable economic growth (Gylfason, 2001). Behbudi et al. (2010) conclude that the multitude of natural resources and bad employment of it may result in a negative impact of human capital on the growth of these countries.

Human capital variables are considered one of the most essential determinants of economic growth, but the role of energy is also potentially important. Pokrovski (2003) states that energy must be deemed not only as a regular intermediate product that adds to the price of produced items, but also a value-creating component that has to be listed as a production factor in line with the traditional factors, capital (K) and labour (L). Most of the studies reviewed have applied Granger causality or unit root and cointegration techniques to investigate the link between energy consumption and economic growth; there have been contradictory results on causation. Sharma (2010) is the only study that I have come across which investigates the role of energy in the context of a growth model. It is known that the sources that are used to generate energy as well as the proportion of energy consumed differ from one country to another. In addition, not all countries possess the same type of energy sources and some countries may need to import energy products. Therefore, Sharma (2010) utilizes six proxies for energy as well as other production factors.[1]

Based on the above, one of the objectives of the second chapter of this thesis is to empirically examine the impact of multiple forms of human capital and energy consumption on economic growth, specifically, the impact of the different levels of educational attainment and enrolment ratios, the effect of the stock of health capital and the influence of energy consumption. Therefore, a neoclassical growth model that is augmented with measures of education, health capital and energy consumption is employed. In order to examine this relationship, the average annual growth of gross domestic product (GDP) per capita is regressed on a number of variables with the focus on human capital and energy consumption variables. Education capital is measured using two different variables, the enrolment ratio and average years of schooling for primary, secondary and tertiary education. These two

[1] The six measures that Sharma (2010) has used are: energy use (kg of oil equivalent per capita), energy use (kt of oil equivalent), electric power consumption (kW h), electricity production (kW h), energy production (kt of oil equivalent), and fossil fuel energy consumption (as a percentage of total consumption).

different measures are used to examine the most significant measure as well as the most significant level of education for economic growth. Health capital is measured using two different variables, life expectancy at birth and the child mortality rate. Energy consumption is proxied by total primary energy consumption per capita, electric power consumption and fossil fuel consumption. The other objective is to investigate the differential impacts of human capital and energy consumption on the economic growth of developed and oil producing countries using interaction terms.

The results of the second chapter show a significant positive impact for the secondary enrolment ratio and average years of schooling on economic growth which suggests that secondary education provides a clear boost to economic development, much more than can be achieved by universal primary education alone. Moreover, improvements in health contribute positively to the economic advancement of nations. Energy consumption also affects economic growth positively.

Another remarkable determinant of economic growth is investment, as it is a crucial factor in aggregate demand. It plays a part in building up capital stock, which may cause economic growth as stated by economic growth models. This depends on the type of investment. For example, government investment in promoting industry might be completely inefficient and fail to increase productivity. However, private sector investment or overseas investment may be more effective in increasing productivity. In the long run, it is essential for improving productivity and raising the competitiveness of an economy.

Given the massive weight of investment in demonstrating economic growth, it is not surprising that investment decisions analysis remains one of the economists' theoretical and empirical interest. However, economic theory and empirical work are yet to agree on the sign of the investment-uncertainty relationship (Hartman, 1972, Abel, 1983, Dixit and Pindyck, 1994). The uncertainty sources that might influence the firm's investment decisions are divided into two parts, either idiosyncratic or macroeconomic uncertainty. Both types of uncertainty are proved to have a significant effect in determining the ideal level of firm's investment (for example, Caballero and Pindyck, 1996, Bo, 2002, Baum et al., 2008, among others).

One of the dominant origins of macroeconomic uncertainty is changes in oil prices. Crude oil is one of the main factor inputs and an essential source of energy that is distinguished from other commodities for its unstable prices which granted it a highly empirical concern. According to Chardon (2007), the price of oil is likely to be the most leading price amongst the various energy sources. As stated in the United States Energy Information Administration, 2006, crude oil exemplifies the largest proportion of global energy demand, and it is anticipated to be the dominant source of energy for at least the coming 20 years, exceeding natural gas, coal, renewable energy sources and nuclear energy. As a consequence, a vast number of research studies have discussed the macroeconomic consequences of changes in oil prices. In general, both empirical and theoretical studies demonstrate that hikes in oil prices negatively influence macroeconomic activities (such as Hamilton, 1983, 1996, 2003, Mork, 1989, Mork et al., 1994, Jiménez-Rodríguez and Sanchez, 2005, Jimenez-Rodriguez, 2009, among others). Kilian (2008) argues that the attention focused on energy prices is not only due to its negative impact on economic activities, but also due to the high volatility of these prices in comparison to other commodities, on one hand, and because of the comparative inelasticity in the demand of energy, on the other hand.

Although the impact of energy or oil prices have been investigated abundantly at the aggregate level of economic activities, few empirical studies have scrutinized their impact on investment decisions at the industry or firm level. At the firm level, Bernanke (1983) states that it is better for firms to postpone irreversible investment expenditures when they experience high uncertainty about future oil prices. Therefore, Mohn and Misund (2009), Ratti et al. (2011), Yoon and Ratti (2011), Henriques and Sadorsky (2011), and Lee et al. (2011) investigate the effect of energy/oil price volatilities on firms level investment. Although Ratti et al. (2011) estimate their model using data from 15 European countries including the United Kingdom, they investigate the effect of the relative price of energy, not the uncertainty, on firm level investment. A noticeable gap in the literature is that previous empirical studies have concentrated on non-financial and manufacturing firms and focused on US companies. Therefore, in the third chapter of this thesis, a Q model of investment is augmented with measures of industry specific uncertainty that is proxied by oil price volatility. The impact of oil price volatility on investment is investigated by dividing the UK firms into financial and non-financial firms. In addition, the non-linear relationship between oil price volatility and firm investment is tested.[2]

[2]With the use of a large panel of non-financial US firms, Henriques and Sadorsky (2011) investigate the existence of a U shape relationship between investment and oil price uncertainty

Market instability is another uncertainty source that is of no less prominence in contrast with oil price uncertainty. Therefore, this relationship has been investigated abundantly, but empirical evidence on the role of the stock market in setting investment expenditure is mixed (Barro, 1990, Morck et al., 1990, Chen et al., 2007). In view of this, the third chapter considers the relationship between stock price volatility and UK firms' investments. In general, the obtained results indicate that the UK stock market is efficient.

The estimation results from the robust two-step GMM show that firms' investment decisions are affected significantly by both industry specific and financial market uncertainty. There is a negative relationship between industry specific uncertainty and investment spending, whereas financial market uncertainty affects investment expenditures positively.

Another factor that plays a significant role in the global economy is the stock market. Traditionally, the stock market has been deemed as a fundamental signal for an economy. A collapse in share prices has the possibility to cause a disruption in the economy, while a large increase in stock prices may suggest future economic growth. This view might be supported by the debate that current stock prices should demonstrate expected future growth of firms' earnings. Therefore, a fall in share prices might lead to a fall in consumers' wealth which might contribute to a drop in consumers' expenditure. Moreover, a drop in stock prices might hinder the capability of firms to raise funds through the stock market, where the easiest way for a firm to expand is by issuing more shares. As the stock market consists of the largest firms' shares, therefore, it is treated as a signal for the nations economy and industrial production. As a consequence, the important role of the stock market has created a considerable field of research on the link between macroeconomic factors and stock returns.

Theoretical models have been built in order to elucidate the behaviour of stock returns and specify the factors that determine them (Sharpe, 1964, Ross, 1976). With the agreement that other variables (other than market risk), particularly macroeconomic variables may affect stock prices, this has encouraged many empirical studies in the essence of Arbitrage Pricing Theory (APT). These studies were done using different types of macroeconomic factors such as: industrial production, interest rate, inflation rate, exchange rate and money supply, most of which are usually unanticipated as stated in Chen et al. (1986).

The global threat from oil price fluctuations has driven a large number of studies to investigate the impact on a number of macroeconomic variables; however, it is just recently that researchers have scrutinized the link between stock prices and oil price changes which is an important issue in energy planning policy and diversification of investors' portfolios. Most of the empirical studies concentrate on aggregate level data (for example, Jones and Kaul, 1996, Huang et al., 1996, Sadorsky, 1999, Basher and Sadorsky, 2006, Park and Ratti, 2008, Apergis and Miller, 2009, Kilian and Park, 2009, among others). Industry level investigations are essential in detecting the impacts of shocks in oil price that are reflected in the influences on the aggregate stock market. Moreover, it is in the interests of investors to consider the variation in sectoral oil exposures when applying portfolio diversification. Most of the studies have been done on the oil and gas industry and transportation industry (for example, Sadorsky, 2001, Hammoudeh et al., 2004, El-Sharif et al., 2005, Boyer and Filion, 2007, Nandha and Brooks, 2009, Mohanty and Nandha, 2011a, Aggarwal et al., 2012, Mohanty et al., 2013).

Since the different sectors have distinct market structures, the returns of the firms in the different sectors are affected variously by the changes in oil prices. As a result, some studies attempt to investigate this relationship at the firm level (for example Manning, 1991, Al-Mudhaf and Goodwin, 1993, Lanza et al., 2005, Mohanty and Nandha, 2011b). Among the small number of studies that have been done on the firm level stock returns and their response to oil shocks, UK firms have received very little attention (Manning, 1991, El-Sharif et al., 2005). Therefore, as an attempt to fill this gap in the literature, chapter four of this thesis investigates the impact of oil price changes and volatility on the monthly stock returns of 25 UK firms from three different sectors: transportation; travel and leisure; and oil and gas from 1998:1 to 2012:12. These firms are specifically chosen due to the availability of long historical data and as they form two different sides of the oil market, consumers and producers of crude oil. It is important to consider the impact of oil prices at the firm level for the benefit of investors when investing in oil-sensitive stocks.

As the investors seek higher rates of return for keeping assets with high risks, hence, recognizing the firms returns' volatility dynamics is essential for all investment decisions. Therefore, a generalized autoregressive conditional heteroscedasticity (GARCH(q, p)) model is conducted with two measures, linear and non-linear specifications of oil price risks. The extent of the exposure of UK transportation and travel and leisure firms is generally negative (negative coefficients on oil price return) and it is significant for a specific number of firms comprising delivery services, travel and tourism, and airlines. However, oil price risk exposures of UK oil and gas companies are generally positive and significant.

In addition, the sensitivity of firms' stock returns might be asymmetric, where the response to increases in the oil price may differ from that to falls in the oil price; as stated in the studies that are done at the aggregate and sectoral level (for example, Park and Ratti, 2008, Arouri, 2011). Therefore, as another contribution, two different specifications of asymmetric measures are used to scrutinize this impact: increases and decreases in the change in oil price and hikes and drops in oil price volatility, respectively. The findings reveal that some firms show strong evidence of asymmetry in the reaction of stock returns to changes in the price of oil comprising travel and tourism, airlines, and integrated oil and gas firms.

The final contribution that this chapter presents is the investigation of oil price risk exposure during global recession. The results state that oil price risk impact alters with time. For example, the global recession of 2008 has significantly contributed to the oil price risk exposure of travel and tourism and integrated oil and gas firms.

The rest of the thesis is structured as follows. Chapter 2 scrutinizes the impact of human capital and energy consumption on economic growth of a panel of 130 countries. Chapter 3 examines the effect of oil price and stock market uncertainties on investment decision of UK firms. Chapter 4 investigates the symmetric and asymmetric response of equity returns of some of the UK firms to the change in oil price. Chapter 5 concludes this thesis.

Chapter 2

The Effect of Human Capital and Energy Consumption on Economic Growth: An Exploration of Oil Exporting and Developed Countries

2.1 Introduction

The concept of the prominent role of human capital in elucidating income disparities has been presented in economists' thoughts for some time. This can originally be ascribed to the work of Adam Smith, though it was not clear until the work of Becker (1962) and others who developed the theory of human capital in the middle of the 20^{th} century. The idea of this theory states that labour income is determined by an individual's education and experience levels. It was initially developed in a microeconomic framework and hassince been applied to macroeconomics. Denison (1967) and Jorgenson and Griliches (1967) examine the impact of changes in human resources (increases in educational investment) to explain the residual (total factor productivity) that is not accounted for by growth in labour and capital inputs.

Nevertheless, it was the evolution of modern theory of growth, that is related to the important contribution of Lucas (1988), which highlighted the importance of human capital to growth. The previous two decades have witnessed an abundance of cross-country and panel regressions which have tried to reveal economic growth factors across countries. Regardless of the fact that countless variables have been used in these regressions, one of the most important and investigated provenances of growth are human capital variables.

The number of empirical studies that consider human capital variables in growth models is increasing. These studies have focused narrowly on accumulation of human capital through education (Barro, 1991, Mankiw et al., 1992, Benhabib and Spiegel, 1994). Yet it has long been realized that the accumulation of human capital can also be through enhancements in health. Theoretically, a healthy person cannot only work efficiently, but also give more time to productive actions. The impact of health capital on growth is investigated less in comparison to that of education capital. Many of the recent studies suggest a favorable effect of health on growth (Barro, 1996, Bloom et al., 2004, Gyimah-Brempong and Wilson, 2004, Baldacci et al., 2008). Therefore, one of the objectives of this chapter is to empirically examine the effect of multiple forms of human capital on economic growth, in particular, the impact of the various levels of educational achievement and enrolment ratios as well as the influence of the health capital stock.

In order to examine this impact, an expanded neoclassical growth model with the separate inclusion of education and health capital is used. A panel dataset covering

130 countries from 1981 to 2009 is employed. The average annual growth of gross domestic product (GDP) per capita is regressed on a number of variables with the focus on human capital variables. For education capital, two widely used measures in the literature are utilized, the enrolment ratio and average years of schooling for primary, secondary and tertiary education. The reason behind these two different variables, flow and stock measures respectively, is to investigate the most significant measure as well as the most effective level of education. For health capital, most of the empirical studies have used either life expectancy at birth or the child mortality rate; and both of these measures are used to proxy health capital in this chapter.

Many of the empirical studies that examined the impact of human capital on growth were done using a large number of countries, either cross sectional or in a panel format. Most of these studies are done on a sample of countries that have similar specifications, such as the same level of development. For example, Keller (2006) analyzes the impact of primary, secondary and higher education on per capita growth using three samples, a global sample and two subsamples of developed and developing countries. She finds that secondary and higher education affect the growth of per capita GDP significantly, but the effect differs according to the sample examined, which indicates that the level of development influences the impact of human capital on growth.

Furthermore, the level of endowments and natural resources that the state owns affect economic growth. For example, in the long run, most oil rich countries, show slower growth than less endowed countries. According to Gylfason (2001), countries that are rich with natural resources usually build a false understanding of security and consider this wealth the most significant asset, ignoring the inexhaustible resource that is presented in human capital accumulation. Behbudi et al. (2010) conclude that human capital can be an important factor explaining the reasons behind the slow growth of natural resource-rich nations. Abundance and bad employment of natural resources in these countries may result in an unfavorable impact of human capital on economic growth.

In addition, energy consumption and its relation to GDP growth has been a subject studied by energy economists since the oil crisis of the 1970s. Moreover, the recent real world issues such as global warming and the consequent climate change has drawn attention to energy consumption economics as well as energy policy.

> "energy must be considered not only as an ordinary intermediate product that contributes to the value of produced products by adding its cost to the price, but also as a value-creating factor which has to be introduced in the list of production factors in line with production factors of conventional neo-classical economics-capital K and labour L"
>
> Pokrovski (2003), p. 770

Therefore, the availability of energy is essential to facilitate economic growth. As a result, efforts to decrease emissions and reduce energy consumption have been an issue to focus on by policy makers in recent studies.

Unlike this chapter which incorporates measures of energy consumption in an augmented neoclassical growth model, many studies have implemented Granger causality or unit root and cointegration approaches to study the association between energy consumption and economic growth and there has been mixed evidence on causation. The approach adopted in this chapter is to estimate the short run effects of the variables under concern and report the long run effect through the catch up term (initial value of GDP per capita). Recent studies have sought to demonstrate the significance of energy in the aggregate production function by testing for the existence and direction of causality between output and energy use (such as Oh and Lee, 2004, Lee and Chang, 2008, Yuan et al., 2008). Only Sharma (2010) models the role of energy using a growth model, by utilizing mainly electricity consumption and production data. This has motivated the study of energy consumption and its impact on economic growth in addition to the separate impacts of education and health capital in a neoclassical growth model.

Countries vary in the sources used to generate energy as well as in the quantity of energy consumed. Furthermore, not all countries own the same energy sources and some countries must import energy products. Based on this, the differential effect of human capital and energy consumption on output growth of the developed and oil exporting countries is investigated as well as examining whether the impact on growth differs between the developing and non-oil exporting countries.

The contribution of this chapter to the existing studies is three-fold. First, an augmented neoclassical growth model that comprises both human capital variables (education and health) and energy consumption as regressors is adopted. The second contribution is to investigate the effects of both stock and flow measures of education capital. Third, the human capital differential impact on economic growth is examined in oil exporting countries using interaction terms. The previous studies of oil producing countries were examining the impact of the natural resources that are available in the country on human capital accumulation and accordingly economic growth, but not the direct effect of human capital on oil producing countries' growth.

The results show a significant positive impact for secondary enrolment ratio and average years of schooling on economic growth which suggests that economic development might be pushed by secondary education, much more than can be acquired by comprehensive primary education alone. Moreover, improvements in health contribute positively to the economic advancement of nations. Energy consumption also affects economic growth positively.

The rest of the chapter is organized as follows: a summary of economic growth theory is in section 2.2. Section 2.3, reviews the impact of education, health capital and energy consumption on economic growth. Sources of data are in section 2.4. Section 2.5 reports the empirical models and the methodology employed. The results and their discussion are in section 2.6, while section 2.7 concludes the study.

2.2 Theoretical Framework

2.2.1 Economic growth theories and human capital

Economic growth remains a very important topic in economics. Its importance springs from the questions it focuses on. There are a number of measures which have been employed to proxy a country's economic development such as, increase in real GNP, rise in overall wellbeing of the people, where people will be considered better off if the citizens of the country are able to obtain and consume more goods and services than before. The last type of measure used is the increase in real income per capita. A continuous rise in income per capita is an indication that the country is proceeding towards a higher living standard. However, increases in GDP do not necessarily result in an improvement in the average standard of living if it is combined with growth in the population. Therefore, when the standard of living is the main focus, economic growth should be expressed on a per capita grounds.[3]

The theory of economic growth has passed through several stages in recent years. The main concern is the sources of productivity growth that are important for policy makers and researchers. There are largely two competing views, neoclassical and new growth theories, that have been widely explored in the economic growth literature.

The models of economic growth scrutinize the development of an economy over time as a result of the change in the quantities and qualities of the different inputs into the production process as well as the change in the techniques of using these inputs. In the Solow (1956) neoclassical model, GDP is produced by a fixed labour force that utilizes manufactured capital. Therefore, output Y is related to its determinants, capital, K, labour, L, and effectiveness of labour, T, in the following aggregate production function:

$$Y = f(K, T, L) \tag{2.1}$$

The main assumption of this model is the diminishing returns to capital which implies that output increases with a decreasing rate as the capital utilized increases. Figure (2.1) shows the relationship between capital (K) and output (Y). It is presumed that a fixed share, s, is saved and invested in the capital stock, while a fixed share of the present capital stock (δ) depreciates each period of time. When the saving and depreciation shares are equal, the capital stock is in equilibrium (K^* in Figure (2.1). To the left of K^*, capital per employee is limited and investment in capital creates a moderately large increase in output. Furthermore, it is apparent from depreciation (D) and saving (S) curves to the left of K^* that the accumulation in the capital stock (S) is greater than depreciation (D) which causes a rise in capital stock. After reaching the stationary state, K^*, any additions to capital stock are offset by depreciation.

The neoclassical production function assumes diminishing returns to physical capital and labour independently and constant returns to scale jointly. By considering the saving rate and population growth as exogenous, Solow (1956) could show that these factors estimate the steady state level of income per capita; where output

[3] In the Harrod Domar model (Domar, 1946), when there is inequality in saving of individual's income between the rich and poor people, capital accumulation will be reduced due to the transfers of wealth from rich to poor which drives slower growth. However, distribution of income is beyond the scope of this chapter.

and capital grow at the same rate as the population (labour). Distinct countries reach different steady states as a result of the variation in saving and population growth rates among them. Once the steady state is reached, technical change is the only source of a rise in income per capita as it is exogenous and undefined by the model. Solow's model shows that in the long run, changes in the rate of saving or population growth have no impact on economic growth. Variation in these factors influence only the level of long run growth but not its slope.

Mankiw et al. (1992) argue that although the Solow model precisely anticipates the tendency of the saving and population growth impacts, it does not exactly estimate their values. They suggest that the impacts of saving and population growth estimated by the Solow model are too large. Thus, they analyzed the reason behind that and found that it results from the elimination of human capital from the Solow model, and there are two reasons for this. First, an increment in saving or decline in population growth increases income which causes a rise in human capital level; thus, the effect of physical capital and population growth on income will be greater when accumulation of human capital is considered. Second, human capital accumulation, saving and population growth might be correlated, which implies that excluding human capital accumulation may result in a biased estimations. Therefore, Mankiw et al. (1992) augment the Solow model by incorporating the accumulation of human capital in addition to physical capital. In their influential contribution, they introduce human capital into the standard Cobb-Douglas production function with labour augmenting technological progress. The production technology function at time t takes the form:

$$Y_t = K_t^{\alpha} H_t^{\beta} \left(A_t L_t\right)^{1-\alpha-\beta} \tag{2.2}$$

where H represents the stock of human capital and A is the technology level. α, β and $1-\alpha-\beta$ are the elasticity of output to the relevant inputs. The function exhibits constant returns to scale but diminishing returns to reproducible factors.

The augmented Solow model considers human capital as a factor input in production. It is appraised as the physical capital factor where it is accumulated by spending a portion of income in its production, the same rate of depreciation and is build up using the same technology as physical capital.

The most remarkable characteristic of the neoclassical model is that, in the long run, the output per capita is driven by growth in exogenous technical progress. Endogenizing technical progress in the model requires neutralizing the assumption of diminishing returns to capital which will result in the whole production function exhibiting increasing returns to scale. However, a production function with increasing returns is incompatible with the competitive general equilibrium framework. This explains the hesitancy of economists to explicitly endogenize technological progress.

The new growth models attempt to endogenize technological change by trying to describe technological development within the growth model. One of the approaches that economists follow to endogenize growth is the AK model (Romer, 1986) in which the relationship between capital and output is in the following form

$$Y = AK \tag{2.3}$$

where capital, K, is identified more broadly compared to the neoclassical model. It is defined as a combination of manufactured and knowledge based capital. To be more specific, technological progress can be considered as a form of capital. Technological change can be accumulated by research and development (R&D), continuous transfer, combination and conversion of different types of knowledge. Technological knowledge has two exceptional characteristics. First, it is regarded as a public good which implies that the stock of it is not exhausted with use. Second, it creates positive externalities in production that exist when a firm's invention not only improves the firm, but be a part of technological knowledge and benefits the whole society. Therefore, the growth of K is a combination of capital stock and technological change. As a result, output, Y, increases at constant rate, A, of capital stock and is not subject to diminishing returns as that in Figure 2.1 .

This approach assumes that capital has two different impacts on output: a direct (private) impact by the usual marginal productivity and an indirect social impact. The social impact is a bi-product that causes higher capital productivity for the economy and eliminates diminishing returns. It works through improving the efficiency of capital (Phelps, 1966, termed his "embodied technical progress"), or through improving the effectiveness of labour (which Arrow, 1962, called "learning by doing") or via improving human capital (Lucas, 1988). The second approach abandoned the competitive framework explicitly. Accordingly, in an endogenous growth model, the economy maintains a constant growth rate in which the technological growth external impact balances the diminishing returns to manufactured capital.

The literature of endogenous growth has presented two different paths on augmenting economic growth models with human capital. The first approach of Lucas (1988), who considered the accumulation of human capital as the engine of growth. The second approach highlights the function of the human capital stock in the process of innovation and acquisition of new technologies (Rivera-Batiz and Romer, 1991).

Although the new growth theory has spread rapidly, a large portion of the empirical literature that has been done on economic growth has applied a framework which according to Barro (1998), is based more on the older neoclassical model. Therefore in this chapter, the augmented neoclassical growth model is applied with the separate inclusion of education and health capital.

2.2.2 Energy Consumption

The relationship between economic growth and energy consumption has become a controversial issue. The traditional neoclassical growth model considers energy inputs as intermediates whereas capital, land and labour are crucial factors so energy is excluded from the production function that reduces to $Y = Y(K, L)$. Conversely, energy economists consider energy as an important production factor, as it can be used as a final product such as for heating and lighting (Stern, 1997). From an ecological viewpoint, energy is a significant factor in determining income, which suggests that the economies that highly depend on energy use will be notably affected by a change in the level of energy consumption (Cleveland et al., 1984). However, many complexities have plagued the efforts to use econometric methods to explain the function of energy in the production function. These difficulties come from trials to determine the amount of energy that is effectively converted in the process of production. Patterson (1996) reviews a number of indicators to measure energy efficiency, mainly at the policy level. To examine the role of energy in the economy, different energy flows should be aggregated. Aggregation of the main economic indicators has received considerable attention from economists for a number of reasons. It is much easier to see patterns in the data when aggregating inputs and outputs in the economy. For instance, to measure productivity in an economy, aggregation of the goods produced and factors of productivity is required. Many indexes are possible, therefore economists consider the assumptions related to the choice of an index such as substitutability, returns to scale which are also valid for the case of energy.

The easiest method of aggregation, with the assumption that all variables are measured in the same units, is to add the variables in relation to their thermal equivalent (for example, BTU[4]). According to Cleveland et al. (2000), the benefit of the thermal equivalent technique is that it applies a straightforward accounting system that depends on the conservation of energy and the fact that the thermal equivalents are easily measured. This method of aggregation lies behind the majority of energy aggregation approaches in economics and ecology. However, Cleveland et al. (2000) agree with Zarnikau et al. (1996) in that aggregating various energy types using thermal units disregards qualitative disparities along with energy forms. Zarnikau et al. (1996) state that econometric production function models may contain aggregated energy that is expressed in terms of BTU content to estimate elasticities of demand for the different inputs and scale economies in production. They also argue that while the BTU index remains the most common energy resource aggregation method in economic and policy studies, it is deficient when the concern is on economic efficiency. This method pays no attention to the form-value characteristics of the different energy sources that influence their market value. In addition, using a BTU index implies perfect substitutability between energy sources.

Aside from this, one has to consider that energy contributes to production processes through various routes: part of it is utilized as a crude product or may be used as an intermediate product in some chemical processes and many other products. Energy is also used as a final product such as heating and lighting. The cost of energy is added to the cost of the final product in all three previous cases. In contrast, energy might be used to replace labour in technological processes. In this case, energy is used as a value-creating production factor.

Energy can be considered as an input factor where it is employed in different activities such as transport and public activities. This implies that energy is directly connected to the GDP of its economy. This connection can be through investment, exports and imports or consumption because energy production and consumption have an impact upon all these determinants of aggregate demand.

Energy has long been argued as an essential factor for the development of the economy. As argued by Pokrovski (2003), it is essential to differentiate among the two effective functions of energy in the production procedures. Productive energy

[4] A BTU is a British Thermal Unit and this is used internationally as a standard measure of energy.

S, should not only be included in the price of the final product it contributes to producing, but also be considered in line with the other two production factors, (K) and (L). Then the production function Y will be as follows:

$$Y = Y(K, L, S) \tag{2.4}$$

Lee and Chang (2008) believe that eliminating energy use from the production function is likely to be an indication of a lack of judgment because economic activities regard energy as a mandatory input in the production process as well as the fact that the economy is driven by the increase in energy demands.

2.3 Literature Review

2.3.1 Human Capital and Economic Growth

Most of the previous empirical studies on growth accounting have focused on estimation of a production function to identify the major empirical factors affecting economic growth. In doing this, most studies regress GDP per capita growth on a set of explanatory variables. These variables generally include labour, physical and human capital. There is no doubt that the exploration of the empirical determinants of growth is important in formulating growth policies. Recent theoretical contributions to the growth literature underline the human capital role in nations development. In addition, the empirical studies on the relationship among human capital and growth has changed several times during the previous two decades. The perception of human capital is described generally in the economics literature to comprise education, health capital, training and other investments that develop human's output. Yet the majority of empirical studies in growth that include human capital use only education variables.

According to Hanushek and Wößmann (2007), education may affect output growth through different paths. First, from a micro viewpoint, when the labour force is educated, their productivity will increase, which pushes output up and accordingly economic growth (Mankiw et al., 1992). Second, education may enhance the inventive capability of the economy, and the knowledge of new technologies and products that encourage growth (Lucas, 1988, Rivera-Batiz and Romer, 1991). Third, education may smooth the distribution of knowledge required to understand and adapt new technologies developed by others (Benhabib and Spiegel, 1994).

Due to the link that human capital theory creates between education and wealth, education is an important priority for economists, policy makers and politicians. Therefore, many empirical studies have studied the relationship between education and economic growth. Following Barro (1991) and Mankiw et al. (1992), there has been an expansion in the empirical research on human capital and economic growth. These studies focus mainly on the impact of different levels of education and improvements on output growth. The stock of human capital in the labour force was first measured by proxies such as adult literacy rates and school enrolment ratios. These measures were used in a large number of studies due to the availability of data for a large number of countries, rather than their suitability from a theoretical point of view.

Rivera-Batiz and Romer (1991) measure human capital using literacy rates data. However, literacy rates reflect only the first part of investments in human capital which neglects any extra investment in education. Therefore, literacy rates can only represent a part of the total stock of human capital.

Barro (1991) and Mankiw et al. (1992) have used enrolment ratios as proxies for human capital stocks. These ratios measure the number of students enrolled at a particular grade in relation to the total population of the matching age group. Enrolment ratios are flow variables and the pupils are currently enrolled in schools and are not yet part of the labour force, so their education cannot yet be used in production. Therefore, enrolment ratios may be considered as an imperfect proxy for human capital.

Both adult literacy and enrolment ratios appear to be insufficient as proxies for human capital. When seeking for a proxy of human capital that is embodied in the current productive labour force, educational attainment (measured as average years of schooling) is more appropriate. Barro and Lee (1993) and Barro and Lee (2013) provided internationally comparable data on average years of schooling for a large number of countries and years. Average years of schooling, or attainment, are important for growth (Barro, 2000). Educational attainment is obviously a stock variable and it accounts for the total amount of education received by the labour force. Although it is the most frequently used proxy, however, according to Wößmann (2003) who criticizes this measure for two reasons. First, using years of schooling as a human capital measure assumes that the weights of the years of schooling are equal across the schooling systems around the world. For instance, a year of schooling in a developed country such as Japan is the same as that in Papua New Guinea. Second, this measure equalizes the weight of the different number of schooling years attained by an individual, however it should be weighted differently according to the number of years accumulated.

In contrast, some researchers try to find another work-force quality measures which affects economic growth positively. Hanushek and Kimko (2000) and Hanushek and Wößmann (2008) use international test scores of mathematics and science, a measure of cognitive skills, as indicators of a high-quality labor force and find that these scores are strongly positively related to economic growth. However, this type of data is not available for a large number of countries over a long period of time. Also, it would be very difficult to compare results across countries. Therefore, this study employs the measures for education capital which are used in most of the empirical studies, school enrolment and average years of schooling; and compares their impact on economic growth.

Although primary education level might meet the demand for goods and services production, labour with secondary education may be able to employ technology in production, and higher education is probably required to create technology. Therefore, every education level increases labour productivity; yet higher levels need extra resources. Since Barro (1991) concluded that secondary education is the most effective level for economic growth, many empirical studies recognized secondary education as the most important measure of human capital in economic growth models. Keller (2006) investigates which kind of education investment is most important to per capita growth; the types of education are: enrolment rates, public education expenditures as a percentage of GDP and public education expenditures per student as a percenatge of GDP per capita, each for primary, secondary and higher education. Using global panel data for developing and developed country subsamples with ten-year averages over the period 1971-2000, she concludes that there is a significant effect for secondary and higher education enrolment rates and expenditures per student in lower education levels and primary levels. However, the overall public higher education expenditures and expenditure per student are insignificant. She suggested increasing enrolment rates and giving the priority to the lower education stages in public expenditures while raising the expenditures per student with increases in the number of students.

As a result of the rapid change in technology and GDP in the previous decades, some empirical studies (for example Chatterji, 1998, Gyimah-Brempong et al., 2006, among others) draw attention to the importance of tertiary education to economic growth. Others debate that the main source of economic growth is primary education, at least in Less Developed Countries (LDCs) (Petrakis and Stamatakis, 2002).

In addition, many studies have often concentrated on the effect of the initial stock of education capital on growth with the interpretation that the countries with more schooling would be anticipated to have higher level of steady state income. These studies, in general confirm that schooling or enrolment rates enhance economic growth (Barro, 1996, Barro and Sala-i Martin, 1995, Levine and Renelt, 1992, Mankiw et al., 1992). On the other hand, some empirical studies conclude that the macroeconomic evidence is incompatible with the findings of the microeconomic level on returns to education (Benhabib and Spiegel, 1994, Pritchett, 2001). This could be because of difficulties when specifying cross-country regressions (Temple, 1999). For instance, the limited number of countries force researchers to use parsimonious specifications.

These results on the relation between education capital and economic growth stimulate a number of important concerns. The first issue is the subject of country heterogeneity. To clarify this point, the empirical studies that employ samples that incorporate developed countries are likely to find weak results, which is consistent with diminishing returns in education. Second, the variables used to proxy education capital can influence the empirical results (Lindahl and Krueger, 2001).

According to economic theory and the concept that health can influence economic growth through its incentive effect on education investment, the results of McDonald and Roberts (2002) indicate that omitting health capital (in the form of life expectancy and infant mortality rate) from the augmented Solow model produces misspecification biases, and that health capital has a significant impact upon economic growth rates.

Data for human capital in the form of health are restricted in the terms of both coverage of countries and length of time series. Distinct from education, a stock of health capital is defined differently as health capital is not accumulated in the same way as accumulating human capital through schooling. But it is still meaningful to talk about a stock of health capital where it can be accumulated by improving the health condition of the population. Grossman (1972) states that health capital is different from other types of human capital. Specifically, he argues that the level of knowledge that an individual possesses influences market and nonmarket productivity, whereas his stock of health determines the entire amount of time he can use in producing money earnings and goods.

Research scrutinizing the bond between health capital and economic growth, at both levels (individual and national), have commonly investigated two categories of health proxies: inputs into health and health outputs. Inputs into health are physical aspects that affect whether a human being is healthy, such as nutrition at various points in life and the availability of medical care. Health outputs are characteristics that are determined by an individual's health inputs. Examples of health outcomes incorporate life expectancy, height and the ability to work. For the purpose of explaining income variation across countries, the key variable is how health affects the ability to produce output.

The broadest indicator of health capital is self-reported health status in population health surveys. However, this type of data and surveys are not available in a large number of countries. A second health indicator is average life expectancy at birth, although Knowles and Owen (1995) consider it a crude proxy and criticize it for taking no account of the quality of health after survival, it does permit for age distribution of the population. Other studies have used the infant mortality rate, which measures the number of infant deaths before 1 year of age per 1000 live births. Schultz (1999) debates that the child mortality rate is the best indicator that can be employed as a measure for a nation's health human capital. This health measure can be supported on the basis that it shows the current health status of the population through those who are subjected to deterioration in their level of health within the population.

Although many studies argue that health capital has a positive effect on economic growth (Barro, 1996, Caselli et al., 1996, among others) it is only recently that empirical growth studies have started to investigate the effect of health on economic growth.

Bloom et al. (2004) present the main results that are obtained by the different empirical studies that employ the variable (life expectancy) as a measure for health capital in economic growth analysis. Barro and Lee (1994); Bhargava et al. (2001) and Sachs and Warner (1997) are some of the cited studies which conclude that life expectancy has a positive and significant effect on economic growth. However, the countries with high life expectancy tend to have older labour with higher levels of experience which might lead to a potential bias in the estimates. Therefore, Bloom et al. (2004) control for labour experience to separate the function of health from that of experience. Their results demonstrate that life expectancy as a measure of health has a significant positive effect on economic growth which indicates that there is a real productivity effect of health on economic growth.

Gyimah-Brempong and Wilson (2004) scrutinize the impact of two measures of human capital (stock and investment in health capital) on income growth in two different groups; Sub-Saharan African and OECD countries. Their aim is to investigate whether human capital has comparable effect in less developed countries and developed industrial countries. Using an augmented neoclassical growth model, panel data and a dynamic panel Generalized Method of Moments estimator. They have run their estimations using an unbalanced panel of 4-year averages for 23 OECD countries in the period 1961-1995 and for 21 Sub-Saharan African countries during the period 1975-1994. As a result, they found that both measures of health human capital affect the growth of these countries positively and significantly. They employ the inverse of the child mortality rate as a proxy for the stock of health human capital and in order to examine whether their results depend on the measure of health human capital used, they also estimate the model using other measures. These measures were life expectancy and child mortality. However, using these alternative measures does not qualitatively affect their results and regardless of the way they measure health human capital, it has a significant positive effect on income per capita growth.

Baldacci et al. (2008) explore the channels that connect social spending, human capital and growth. They compare the influences of different economic policy involvement by using a panel of 118 countries over the period 1971-2000. Modelling education and health capital and explicitly controling for governance by including a dummy for poor governance, they find that health and education spending jointly have a significant positive effect on health and education capital which results in higher growth. In addition, involvement of policies can attain similar results. When education spending is increased by 1% of GDP, the result is an average of 3 more years of schooling and 1.4% increase in GDP per capita in 15 years. Likewise, if health spending is raised by 1% of GDP, the survival rate of the under-5 child will increase by 0.6% that is associated with 0.5% increase in annual growth of GDP per capita.

2.3.2 Human Capital and Economic Growth in Oil Exporting countries

Better education is a requirement for fast economic development across the world. It encourages economic growth and improves people's lives through many paths. It can be through increasing the effectiveness of the labour force, by promoting democracy and hence generating better circumstances for good governance.

> "Nations that are confident that their natural resources are their most important asset may inadvertently- and perhaps even deliberately! – neglect the development of their human resources, by devoting inadequate attention and expenditure to education. Their natural wealth may blind them to the need for educating their children"

Gylfason (2001); p. 850

Natural resources appear to be more of a curse than a blessing for many countries. Various studies have supported the idea which suggests that resource-poor countries usually do better than the resource-rich countries in economic growth. Sachs and Warner (1995) found that there is a negative relationship between natural resource abundance and economic growth in a large cross-country study.

There are inconsistent results from the different studies that investigated the various transmission channels of the impacts of natural resource wealth on economic growth. For instance, Gylfason (2001) concludes that the negative impact of natural resource abundance on economic growth arises from lower education spending and low level of schooling in resource-rich countries. Bravo-Ortega and De Gregorio (2007) find that the negative impact of natural resources can be compensated by higher education levels; this reflects that the natural resource abundance is a blessing for the countries with high levels of human capital. On the other hand, Stijns (2006) concludes that the per capita resource rents (which capture the contribution of rents in the mineral industry to income per capita) are positively correlated with human capital accumulation.

> "it is not the existence of natural wealth as such that seems to be the problem, but rather the failure of public authorities to avert the dangers that accompany the gifts of nature. Good policies can turn abundant natural resource riches into an unambiguous blessing".

Gylfason (2001); p.851

2.3.3 Physical Capital and Economic Growth

Solow (1956) showed that when considering the rates of saving and population growth as exogenous, they determine the steady-state level of income per capita. Economies must invest in developing physical capital to create economic growth. Physical capital represents the factories and equipment that are used in the production process. Hence, a rise in the stock of physical capital causes developments of the nations.

Many empirical studies that investigate economic growth and its determinants have included capital stock in their models. Most of these studies have measured capital stock as the investment/GDP ratio such as Barro (1991), Mankiw et al. (1992), Levine and Renelt (1992), Gyimah-Brempong and Wilson (2004), Keller (2006) and Baldacci et al. (2008) among others. These studies conclude that the investment/GDP ratio has a positive significant effect on economic growth.

2.3.4 Energy Consumption and Economic Growth

The role played by the energy sector in the economic progress must not be lost. Without heat, light and power, factories and cities cannot be built that provide goods, jobs and homes. Energy is the oxygen of the economy and life blood of growth.

A wide range of the literature that studies the energy and economic growth nexus has used cointegration and Granger causality. In general, they find an indication of cointegration between energy and growth, but there have been mixed findings on the direction of causation. Panel data studies are less common in the literature and these studies use panel unit root and panel cointegration. The focus here will be reviewing panel data studies since they are much closer to our field and thereby give an overall view of the relationship between energy and economic growth.

Niu et al. (2011) assess the direction of causality between energy consumption, GDP growth and carbon emissions for eight Asian-Pacific countries (four developed and another four developing countries) from 1971-2005 using panel data. They find that there are long-run equilibrium relationships between these variables and the results differ between developed and developing countries. They conclude that GDP is a source of the increase in energy consumption.

Employing a panel of G7 countries, Narayan and Smyth (2008) investigate the relationship between capital formation, energy consumption and real GDP using panel unit root, panel cointegration, panel Granger causality tests and long run structural estimation for the period 1972-2002. They find that the three variables are cointegrated and that in the long run, real GDP is positively Granger-caused by capital formation and energy consumption.

Middle Eastern countries should increase their investment in electricity infrastructure to avoid any reduction in consumption that might negatively affect economic growth. This was concluded by Narayan and Smyth (2009) who investigate the causal relationship between electricity consumption, exports and GDP and find that causality between electricity consumption and real GDP runs in both directions.

Sharma (2010) is the first study that examines the relationship between energy and economic growth using a panel of 66 countries. She employs a growth model framework to depict the short run impacts with the implication of other determinants of growth, such as inflation, trade, labor force and capital stock. Moreover, she uses six different proxies to measure energy consumption and production. She investigates the effect of these six proxies in four regional panels; namely, East/South Asian and Pacific region, Europe and Central Asian region, Latin America Caribbean region, and Sub-Saharan, North Africa and Middle Eastern region. In general, the results on the impact of energy on growth are mixed.

In general, it can be concluded that both human capital and energy consumption are essential factors in determining economic growth. Most of the empirical studies were done on a worldwide sample of countries and some of them used subsamples of developed and developing countries. In this chapter, the effects of both human capital and energy consumption on economic growth are investigated using an augmented neoclassical growth model. Moreover, the differential effect of these variables in oil exporting countries and developed countries is also considered.

2.4 Empirical Models and Methodology

2.4.1 Empirical Models

Drawing upon Mankiw et al. (1992) and Barro (1996), the growth equation is based on a neoclassical growth model augmented by the separate inclusion of education and health capital as human capital variables. Also, Pokrovski (2003) considered productive energy to be in the list of production factors of conventional neoclassical economics-capital and labour. Therefore, in our proposed model, the GDP per capita growth equation depends on the following:

$$Growth = f(K, Edu, H, EC, \Omega) \tag{2.5}$$

where *Growth* is *GDP* per capita growth, K is total investment as a percentage of *GDP*, *Edu* stands for education capital, H stands for health capital, *EC* is energy consumption and Ω represents the set of control variables.

As a result, our baseline growth model is as follows:

$$Growth_{it} = \beta_0 + \sum_{a=1}^{b} \beta_a X_{it}^a + \sum_{m=b+1}^{n} \beta_m \Omega_{it}^m + u_{it} \tag{2.6}$$

where

- $Growth_{it}$ is PPP *GDP* per capita growth which is measured by the average annual difference of natural logarithms ($\ln GDPC_{it} - \ln GDPC_{i,t-1}$);[5]
- X_{it} is a vector of the variables under concern including:
  - initial natural logarithm of *GDP* per capita for each period ($\ln GDP_{it}$);
  - population growth in percentage;
  - natural logarithm of total investment as a percentage of *GDP*;

[5]PPP is the Purchasing Power Parity and this is an economic theory that estimates the amount of adjustment needed on the exchange rate between countries in order for the exchange to be equivalent to each currency's purchasing power.

- natural logarithm of stock of education capital measured by the enrolment ratios of primary, secondary and tertiary levels, as well as the average years of schooling in the former levels;
- natural logarithm of stock of the health capital measured using two variables, life expectancy at birth and infant mortality rate;
- natural logarithm of energy consumption proxied by the total primary energy consumption.

- Ω_{it} includes the control variables: changes in terms of trade, inflation rate and;
- u_{it} is the error term.

While estimating the effects of initial GDP per capita, physical capital, education, health capital and energy consumption on economic growth, equation (2.6) does not allow for testing whether the effects of these variables on economic growth in developed countries are statistically different from that of developing countries. In addition, it does not show the diversity in the effect between oil exporting and non-oil exporting countries. To explore this issue, the previous model is augmented with the intention that all the variables under study can have altered slopes over the developed, developing, oil and non-oil producing countries. Therefore, two different dummy variables are created. The first one is a dummy for the developed countries (D_i^{DC}) which is set to one if the country is classified as a developed country and zero otherwise. Similarly, the second is a dummy for oil exporting countries (D_i^{OC}) which is equal to one if the country is categorized as an oil exporting country and zero otherwise (Country samples are defined in Table A2.1). In order to allow for differential slopes, the dummies are interacted with the variables of interest. Specifically, the following models are estimated:

$$Growth_{it} = \beta_0 + \sum_{a=1}^{b} \beta_a X_{it}^a + \sum_{m=b+1}^{n} \beta_m \Omega_{it}^m + \beta_{n+1} D_i^{DC} + \sum_{p=n+2}^{q} \beta_p \left(D_i^{DC} \times X_{it}^p \right) + u_{it} \tag{2.7}$$

$$Growth_{it} = \beta_0 + \sum_{a=1}^{b} \beta_a X_{it}^a + \sum_{m=b+1}^{n} \beta_m \Omega_{it}^m + \beta_{n+1} D_i^{OC} + \sum_{p=n+2}^{q} \beta_p \left(D_i^{OC} \times X_{it}^p \right) + u_{it} \tag{2.8}$$

All the regressions are estimated by ordinary least squares (OLS) using 5-year averages over the period 1981-2009. The use of 5-year averages help decrease measurement error. Temple (1999) and Lindahl and Krueger (2001) underline the diffusion of measurement errors in the indicators of human capital and its remarkable effect on empirical estimates of the relationship between economic growth and human capital. Moreover, five year averages is beneficial in polishing any potential business cycle impacts. Utilizing the dummies and their interaction with the independent variables is favoured over estimating the model for each group of countries separately as this design allows us to observe the differential impacts of the variables on the economic growth for the different groups of countries. In other words, we are testing the following null hypotheses:

H_0^{DC} :The influence of the regressors on *growth* is the same across the developed and developing countries (i.e. $\beta_p = 0$ and $\beta_{n+1} = 0$)

H_0^{OC} : The influence of the regressors on *growth* is the same across the oil and non-oil exporting countries (i.e. $\beta_p = 0$ and $\beta_{n+1} = 0$).

2.4.2 The Methodology

Many of the early empirical studies that were done to investigate economic growth were done using cross sectional data.[6] Although this type of data has an advantage of ease of gathering data, there is also number of disadvantages. One of these disadvantages is the assumption of the same aggregate production function for all the countries which ignores the country specific effect in a single cross-section regression that may lead to omitted variable bias. Therefore, panel data is used in this chapter and the advantages of using panel data to study growth are numerous. Baltagi (2008) discusses the advantages of employing panel data as compared to utilizing time series or cross sectional data. Utilizing panel datasets allows for having more useful data though its variability, less collinearity between the variables and higher degrees of freedom.

Regressions are run using ordinary least square method with robust standard errors. The dummy variable approach is utilized to allow for the differential effects across countries. In order to check for the joint significance of the human capital and energy consumption as well as the joint significance of the dummy variables interaction terms, an F-test is applied.[7] Moreover, the models are estimated using 5-year average periods panel to conserve the time series information present in the data. Empirical growth literature uses panel data with 5-year averages which allows for smoothing temporal fluctuations in annual growth rates, stabilizes business cy-

[6] Barro (1991); Mankiw et al. (1992) and Chatterji (1998) among others use cross sectional data to study the effect of human capital on economic growth.

[7] A description of the F test is given in Appendix C.

cle variations in output growth that include expansion and contraction of a national economy and the noise in the data (Caselli et al., 1996).

2.5 Data

The basic dataset consists of an unbalanced panel of annual observations from 130 countries over the period 1981 to 2009. The sample contains 22 developed countries[8] and 10 oil exporting developing countries.[9] For the list of countries and subsamples see Table A2.1 in Appendix A.

All the variables that are used are based upon annual data. 5-year averages of the variables are adopted in estimating the equation. Thus, the first observation is the average for the 1981-1985 period, the second observation covers the years 1986-1990, and so on. The last observation only comprises the years 2006-2009.

The dependent variable is the average annual growth rate of gross domestic product based on purchasing-power-parity (PPP) per capita GDP in current international dollars from the World Economic Outlook (September 2011). The annual growth of GDP per capita is obtained by differencing the annual data after taking its natural logarithm. Then the annual growth data are averaged over time. The initial logarithm of income per capita is used to control for the expected reduction in the growth rates as the GDP per capita increases (Barro, 1991, 1996, Keller, 2006, Baldacci et al., 2008).

For the capital stock, (Barro, 1991, Levine and Renelt, 1992, Gyimah-Brempong et al., 2006, Baldacci et al., 2008) are followed to employ total investment as a percentage of GDP from the World Economic Outlook which is measured as gross capital formation in percent of GDP. Gross capital formation is used because it comprises expenditures on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements, plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in

[8]Sources: World Economic Outlook (October 2010), Human Development Report 2010, and World Development Indicators (October 2010).

[9]Source: Energy Information Administration (http://www.eia.gov/countries/index.cfm?topL=exp)

progress".

Education capital is measured using gross primary, secondary and tertiary enrolment rates, respectively. The enrolment rate is the ratio of total enrolment, disregard of age, to the age group population that formally coincides to the level of education shown. These data are obtained from the World Development Indicators (WDI, 2011) in annual form and averaged over each 5-year period. In addition, regressions are also estimated using another measure of schooling, the average years of schooling in primary, secondary and tertiary levels obtained from Barro and Lee (2013) where these data are available in 5-year average form.

Variables that are employed to measure health capital are total life expectancy derived from male and female life expectancy at birth in addition to the infant mortality rate per 1,000 live births. Life expectancy and infant mortality rates are acquired in annual form from the World Development Indicators (WDI, 2011).

For the energy consumption variables, three different measures are employed. The first one is total primary energy consumption per capita in annual form measured in quadrillion BTU[10] and extracted from the International Energy Agency webpage.[11] Narayan et al. (2011) have employed monthly data on total primary energy consumption in their study. The other measures are electric power consumption (in KWh) and fossil fuel consumption (% of total consumption) (Sharma, 2010); these two measures are obtained from the World Development Indicators (WDI, 2011).

Other control variables added are population growth, changes in terms of trade and inflation. These variables have been used as determinants of economic growth by Levine and Renelt (1992) and Barro (1996); Keller (2006) and Baldacci et al. (2008) have used them as control variables. Adding control variables strengthens the model and increase its efficiency. Terms of trade, as an indicator for the openness of the economy and external competitiveness is calculated as the ratio of the exports value index to the imports value index where the World Bank data (WDI, 2011) are used. Changes in terms of trade have often been asserted to be an impor-

[10]A quadrillion is a unit of energy equal to 10^{15} BTU or 1.055×10^{18} joules in System International units. The unit is used by the U.S. Department of Energy in discussing world and national energy budgets.

[11]Source: Energy Information Administration: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=2$

tant factor for the developing economies, which usually specialize their exports in a limited number of primary products. The inflation index that captures the impact of inflation and the effects of fiscal-monetary policy is from the World Economic Outlook. When there is an increase in most prices, economic agents may find it puzzling to differentiate between variations in relative prices and variations in the overall price level. This complexity may contradict the efficient operation of the price system which may lead to a slower growth. Moreover, at the time of high inflation which is usually hard to forecast, saving and investment decisions will be affected and the proportion of GDP dedicated to investment will be less resulting in less accumulation of physical and human capital. The resulting shrinked stocks of capital may reveal lower levels of economic growth.

2.5.1 Descriptive Statistics

Tables 2.1 and 2.2 present the descriptive statistics for the full sample as well as oil exporting, non-oil exporting, developed and developing countries. T tests are constructed to examine whether the means of the variables utilized in the models differ across these subsamples.

The health capital variables, life expectancy and infant mortality, are significantly different across the oil and non-oil exporting countries. Specifically, life expectancy in the oil exporting countries is 69.9 years while the corresponding figure is 66.3 years for the non-oil exporting countries. It is significantly higher in the developed countries (77.5 years) than the developing countries (64.4 years). In addition, the developed countries have a lower infant mortality rate than the developing countries, (6.4 vs. 48.4 per 1000 live births). Figure 2.2 shows the positive relation between growth of GDP per capita and life expectancy. Likewise, the average infant mortality rate of the oil exporting countries is less than that of the non-oil exporting countries and the difference is statistically significant (Figure 2.3).

These tables report the summary statistics of the gross educational enrolment rates which are defined as the ratio of the number of persons enrolled in school to the population of the corresponding age group by educational level. It is clear from the mean values of primary enrolment ratio that are reported in Tables 2.1 and 2.2 that there is almost 100% enrolment at this level of education across all the samples. However the difference between the means of the oil, and non-oil exporting countries and between the means of the developed and developing countries is statistically significant. In contrast, the average secondary school enrolment ratio is only about 80% in the oil exporting countries whereas it is higher than 100% in most of the developed countries.[12] Figure 2.4 shows the relation between GDP per capita growth and secondary enrolment ratio. The largest dispersion is found in the tertiary education level. There is no significant difference in the mean tertiary enrolment ratio in the oil exporting countries as compared to that of the non-oil exporting countries. Conversely, the difference between the developed and developing countries is highly significant.

Educational attainments expressed in the average years of schooling in the different levels of education are summarized in Tables 2.1 and 2.2. The average years of primary schooling in the developed countries is higher than that of the developing countries whereas the oil exporting countries have less average years of primary schooling when compared with that of the non-oil exporting countries. Similarly, the years of the secondary schooling in the developed countries is higher and statistically different from the developed countries while the diversity between the means of the oil and non-oil exporting countries is not considerable. As expected, the developed countries have the highest average years of tertiary schooling though it is much less than the primary and secondary years of schooling.

Energy consumption is expressed using three different measures, total primary energy consumption per capita, electric power consumption and fossil fuel energy consumption. The means of the total primary energy consumption per capita and fossil fuel energy consumption for the developed and oil exporting countries are significantly higher than their counterparts. However, there is no variation in the mean values of the electric power consumption among the different samples. Figure 2.5 shows the relation between the total energy consumption per capita (in log) and the GDP per capita growth (difference of natural log).

2.6 Empirical Results

We start our examination by estimating an augmented neoclassical growth model. Specifically, regressing per capita GDP growth on the initial GDP per capita, human and physical capital, energy consumption and the other macro control variables as shown in equation (2.6). In estimating equation (2.6), 5-year averages of observa-

[12]The gross enrolment ratio can exceed 100% due to the inclusion of over-aged and under-aged students because of early or late school entrance or grade repetition.

tions are used; this regression is viewed as the baseline model. We next examine whether the variables of interest have a differential effect on the per capita *GDP* growth of the developed, developing, oil and non-oil exporting countries. In particular, we estimate equations (2.7) and (2.8); where we interact the variables of interest with dummies for developed and oil exporting countries.

2.6.1 The Impact of Human Capital on Economic Growth

Table 2.3 presents the results of the baseline model stated in equation (2.6) that shows the impact of physical and human capital on the growth of GDP per capita along with the effects of other determinants of economic growth.[13] The model of equation (2.6) is run with the exclusion of the energy variable to observe and focus on the effect of the human capital variables on economic growth. Particularly, we estimate the model using the three different levels of education, primary, secondary and tertiary with two different measures, specifically, enrolment ratios and average years of schooling. In particular, Models I, II and III of Table 2.3 shows the results for the enrolment ratios, whereas Models IV, V and VI of the same Table summarize the results for average years of schooling. The infant mortality rate is used as a measure of the health capital.[14]

Model I of Table 2.3 includes the enrolment ratios for all three different levels of education. It can be seen that only the tertiary enrolment ratio is significant at the 5% level, and positively affects economic growth. Chatterji (1998) and Gyimah-Brempong et al. (2006) draw attention to the importance of tertiary education for economic growth.

In Models II and III of Table 2.3, we have used only one measure of education, secondary and tertiary enrolment ratios, respectively. The two variables are highly significant when included individually, but the coefficient of the secondary enrolment ratio is higher than that of the tertiary enrolment ratio, 0.01 and 0.005, respectively. This implies that if the secondary and tertiary enrolment ratios increase by 1%, the growth rate of GDP per capita will increase by 0.01% and 0.005%, respectively. This

[13]The models reported in Table 2.3 have varying sample sizes due to differential availability of years of data; the models of this Table are repeated with the same number of observations for all the models to check whether the missing data are affecting the results. No difference in the results is found, these results are reported in Tables A2.4 to A2.7.

[14]If the life expectancy variable is used as health capital, it appears with a high significant positive impact on economic growth. However, using the life expectancy affects the significance of education due to high multicollinearity (see Tables A2.2 and A2.3).

difference might be because tertiary is needed to create technology which is more applicable in the developed countries while secondary education is needed to use the technology in the workplace which is more applicable in most of the less developed countries.

Model IV of Table 2.3 summarizes the results of another proxy for education capital, average years of schooling for the three different levels of education. The average years of schooling of all the three different levels appear insignificant. However, when we estimate the equation using each level of education individually, we get significant and positive effects for secondary and tertiary average years of schooling as can be seen in Models V and VI of Table 2.3. Although the average years of secondary and tertiary schooling are both significant, secondary attainment is more significant and has a larger magnitude than that of the tertiary attainment, which confirms the results for enrolment ratios. Regardless of which education measure is used, the estimated coefficients on the other variables are more or less unchanged.

For health capital, measured by the infant mortality rate, all the models of Table 2.3 show a highly significant negative impact of the infant mortality rate on economic growth. This suggests that individuals' lifetime interval plays a essential role for human capital investments, which accordingly shape economic growth. Furthermore, a large number of empirical evidence supports the view of the high correlation between economic development and longer life expectancy. An increase in knowledge of common diseases treatments and concern for hygiene and sanitation help to increase life expectancy over time. This confirms that the global potential to improve poor health conditions in the less developed countries might be highly efficient. These results are consistent with McDonald and Roberts (2006) who found that the impact of infant mortality on income is negative.

The coefficient on the total investment as a percentage of GDP is positive and highly significant in all the Models of Table 2.3 suggesting that increases in physical capital cause an increase in per capita GDP growth (see Figure 2.6). Specifically, a 1% increase in the investment ratio results in an increase in per capita GDP growth of 0.03%. Levine and Renelt (1992) find that the relationship between growth and most of the macroeconomic determinants other than the investment ratio is insignificant. The most significant results are for investment in physical capital which increases the rate of growth.

All the models of Table 2.3 predict a negative and significant coefficient on the log value of the initial GDP per capita. This coefficient shows the conditional rate of convergence. When holding other explanatory variables constant, the economy reaches its long run position at the rate indicated by the magnitude of the coefficient. Most of the models estimated a coefficient of about -0.015 that implies a conditional rate of convergence of 0.015% per year.

The coefficient on population growth appears as expected; it has a negative significant impact on economic growth in all the models of Table 2.3 (see Figure 2.7). For the control variables such as the terms of trade; it has a positive and significant impact on growth in most of the models whereas the inflation rate has an inverse effect; it reduces growth. The sign of the control variables accord with the results of Baldacci et al. (2008).

2.6.2 The Impact of Energy Consumption on Economic Growth

Table 2.4 provides the estimates of a model similar to Table 2.3 except that we now concentrate on the effects of total primary energy consumption per capita on economic growth. Initially, one measure for energy consumption (total primary energy consumption per capita) with the two measures of schooling to proxy education capital.

By comparing the coefficients and significance of the enrolment ratios and average years of schooling as well as the mortality rate with that of Table 2.3, we find that there is almost no change in the coefficients of the human capital variables when the energy consumption measure is added to the model in Table 2.4.

> "A part of consumed energy [...] productive energy has to be considered not only as an ordinary intermediate product that contributes to the value-creating factor which has to be introduced in the list of production factors equally with production factors of conventional neo-classical economics-capital K and labour L"

Pokrovski (2003); p. 771

It is expected that there is a positive relationship between energy consumption and economic growth. From the results of Table 2.4, we can see that the total primary energy consumption per capita is significant at the 5% level in all the models and it affects growth positively, which means that as energy consumption increases, economic growth will also increase. Specifically, as the total primary energy consumption per capita increases by 1% the GDP per capita growth will increase by 0.006%. The heart of the debate depends on the issue of identifying the economically efficient level of energy consumption and determining whether policy directed specifically to energy efficiency is necessary to bring economic growth to the acquired level and at the same time reduce greenhouse gas production and preserve the environment.

Panel B of Table 2.4 shows the results of the Wald F-test. The t statistics show the significant impact of each variable individually, however, the Wald test show the joint significance of a number of variables. Therefore, an F-test is applied to examine the joint significance of the human capital variables (education and health capital) and energy consumption per capita throughout the models of this Table. The results in the first column of Table 2.4 show high joint significance of the primary enrolment, secondary enrolment, tertiary enrolment ratios, infant mortality rate and total primary energy consumption per capita. Columns 2 and 3 of Table 2.4 show also the joint significant impact of the previously mentioned variables but with one education capital indicator at a time. The results are also highly significant. Columns 4, 5 and 6 report the joint significance of average years of schooling of the different levels, infant mortality rate and energy consumption and the F-statistics are significant at the 1% level.

Pooled OLS may not, however, treat all problems, comprising those concerning endogeneity. For instance, endogeneity may emerge in the applied model as a consequence of the reverse causality between the independent and dependent variables, such as energy consumption and human capital variables with economic growth. In view of this, an IV-type estimator, GMM is estimated to correct for endogeneity. The system GMM estimator addresses endogeneity by simultaneously solving level and difference equations with the utilization of instruments in first differences for the level equation in addition to the use of instruments in levels for the first difference equations. Lags of endogenous variables are used as instruments. The validity of the instruments used is evaluated by utilizing J test of overidentification restrictions

(Hansen, 1982). The null hypothesis of the J test statistics tests that the model is valid. Table B2.1 reports the robust two-step system Generalized Methods of Moments estimation for the three columns of Table 2.4 which confirms the obtained results with higher significant coefficients.

Having established the positive effect of total primary energy consumption per capita on economic growth, equation (2.6) is estimated using other measures of energy consumption. This attempt may be observed as a robustness check of those findings reported in Table 2.4. Model I of Table 2.5 is the same as that of Model III of Table 2.4, but it is reported in Table 2.5 to facilitate the comparison between the different measures of energy consumption. In Model II of Table 2.5, electric power consumption is used to proxy the energy consumption variable. It appears positive and has a significant impact on economic growth, but its coefficient is less than that of the primary energy consumption per capita, 0.001 and 0.005, respectively. Fossil fuel consumption as a percentage of total consumption is used in Model II. The results show a highly significant and positive effect of fossil fuel consumption on economic growth with a higher coefficient than that of total primary energy consumption per capita. The GDP per capita growth increases by 0.008% if the fossil fuel consumption raises by 1%. These findings provide evidence for the positive and significant effect of energy consumption on economic growth.

2.6.3 The Differential Effect of Human Capital and Energy Consumption

Although, the results of Tables 2.3 and 2.4 provide strong evidence for the existing positive relationship between per capita GDP growth and human capital and energy consumption, these results do not allow us to explain whether the impacts of these variables on GDP growth differ across oil and non-oil exporting countries and developed and developing countries in the same model. To examine the differential effect of being an oil exporting country or a developed country on per capita GDP growth, D_i^{OC} and D_i^{DC} dummies are added to the model and interacted with the underlying variables.

2.6.3.1 Oil versus Non-Oil Exporting Countries

In Table 2.6, the model that is presented in Table 2.5 is replicated, where now all the variables under concern, physical and human capital and energy consumption variables are interacted with oil exporting countries dummy D_i^{OC} to test for the differential effects. D_i^{OC} is set to one if the country is oil exporting and zero otherwise. Secondary enrolment ratio is used as a proxy for the education capital as it appears from the previous results as the most important level and the infant mortality rate is employed to measure health capital because life expectancy has very high multicollinearity with the education variables. Energy consumption is measured by the total primary consumption per capita. These variables are interacted with the oil exporting countries dummy and the results are presented in Model I of Table 2.6.

Focusing on the differential effect of human capital variables, secondary enrolment and mortality rate, it can be observed that the coefficients associated with these interactions are insignificant. This suggests that human capital variables do not have a differential impact in the oil exporting countries. According to Behbudi et al. (2010), many oil exporting countries have a relatively low level of institutional and human development with large deficits in areas such as education and health.

> "Nations that believe that natural capital is their most important asset may develop a false sense of security and become negligent about accumulation of human capital".

Gylfason (2001); p. 858

For the energy interaction consumption variable, it appears positive and significant at the 5% percent level, which shows that energy consumption has a differential impact in oil exporting countries. Particularly, as total energy consumption per capita increases by 1%, GDP per capita growth increases by (0.004+0.02)% in oil exporting countries compared to (0.004%) in non-oil exporting countries. This significant result may be due to the reliance of the oil exporting countries on natural capital available in running their economies.

The differential effect of the investment as a percentage of GDP has a positive coefficient which is statistically significant at 1% level. As total investment as a percentage of GDP increases by 1%, the growth rate of GDP per capita increases by (0.026+0.059)% in contrast to (0.026%) in the non-oil exporting countries.

The F-test statistics are reported in Panel B of Table 2.6. The joint significance statistics of the oil dummy variable and all the interaction terms has a probability of 0.022 which implies that they are jointly significant at the 5% significance level. This result suggests that the unrestricted model (Equation (2.8)) is preferred over the restricted model (Equation (2.6)) since the null hypotheses H_o^{OC} stated in subsection 2.4.1 can be rejected and the coefficients of the interaction terms are significantly different than zero.

2.6.3.2 Developed Versus Developing Countries

The full sample contains 22 developed countries. Thus, a dummy D_i^{DC} that equals one for the developed countries and zero otherwise is generated. To inspect the differential impact through developed and developing countries, this dummy is interacted with the regressors included in the model.

Model II of Table 2.6 shows the results of equation (2.7), the coefficient of the education interaction term ($D_i^{DC} \times Sec.Enrol.$) shows insignificant impacts. This indicates that the influence of the secondary education is the same in the developed and developing countries. The same insignificant results for education variables are obtained even when adding the three different levels of education enrolment ratios (primary, secondary and tertiary).[15] These results may be explained by the period of the sample as it starts in the 1980's and the significant impact of the education in the developed countries was in the 1950's and 1960's. Gyimah-Brempong et al. (2006) and Chatterji (1998) argue that education is essential for countries that tend to come up to the level of the developed countries; however, it is of less significance for the developed ones. The coefficient of the infant mortality rate interaction term ($D_i^{DC} \times Mortality$) has a significant negative impact on the growth of developed countries. To be specific, the GDP per capita growth of developed countries declines by (0.013+0.022) % compared to only (0.013%) for the developing countries when the infant mortality rate increases by 1%. Finally, the total primary energy consumption per capita differential effect appears significant at the 10% level and affects positively the economic growth of the developed countries.

The results of the joint significance imply that the joint effect of the developed countries' dummy variable and the interaction terms is statistically significant at 1% level. Therefore the null hypotheses H_0^{DC} stated in subsection 2.4.1 can be rejected and the unrestricted model is favoured over the restricted model.

[15] The results containing the three levels of education interaction terms with the D^{OC} and D^{DC} are reported in Table A2.8.

2.7 Conclusion

The major purpose of this study is to scrutinize the impact of the multiple forms of human capital and energy consumption on per capita income growth. An expanded neoclassical growth model, panel data and different measures for all the variables under consideration are used. This study estimates the individual effects of primary, secondary and tertiary enrolment ratios as well as average years of schooling. In addition, the effect of health variables on GDP per capita growth is examined. Moreover, total primary energy consumption per capita affects GDP per capita growth positively and significantly.

The consensus from the studies that examine the relationship between the different forms of energy and GDP is that there is cointegration between energy consumption and GDP. The evidence is mixed regarding the direction of causality between energy consumption and income. Kraft and Kraft (1978) find unidirectional causality running from income to energy consumption for USA; as did Al-Iriani (2006) for Gulf Contribution Council (GCC) countries, among others. In contrast, Stern (2000) concludes that a quality-weighted index of energy input Granger-causes GDP in the US. Moreover, recent studies have sought to demonstrate the significance of energy in the production process. They do so based on the aggregate production function and including energy consumption per capita in a growth model. Oh and Lee (2004), Lee and Chang (2008), Lee et al. (2008) and Yuan et al. (2008) all argue that energy is an essential factor in production and hence contributes positively to growth. Energy has long been argued as an essential factor for the development of the economy. As argued by Pokrovski (2003), it should be brought in line with other production factors of neoclassical economics, capital (K) and labour (L). Since energy production and consumption have an impact upon all the components of aggregate demand (investment, exports and imports), energy consumption is considered as an input in the production process and hence in the growth model of this chapter.

The contribution of this study is three-fold. First, the joint impact of human capital and energy consumption upon economic growth is examined through an augmented neoclassical growth model. Second, it investigates the effects of both the stock and flow measures of education capital. Third, it scrutinizes the impact of three different measures of energy consumption. Finally, the differential impact of human capital on economic growth in oil exporting countries is examined with the aid of interaction terms while the literature examine the effect of the stock of natural resources on the human capital accumulation and hence the economic growth but not the direct impact of human capital on economic growth.

For international policy makers, more and better education should become the top priority because it empowers the people to help themselves and this may help to improve governance and reduce corruption. A concentrated effort for much more primary and secondary education combining national and international forces would appear the most promising route out of poverty and toward sustainable development. Health capital is contributing positively in increasing economic growth of nations which agrees with the theory that the healthier is the worker, the more productive. In addition the energy consumption may be used in levels that keep the environment clean and decrease the amount of emissions.

Furthermore, the differential effect of the developed and oil-exporting countries has been investigated by looking at the interaction between the binary dummies and all the explanatory variables. Energy consumption per capita has a significant positive effect in both types of countries. The education variables do not affect the oil exporting countries and developed countries differently. Behbudi et al. (2010) investigate the relationship between human capital and economic growth in a number of petroleum exporting countries and conclude that human capital can be major feature to explain the lag in growth of resource-rich countries. This point needs more investigation to explore whether the oil exporting countries use their wealth in augmenting their human capital.

Table 2.1: Descriptive Statistics for the full and oil exporting countries samples

Variable	Statistics					
	Sample	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
GDP per capita growth (current international dollars)	Full	738	372.83	520.88	-2352.4	3904.06
	Oil	56	338.99	1029.51	-2352.4	3904.06
	Non-oil	682	375.61	455.98	-646.04	3010.42
	Diff t-test		36.62			
Investment ratio %	Full	744	22.59	7.43	2.96	69.17
	Oil	57	24.8	6.51	9.11	39.94
	Non-oil	687	22.4	7.48	2.96	69.17
	Diff t-test		-2.40**			
Pop. Growth %	Full	780	1.66	1.55	-4.88	16.65
	Oil	60	2.93	3.14	-2.75	16.65
	Non-oil	720	1.55	1.28	-4.88	11.96
	Diff t-test		-1.37***			
Life expectancy at birth	Full	780	66.61	10.24	28.4	82.59
	Oil	60	69.93	4.67	50.75	77.69
	Non-oil	720	66.34	10.53	28.4	82.59
	Diff t-test		-3.60***			
Infant Mortality rate (per 1000 live births)	Full	774	41.25	36.15	1.9	174.44
	Oil	60	28.08	15.81	7	76.38
	Non-oil	714	42.35	39.62	1.9	174.44
	Diff t-test		14.27***			
Primary enrolment ratio (% of population)	Full	738	99.14	18.9	22.84	211.46
	Oil	55	104.16	8.14	70.65	121.06
	Non-oil	683	98.74	19.46	22.84	211.46
	Diff t-test		-5.42**			
Secondary enrolment ratio (% of population)	Full	698	67.57	32.44	2.98	155.58
	Oil	53	79.09	16.41	39.47	106.62
	Non-oil	645	66.63	33.24	2.98	155.58
	Diff t-test		-12.47***			
Tertiary enrolment ratio (5 of population)	Full	679	23.46	21.5	0	96.97
	Oil	57	26.05	17.65	3.66	78.43
	Non-oil	622	23.22	21.82	0	96.97
	Diff t-test		-2.83			
Average years of primary schooling	Full	780	4.2	1.76	0.08	8.99
	Oil	60	3.51	0.89	1.71	5.33
	Non-oil	720	4.26	0.07	0.08	8.99
	Diff t-test		0.75***			
Average years of secondary schooling	Full	780	2.23	1.44	0.02	7.76
	Oil	60	2.64	1.28	0.73	5.84
	Non-oil	720	2.2	1.45	0.02	7.76
	Diff t-test		-0.44**			
Average years of tertiary schooling	Full	780	0.33	0.3	0.004	1.71
	Oil	60	0.45	0.32	0.04	1.58
	Non-oil	720	0.33	0.3	0.004	1.711
	Diff t-test		-0.12***			
Total primary energy consumption per capita (quadrillion Btu)	Full	751	96.77	141.12	0.46	1173.89
	Oil	56	290.22	289.01	41.4	1173.89
	Non-oil	695	81.19	107.88	0.46	744.53
	Diff t-test		-209.03***			
Electric power consumption (KWh)	Full	695	1.05E11	3.65E11	8151928	4.13E12
	Oil	58	1.15E11	2.33E11	3.01E9	9.9E11
	Non-oil	637	1.04E11	3.75E11	8151928	4.13E12
	Diff t-test		-1.09E10			

Table 2.1 – Continued

	Statistics					
Variable	**Sample**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Fossil fuel energy consumption (% of total)	Full	650	68.92	28.46	3.02	102.07
	Oil	58	97.84	3.41	87.74	100.03
	Non-oil	592	66.09	28.26	3.02	102.07
	Diff t-test		-31.75***			

Notes: The gross enrolment ratio can exceed 100% due to the inclusion of over-aged and under-aged students because of early or late school entrance or grade repetition.***, **, * denote statistical significance at 1%, 5% and 10% respectively.

Table 2.2: Descriptive Statistics for the full and developed countries samples

	Statistics					
Variable	**Sample**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
GDP per capita growth (current international dollars)	Full	738	372.83	520.88	-2352.4	3904.06
	Developed	132	889.55	330.11	162.15	2220.64
	Developing	606	260.28	485.77	-2352.4	3904.06
	Diff t-test		-629.27***			
Investment ratio %	Full	744	22.59	7.43	2.96	69.17
	Developed	132	22.04	3.26	16.45	32.24
	Developing	612	22.7	8.05	2.96	69.17
	Diff t-test		0.66			
Pop. Growth	Developed	132	0.61	0.45	-0.23	1.8
	Developing	648	1.87	1.6	-4.88	16.65
	Diff t-test		1.26***			
Life expectancy at birth	Full	780	66.61	10.24	28.4	82.59
	Developed	132	77.51	2.18	72.32	82.59
	Developing	648	64.39	9.8	28.4	82.45
	Diff t-test		-13.12***			
Infant Mortality rate (per 1000 live births)	Full	774	41.25	36.15	1.9	174.44
	Developed	132	6.39	2.86	1.9	18.9
	Developing	642	48.41	35.67	2.2	174.44
	Diff t-test		42.02***			
Primary enrolment ratio (% of population)	Full	738	99.14	18.9	22.84	211.46
	Developed	130	102.53	5.69	82.94	125.02
	Developing	608	98.42	20.59	22.84	211.46
	Diff t-test		-4.12**			
Secondary enrolment ratio (% of population)	Full	698	67.57	32.44	2.98	155.58
	Developed	127	104.55	15.41	58.73	155.58
	Developing	571	59.35	29.35	2.98	109.96
	Diff t-test		-45.20***			
Tertiary enrolment ratio (5 of population)	Full	679	23.46	21.5	0	96.97
	Developed	126	48.7	19.47	12.14	93.11
	Developing	553	17.71	17.42	0	96.97
	Diff t-test		-30.99***			
Average years of primary schooling	Full	780	4.2	1.76	0.08	8.99
	Developed	132	5.49	0.98	3.53	7.64
	Developing	648	3.94	1.76	0.08	8.99
	Diff t-test		-1.55***			
Average years of secondary schooling	Full	780	2.23	1.44	0.02	7.76
	Developed	132	3.69	1.18	1.13	7.76
	Developing	648	1.94	1.31	0.02	5.91
	Diff t-test		-1.75***			
Average years of tertiary schooling	Full	780	0.33	0.3	0.004	1.71
	Developed	132	0.68	0.34	0.14	1.71
	Developing	648	0.26	0.24	0.004	1.58
	Diff t-test		-0.41***			
Total primary energy consumption per capita (quadrillion Btu)	Full	751	96.77	141.12	0.46	1173.89
	Developed	132	209.77	96.46	49.02	592.92
	Developing	619	72.68	137.43	0.46	1173.89
	Diff t-test		-137.09***			
Electric power consumption (KWh)	Full	695	1.05E11	3.65E11	8151928	4.13E12
	Developed	132	3.31E11	7.03E11	3.41E09	4.13E12
	Developing	563	5.16E10	1.86E11	8151928	3.02E12
	Diff t-test		-2.79E11			

Table 2.2 – Continued

Variable	Statistics					
	Sample	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Fossil fuel energy consumption	Full	650	68.92	28.46	3.02	102.07
(% of total)	Developed	132	75.02	18.92	18.54	97.72
	Developing	518	67.37	30.24	3.02	102.07
	Diff t-test		-7.65***			

Notes: The gross enrolment ratio can exceed 100% due to the inclusion of over-aged and under-aged students because of early or late school entrance or grade repetition.***, **, * denote statistical significance at 1%, 5% and 10% respectively.

Table 2.3: Results of the baseline model with per capita GDP growth as the dependent variable using two different measures for the education variable over the period 1981 to 2009

	Model I		**Model II**		**Model III**		**Model IV**		**Model V**		**Model VI**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	0.035	(0.041)	0.045	(0.031)	0.084	(0.038)**	0.086	(0.033)***	0.081	(0.033)**	0.084	(0.034)**
Initial GDP	-0.016	(0.003)***	-0.016	(0.002)***	-0.016	(0.003)***	-0.015	(0.002)***	-0.015	(0.002)***	-0.014	(0.002)***
Investment	0.027	(0.004)***	0.028	(0.004)***	0.031	(0.005)***	0.030	(0.004)***	0.031	(0.004)***	0.031	(0.004)***
Pop. growth	-0.003	(0.001)*	-0.002	(0.001)**	-0.002	(0.001)*	-0.002	(0.001)**	-0.002	(0.001)**	-0.003	(0.001)***
Prim. Enrol	0.011	(0.008)										
Sec. Enrol	0.002	(0.004)	0.010	(0.003)***								
Tertiary Enrol	0.004	(0.002)**			0.005	(0.002)***						
Prim. Yr. Sch							0.002	(0.004)				
Sec. Yr. Sch							0.004	(0.003)	0.006	(0.002)***		
Tert. Yr. Sch							0.002	(0.002)			0.004	(0.001)**
Inf. Mort.	-0.010	(0.003)***	-0.009	(0.002)***	-0.010	(0.003)***	-0.010	(0.002)***	-0.011	(0.002)***	-0.010	(0.002)***
Terms of trade	0.007	(0.005)	0.009	(0.004)**	0.005	(0.005)	0.007	(0.004)*	0.007	(0.004)*	0.007	(0.004)*
Inflation	-0.027	(0.009)***	-0.028	(0.009)***	-0.018	(0.007)***	-0.021	(0.007)***	-0.019	(0.006)***	-0.020	(0.006)***
R2	0.2838		0.274		0.2705		0.2758		0.2642		0.262	
Observations	534		588		565		648		648		648	
Countries	130		130		130		130		130		130	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table 2.4: Results of the baseline model including energy consumption with per capita GDP growth as the dependent variable using two different measures for the education variable over the period 1981 to 2009

Panel A: Results of estimation												
	Model I		**Model II**		**Model III**		**Model IV**		**Model V**		**Model VI**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	0.057	(0.042)	0.074	(0.034)**	0.108	(0.04)***	0.108	(0.035)***	0.106	(0.035)***	0.109	(0.035)***
Initial GDP	-0.021	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***	-0.019	(0.003)***
Investment	0.026	(0.004)***	0.027	(0.004)***	0.029	(0.005)***	0.029	(0.004)***	0.029	(0.004)***	0.029	(0.004)***
Pop. growth	-0.003	(0.001)*	-0.003	(0.001)**	-0.002	(0.001)*	-0.002	(0.001)**	-0.002	(0.001)**	-0.003	(0.001)***
Prim. Enrol	0.014	(0.008)*										
Sec. Enrol	-0.001	(0.004)	0.008	(0.003)***								
Tertiary Enrol	0.004	(0.002)*			0.004	(0.002)**						
Prim. Y. Sch							0.002	(0.004)				
Sec. Y. Sch							0.003	(0.003)	0.004	(0.002)***		
Tert. Y. Sch							0.001	(0.002)			0.003	(0.002)*
Inf. Mort.	-0.009	(0.003)***	-0.009	(0.002)***	-0.010	(0.003)***	-0.010	(0.002)***	-0.010	(0.002)***	-0.010	(0.002)***
Tot. En./Capita	0.006	(0.002)***	0.005	(0.002)**	0.004	(0.002)**	0.005	(0.002)**	0.005	(0.002)***	0.005	(0.002)***
Terms of trade	0.007	(0.005)	0.009	(0.004)**	0.005	(0.004)	0.007	(0.004)*	0.007	(0.004)*	0.007	(0.004)*
Inflation	-0.029	(0.01)***	-0.029	(0.01)***	-0.019	(0.007)***	-0.021	(0.007)***	-0.020	(0.006)***	-0.021	(0.006)***
R2	0.2959		0.2827		0.2784		0.2758		0.2784		0.2780	
Observations	534		588		565		648		565		565	
Countries	130		130		130		130		130		130	
Panel B: F-test (Joint Significance)												
$\beta_{Prim.Enrol} = \beta_{Sec.Enrol}$ $\beta_{Ter.Enrol} = \beta_{Inf.Mort.}$ $\beta_{Tot.En./Capita} = 0$	8.94 (0.000)		9.40 (0.000)		10.88 (0.000)		7.63 (0.000)		12.57 (0.000)		12.21 (0.000)	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table 2.5: Results of the baseline model including energy consumption in different measures with per capita GDP growth as the dependent variable using secondary enrolment ratio as a proxy for education over the period 1981 to 2009

Panel A: Results of estimation						
	Model I		**Model II**		**Model III**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	0.074	(0.034)**	0.035	(0.034)	-0.017	(0.003)
Initial GDP	-0.020	(0.003)***	-0.015	(0.002)***	-0.017	(0.003)***
Investment	0.027	(0.004)***	0.028	(0.004)***	0.028	(0.005)***
Pop. growth	-0.003	(0.001)**	-0.003	(0.001)**	-0.003	(0.001)**
Sec. Enrol	0.008	(0.003)***	0.008	(0.003)**	0.003	(0.004)
Inf. Mort.	-0.009	(0.002)***	-0.007	(0.003)***	-0.010	(0.003)***
Tot. En/ Capita	0.005	(0.002)**				
Elec. Consum.			0.001	(0.0005)**		
Fossil fuel					0.008	(0.002)***
Terms of trade	0.009	(0.004)**	0.005	(0.005)	0.003	(0.005)
Inflation	-0.029	(0.01)***	-0.029	(0.01)***	-0.027	(0.009)***
R^2	0.2827		0.2902		0.3154	
Observations	588		535		500	
Countries	130		130		130	
Panel B: The Wald Test (Joint Significance)						
$\beta_{Prim.Enrol} = \beta_{Sec.Enrol}$ $\beta_{Ter.Enrol} = \beta_{Inf.Mort.}$ $\beta_{Tot.En./Capita} = 0$	10.88 (0.000)		6.07 (0.001)		7.73 (0.000)	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table 2.6: **Results of the oil exporting and developed countries interaction terms**

Panel A: Results of estimation				
	Model I		**Model II**	
Regressors	Coef.	Std.Err	Coef.	Std.Err
Constant	0.078	(0.034)**	0.089	(0.038)**
Initial GDP	-0.020	(0.003)***	-0.018	(0.003)***
Investment	0.026	(0.004)***	0.026	(0.004)***
Pop. growth	-0.003	(0.001)**	-0.002	(0.001)**
Sec. Enrol	0.009	(0.003)***	0.007	(0.003)**
Inf. Mort.	-0.008	(0.002)***	-0.013	(0.003)***
Tot. En./capita	0.004	(0.002)**	0.002	(0.002)
Terms of trade	0.008	(0.004)**	0.008	(0.004)**
Inflation	-0.029	(0.01)***	-0.028	(0.01)***
D^{OC}	-0.093	(0.062)		
$D^{OC} \times InitialGDP$	-0.012	(0.014)		
$D^{OC} \times Investment$	0.059	(0.02)***		
$D^{OC} \times Pop.Growth$	-0.003	(0.003)		
$D^{OC} \times Sec.Enrol.$	-0.005	(0.032)		
$D^{OC} \times Inf.Mort.$	-0.018	(0.013)		
$D^{OC} \times Tot.En./capita$	0.020	(0.01)**		
D^{DC}			0.007	(0.082)
$D^{DC} \times InitialGDP$			-0.009	(0.006)
$D^{DC} \times Investment$			0.003	(0.011)
$D^{DC} \times Pop.Growth$			-0.006	(0.004)
$D^{DC} \times Sec.Enrol.$			-0.005	(0.008)
$D^{DC} \times Inf.Mort.$			-0.022	(0.006)***
$D^{DC} \times Tot.En./capita$			0.010	(0.004)*
Observations	588		588	
R^2	0.312		0.312	
Countries	130		130	
Panel B: F-test (Joint Significance)				
$\beta_{Prim.Enrol} = \beta_{Sec.Enrol}$ $\beta_{Ter.Enrol} = \beta_{Inf.Mort.}$ $\beta_{Tot.En./Capita} = 0$	2.37 (0.022)		9.94 (0.000)	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Figure 2.1: The neoclassical growth model

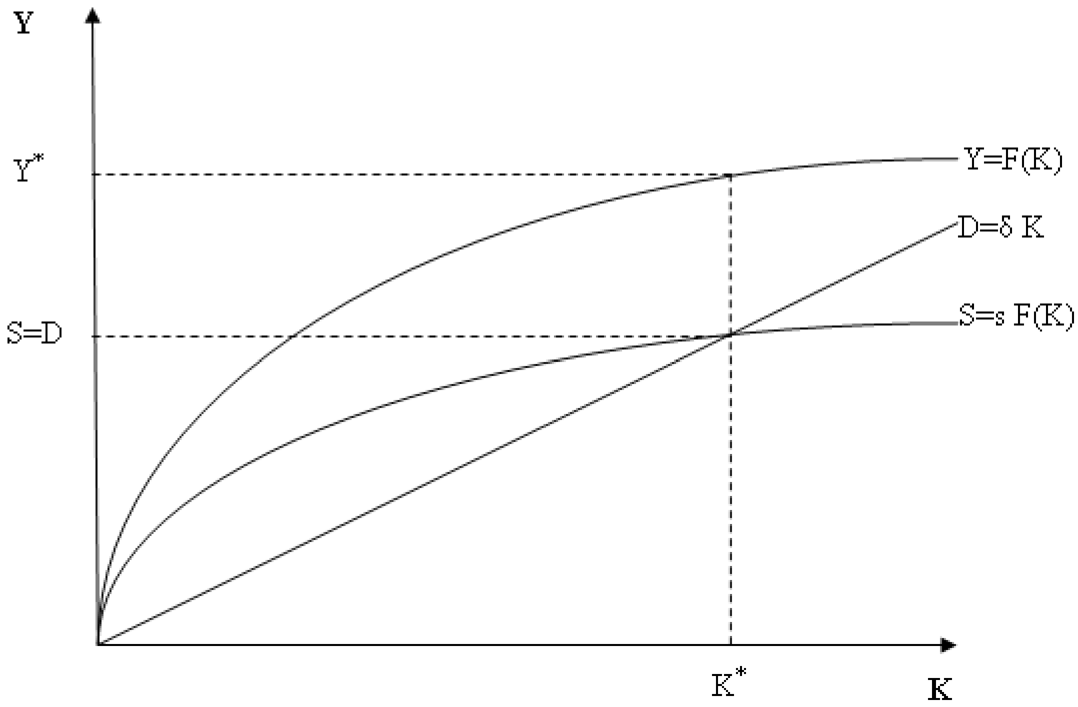


Figure 2.2: Growth rate vs. life expectancy

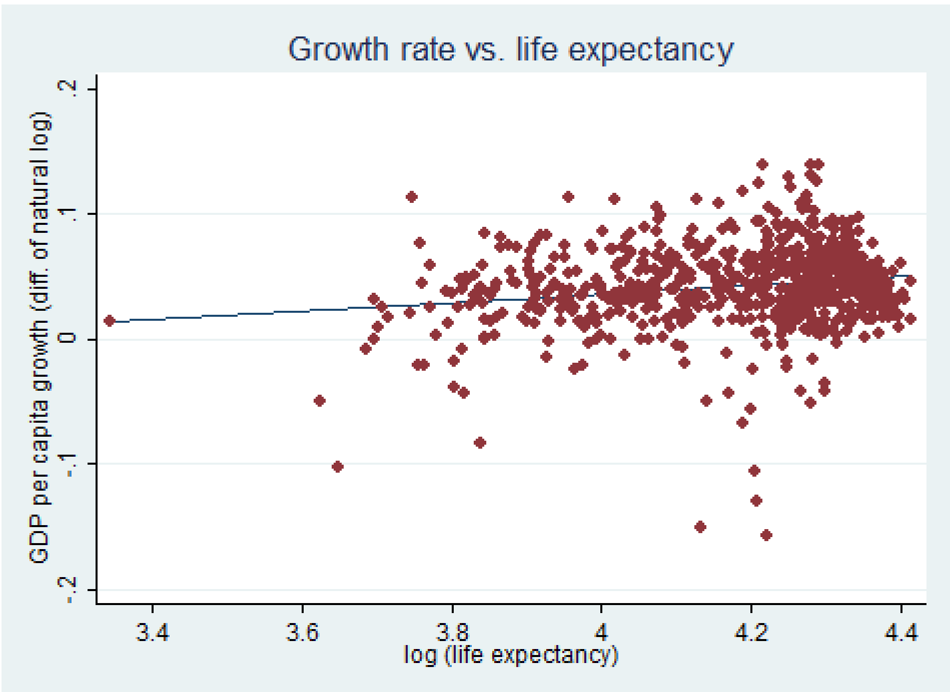


Figure 2.3: Growth rate vs. infant mortality rate

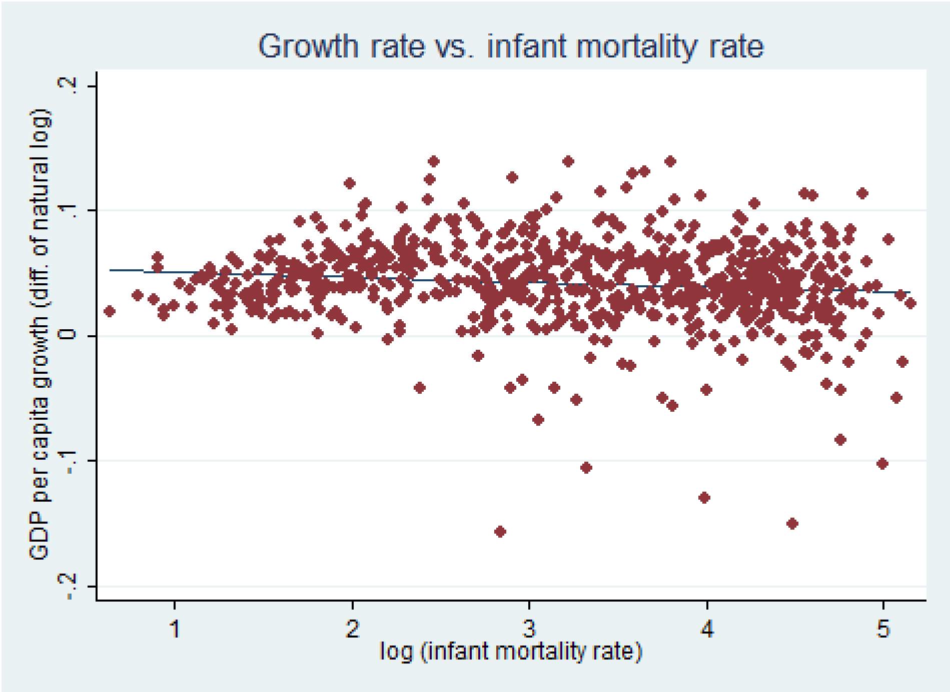


Figure 2.4: Growth rate vs. secondary enrolment ratio

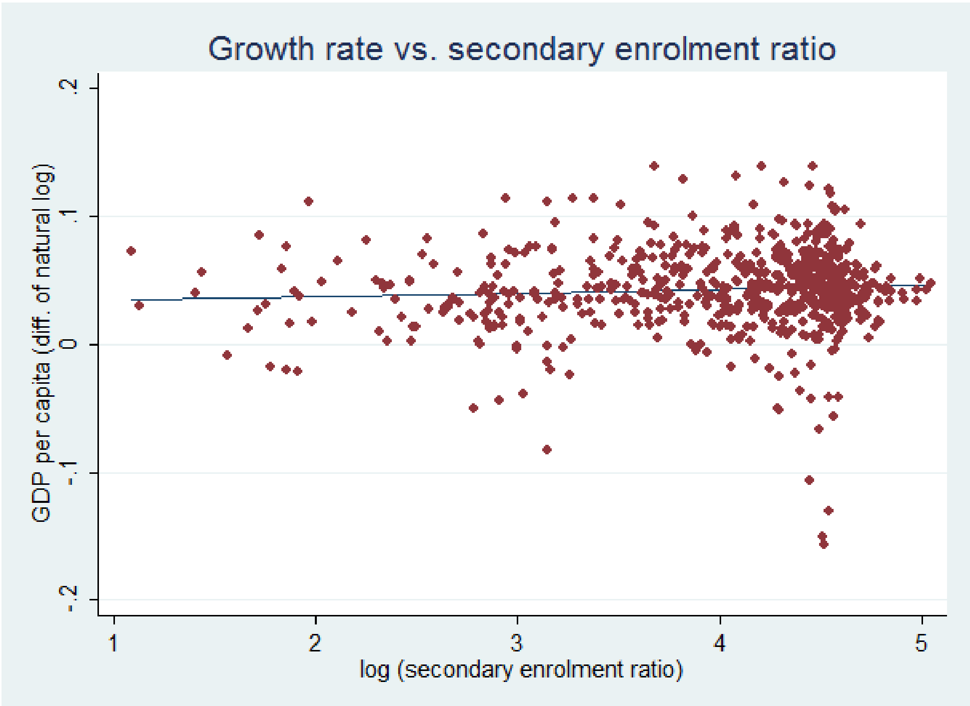


Figure 2.5: Growth rate vs. total energy consumption

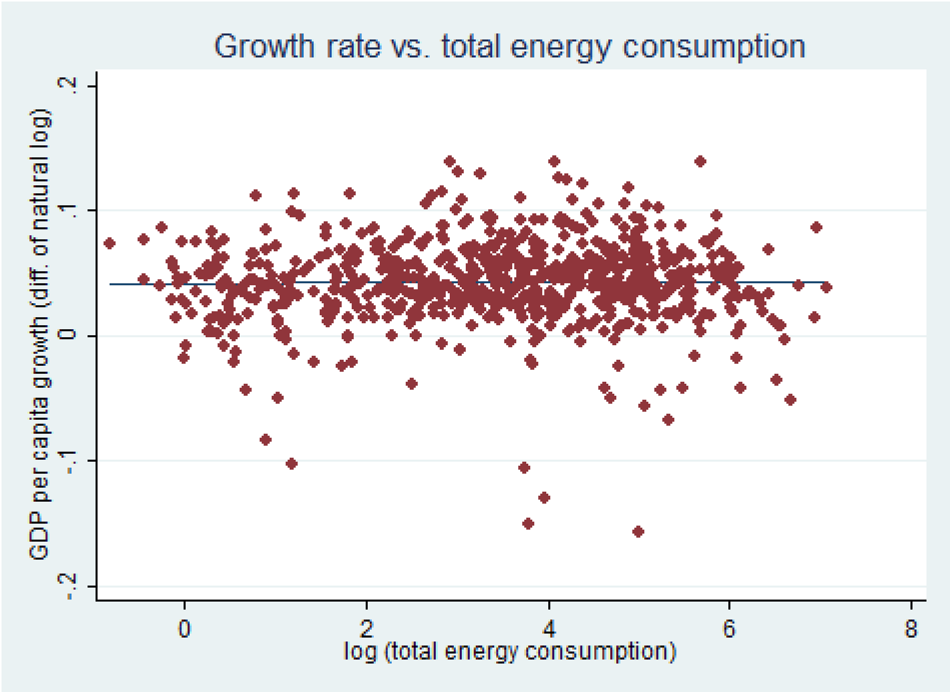


Figure 2.6: Growth rate vs. Investment

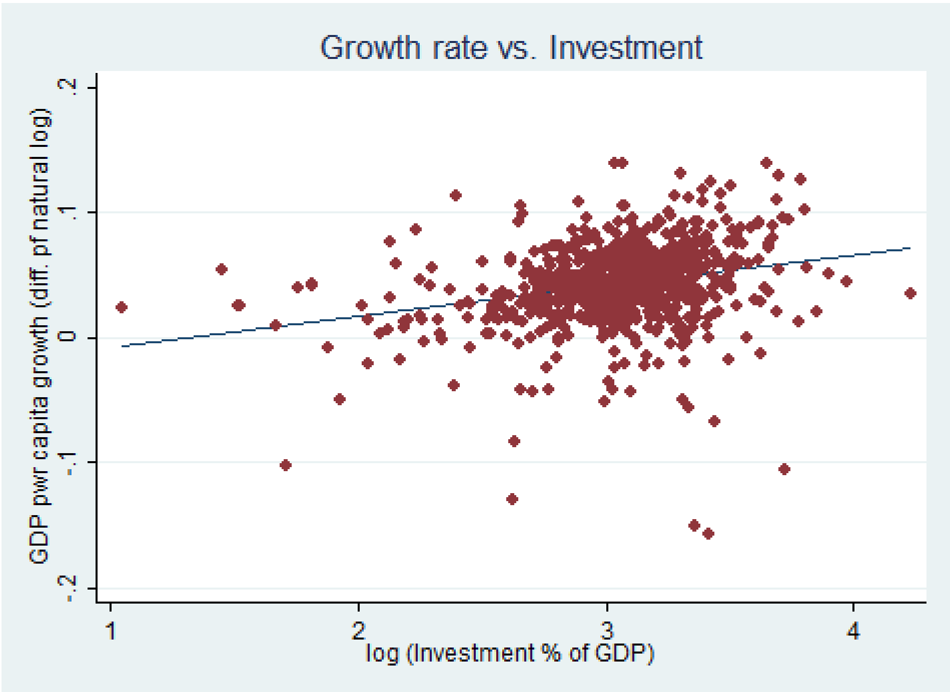
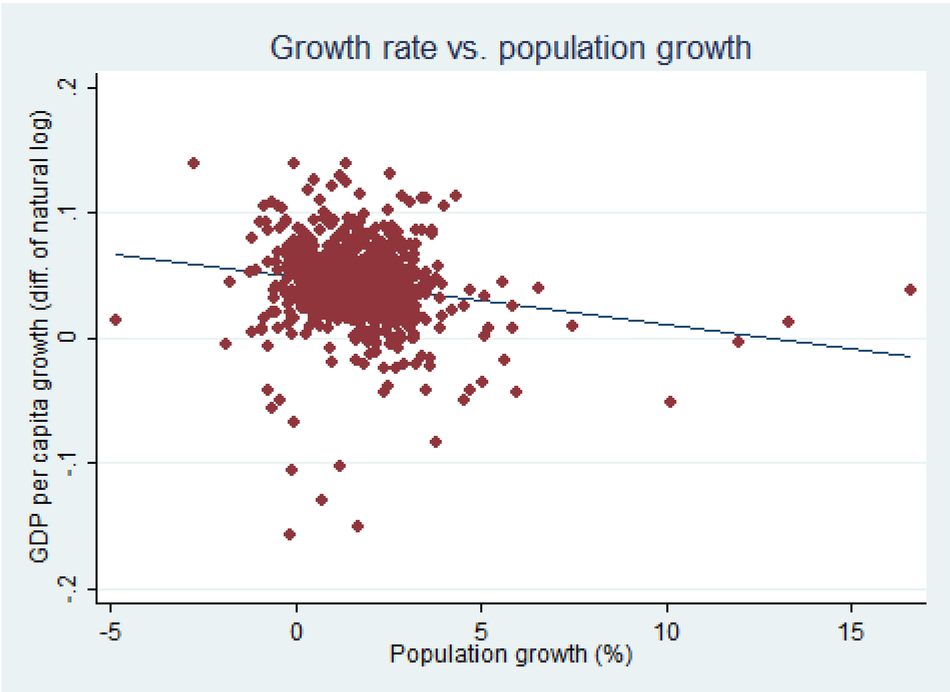


Figure 2.7: **Growth rate vs. population growth**



Appendix A: Some more results

Table A2.1: List of countries included in the samples

Full Sample					Developed	Oil-Exporting
Algeria	Czech Republic	Iran	Mozambique	Slovenia	Australia	Algeria
Argentina	Cte d'Ivoire	Italy	Namibia	South Africa	Austria	Kazakhstan
Armenia	D. Republic of Congo	Jamaica	Nepal	Spain	Belgium	Kuwait
Australia	Denmark	Japan	Netherlands	Sri Lanka	Canada	Libya
Austria	Dominican Republic	Jordan	New Zealand	Sudan	Denmark	Iran
Bahrain	Ecuador	Kazakhstan	Niger	Swaziland	Finland	Qatar
Bangladesh	Egypt	Kenya	Norway	Sweden	France	Russia
Barbados	El Salvador	Korea	Pakistan	Switzerland	Germany	Saudi Arabia
Belgium	Estonia	Kuwait	Panama	Syria	Greece	UAE
Belize	Fiji	Kyrgyz Republic	Papua New Guinea	Tajikistan	Iceland	Venezuela
Benin	Finland	Latvia	Paraguay	Tanzania	Ireland	
Bolivia	France	Lesotho	Peru	Thailand	Italy	
Botswana	Gabon	Libya	Philippines	The Gambia	Japan	
Brazil	Germany	Lithuania	Poland	Togo	Netherlands	
Brunei Darussalam	Ghana	Luxembourg	Portugal	Tunisia	New Zealand	
Bulgaria	Greece	Malawi	Qatar	Turkey	Norway	
Burundi	Guatemala	Malaysia	Republic of Congo	Uganda	Portugal	
Cambodia	Guyana	Maldives	Yemen	Ukraine	Spain	
Cameroon	Haiti	Mali	Romania	UAE	Sweden	
Canada	Honduras	Malta	Russia	UK	Switzerland	
C. African Republic	Hong Kong SAR	Mauritania	Rwanda	USA	United Kingdom	
Chile	Hungary	Mauritius	Saudi Arabia	Uruguay	United States	
China	Iceland	Mexico	Senegal	Venezuela		
Colombia	India	Moldova	Sierra Leone	Vietnam		
Croatia	Indonesia	Mongolia	Singapore	Zambia		
Cyprus	Ireland	Morocco	Slovak			

Table A2.2: Correlation matrix of education (enrolment rates) and health capital variables

	Prim. enrol.	Sec. enrol.	Ter. enrol.	Life expec.	Infant mort.
Prim. enrol.	1				
Sec. enrol.	0.6297	1			
Ter. enrol.	0.4652	0.8623	1		
Life expec.	0.5321	0.86	0.8314	1	
Inf. Mort.	-0.3631	-0.7767	-0.7744	-0.8668	1

Table A2.3: Correlation matrix of education (average years of schooling) and health capital variables

	Prim. sch.	Sec. sch.	Ter. sch.	Life expec.	Infant mort.
Prim. sch.	1				
Sec. sch.	0.5264	1			
Ter. sch.	0.5429	0.7521	1		
Life expec.	0.6479	0.6473	0.6038	1	
Inf. Mort.	-0.704	-0.6974	-0.6766	-0.8568	1

Table A2.4: Results of the baseline model with per capita GDP growth as the dependent variable using two different measures for the education variable over the period 1981 to 2009 (534 observations)

	Model I		**Model II**		**Model III**		**Model IV**		**Model V**		**Model VI**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	0.035	(0.041)	0.054	(0.035)	0.072	(0.035)**	0.085	(0.037)**	0.077	(0.036)**	0.086	(0.037)**
Initial GDP	-0.016	(0.003)***	-0.016	(0.003)***	-0.015	(0.003)***	-0.016	(0.003)***	-0.015	(0.003)***	-0.015	(0.002)***
Investment	0.027	(0.004)***	0.028	(0.004)***	0.029	(0.004)***	0.029	(0.004)***	0.030	(0.004)***	0.030	(0.004)***
Pop. growth	-0.003	(0.001)*	-0.003	(0.001)*	-0.003	(0.001)*	-0.003	(0.001)*	-0.003	(0.001)**	-0.003	(0.001)**
Prim. Enrol	0.011	(0.008)										
Sec. Enrol	0.002	(0.004)	0.009	(0.003)***								
Tertiary Enrol	0.004	(0.002)**			0.005	(0.002)***						
Prim. Y. Sch							0.004	(0.004)				
Sec. Y. Sch							0.004	(0.003)	0.008	(0.003)***		
Tert. Y. Sch							0.003	(0.002)			0.005	(0.002)***
Inf. Mort.	-0.010	(0.003)***	-0.010	(0.003)***	-0.009	(0.003)***	-0.008	(0.003)***	-0.010	(0.003)***	-0.009	(0.003)***
Terms of trade	0.007	(0.005)	0.008	(0.005)*	0.007	(0.005)	0.007	(0.005)	0.008	(0.004)**	0.008	(0.005)*
Inflation	-0.027	(0.009)***	-0.027	(0.009)***	-0.027	(0.009)***	-0.027	(0.009)***	-0.026	(0.009)***	-0.027	(0.009)***
R2	0.2838		0.2748		0.2764		0.2839		0.2781		0.2758	
Observations	534		534		534		534		534		534	
Countries	130		130		130		130		130		130	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table A2.5: Results of the baseline model including energy consumption with per capita GDP growth as the dependent variable using two different measures for the education variable over the period 1981 to 2009

	Model I		**Model II**		**Model III**		**Model IV**		**Model V**		**Model VI**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	0.057	(0.042)	0.086	(0.038)**	0.100	(0.037)***	0.106	(0.038)***	0.101	(0.037)***	0.109	(0.038)***
Initial GDP	-0.021	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***	-0.020	(0.003)***
Investment	0.026	(0.004)***	0.027	(0.004)***	0.028	(0.004)***	0.028	(0.004)***	0.028	(0.004)***	0.028	(0.004)***
Pop. growth	-0.003	(0.001)*	-0.003	(0.001)**	-0.003	(0.001)**	-0.003	(0.001)**	-0.003	(0.001)**	-0.003	(0.001)**
Prim. Enrol	0.014	(0.008)*										
Sec. Enrol	-0.001	(0.004)	0.007	(0.003)**								
Tertiary Enrol	0.004	(0.002)*			0.004	(0.002)**						
Prim. Y. Sch							0.004	(0.004)				
Sec. Y. Sch							0.003	(0.003)	0.006	(0.003)**		
Tert. Y. Sch							0.002	(0.002)			0.004	(0.002)**
Inf. Mort.	-0.009	(0.003)***	-0.009	(0.003)***	-0.008	(0.003)***	-0.008	(0.003)***	-0.009	(0.003)***	-0.009	(0.003)***
Tot. En./Capita	0.006	(0.002)***	0.005	(0.002)**	0.005	(0.002)***	0.005	(0.002)**	0.005	(0.002)**	0.005	(0.002)***
Terms of trade	0.007	(0.005)	0.008	(0.005)*	0.007	(0.005)	0.007	(0.005)	0.008	(0.005)*	0.008	(0.005)*
Inflation	-0.029	(0.01)***	-0.028	(0.01)***	-0.028	(0.01)***	-0.029	(0.01)***	-0.028	(0.01)***	-0.028	(0.01)***
R^2	0.2959		0.2859		0.2886		0.2928		0.2883		0.2871	
Observations	534		534		534		534		534		534	
Countries	130		130		130		130		130		130	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table A2.6: Results of the baseline model including energy consumption in different measures with per capita GDP growth as the dependent variable using secondary enrolment ratio as a proxy for education over the period 1981 to 2009

	Model I		**Model II**		**Model III**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	0.085	(0.045)*	0.024	(0.04)	0.096	(0.042)**
Initial GDP	-0.020	(0.003)***	-0.015	(0.003)***	-0.018	(0.003)***
Investment	0.032	(0.005)***	0.032	(0.005)***	0.028	(0.005)***
Pop. growth	-0.004	(0.002)**	-0.003	(0.002)**	-0.003	(0.002)**
Sec. Enrol	0.004	(0.004)	0.007	(0.004)*	0.0005	(0.004)
Inf. Mort.	-0.008	(0.003)**	-0.008	(0.003)**	-0.012	(0.003)***
Tot. En/ Capita	0.007	(0.002)***				
Elec. Consum.			0.002	(0.001)**		
Fossil fuel					0.010	(0.003)***
Terms of trade	0.005	(0.005)	0.004	(0.005)	0.004	(0.005)
Inflation	-0.028	(0.01)***	-0.027	(0.01)***	-0.026	(0.009)***
R^2	0.319		0.3116		0.3243	
Observations	458		458		458	
Countries	130		130		130	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table A2.7: Results of the oil exporting and developed countries interaction terms

Regressors	**Model I** Coef.	Std.Err	**Model II** Coef.	Std.Err
Constant	0.091	(0.038)**	0.107	(0.042)**
Initial GDP	-0.020	(0.003)***	-0.019	(0.003)***
Investment	0.025	(0.004)***	0.026	(0.004)***
Pop. growth	-0.003	(0.002)**	-0.003	(0.001)*
Sec. Enrol	0.007	(0.003)**	0.006	(0.003)*
Inf. Mort.	-0.008	(0.003)***	-0.014	(0.003)***
Tot. En./capita	0.005	(0.002)**	0.003	(0.002)
Terms of trade	0.0007	(0.004)	0.008	(0.005)*
Inflation	-0.028	(0.01)***	-0.027	(0.01)***
D^{OC}	-0.053	(0.067)		
$D^{OC} \times InitialGDP$	-0.016	(0.015)		
$D^{OC} \times Investment$	0.054***	(0.02)		
$D^{OC} \times Pop.Growth$	-0.002	(0.003)		
$D^{OC} \times Sec.Enrol.$	0.01	(0.033)		
$D^{OC} \times Inf.Mort.$	-0.031	(0.014)**		
$D^{OC} \times Tot.En./capita$	0.016	(0.01)*		
D^{DC}			-0.021	(0.085)
$D^{DC} \times InitialGDP$			-0.007	(0.006)
$D^{DC} \times Investment$			0.004	(0.011)
$D^{DC} \times Pop.Growth$			-0.006	(0.005)
$D^{DC} \times Sec.Enrol.$			-0.004	(0.009)
$D^{DC} \times Inf.Mort.$			-0.024	(0.006)***
$D^{DC} \times Tot.En./capita$			0.010	(0.005)**
Observations	534		534	
R^2	0.3231		0.3177	
Countries	130		130	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Table A2.8: Results of the oil exporting and developed countries interaction terms with the three different levels of education

	Model I		Model II	
Regressors	Coef.	Std.Err	Coef.	Std.Err
Constant	0.058	(0.042)	0.081	(0.046)*
Initial GDP	-0.021	(0.003)***	-0.019	(0.003)***
Investment	0.024	(0.004)***	0.025	(0.004)***
Pop. growth	-0.003	(0.002)**	-0.002	(0.001)*
Prim. Enrol	0.016	(0.008)**	0.013	(0.008)*
Sec. Enrol	-0.001	(0.005)	-0.002	(0.005)
Ter. Enrol.	0.004	(0.002)*	0.004	(0.002)**
Inf. Mort.	-0.008	(0.003)***	-0.014	(0.003)***
Tot. En./capita	0.005	(0.002)**	0.003	(0.002)
Terms of trade	0.005	(0.004)	0.007	(0.005)
Inflation	-0.029	(0.010)***	-0.028	(0.009)***
D^{OC}	-0.079	(0.085)		
$D^{OC} \times InitialGDP$	-0.015	(0.024)		
$D^{OC} \times Investment$	0.056	(0.020)***		
$D^{OC} \times Pop.Growth$	-0.002	(0.003)		
$D^{OC} \times Prim.Enrol.$	0.006	(0.053)		
$D^{OC} \times Sec.Enrol.$	-0.005	(0.033)		
$D^{OC} \times Ter.Enrol.$	0.005	(0.009)		
$D^{OC} \times Mortality$	-0.027	(0.024)		
$D^{OC} \times Tot.En./capita$	0.020	(0.013)		
D^{DC}			0.009	(0.142)
$D^{DC} \times InitialGDP$			-0.006	(0.007)
$D^{DC} \times Investment$			0.005	(0.012)
$D^{DC} \times Pop.Growth$			-0.006	(0.005)
$D^{DC} \times Prim..Enrol.$			-0.013	(0.025)
$D^{DC} \times Sec.Enrol.$			0.004	(0.01)
$D^{DC} \times Ter.Enrol.$			-0.005	(0.006)
$D^{DC} \times Mortality$			-0.023	(0.006)***
$D^{DC} \times Tot.En./capita$			0.010	(0.005)**
Observations	534		534	
R^2	0.3359		0.3275	
Countries	130		130	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Appendix B: GMM results

Table B2.1: **Results of the baseline model including energy consumption with per capita GDP growth as the dependent variable using two different measures for the education variable over the period 1981 to 2009 (GMM estimation)**

Panel A: Results of estimation						
	Model I		**Model II**		**Model III**	
Regressors	Coef.	Std.Err	Coef.	Std.Err	Coef.	Std.Err
constant	-0.289	(0.161)*	-0.093	(0.200)**	0.098	(0.267)***
Initial GDP	-0.046	(0.011)***	-0.063	(0.017)***	-0.064	(0.020)***
Investment	0.049	(0.024)**	0.096	(0.025)**	0.079	(0.023)***
Pop. growth	-0.004	(0.003)	0.002	(0.003)	-0.0004	(0.002)
Prim. Enrol	0.099	(0.046)**				
Sec. Enrol	-0.023	(0.017)	0.042	(0.021)**		
Tertiary Enrol	0.007	(0.005)			0.022	(0.011)**
Prim. Y. Sch						
Sec. Y. Sch						
Tert. Y. Sch						
Mortality	-0.015	(0.007)**	-0.020	(0.010)**	-0.017	(0.008)**
Tot. En./Capita	0.022	(0.006)**	0.015	(0.008)*	0.019	(0.007)***
Terms of trade	0.036	(0.013)***	0.049	(0.020)**	0.040	(0.029)
Inflation	-0.066	(0.042)	-0.105	(0.054)**	-0.063	(0.031)**
R2						
Observations	423		522		502	
Countries	122		125		125	
Panel B: Diagnostic tests						
J-test	44.74		20.45		26.18	
J, *p*-value	0.179		0.117		0.200	
AR(2)	0.61		-0.48		-1.43	
AR(2), *p*-value	0.539		0.634		0.151	

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively. Standard errors are calculated using robust estimator in Stata 11.0.

Appendix C: F-Test

The t-statistic is useful for hypothesis testing of regression coefficients and sample means. However, when the hypothesis is complicated comprising multiple regression coefficients, it requires different test statistic and a different null distribution. After R. A. Fisher who first developed the statistic as the variance ratio in the 1920's, this test is called the F-test and its null distribution is F-distribution.

The general strategy of F-test is that there is a larger model, the unrestricted model:

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots + \beta_k X_{ki} + u_i \tag{C.1}$$

and a smaller model (restricted model) that is obtained by deleting some variables from the larger one such that the null hypothesis is

$$H_0 : \beta_4 = \beta_5 = \beta_6 = 0 \tag{C.2}$$

or by putting some linear restrictions on one or more coefficients of the larger model such as

$$H_0 : \beta_2 = \beta_3 \tag{C.3}$$

These hypotheses or restrictions can be tested using the F-test formula:

$$F = \frac{RSS_R - RSS_{UR}/m}{RSS_{UR}/n - k} \tag{C.4}$$

where

- RSS_R: Residual sum of squares of the restricted model
- RSS_{UR}: Residual sum of squares of the unrestricted model
- m: number of linear restrictions
- k: number of parameters including the intercept in the unrestricted model
- n: number of observations

The F-test can also be expressed in terms of

$$F = \frac{R^2_{UR} - R^2_R/m}{1 - R^2_{UR}/n - k} \tag{C.5}$$

where R^2_R and R^2_{UR} are the R^2 values obtained from the restricted and unrestricted models, respectively. After computing the F ratio, the decision rule must be used. That is if the computed F exceeds $F_\alpha(m, n-k)$ where $F_\alpha(m, n-k)$ is the critical

F at the α level of significance, the null hypothesis is rejected: otherwise it is not rejected.

For example, to test the null hypothesis that the slopes of education, health capital and energy consumption are zero in Column 1 in Table 2.4. That is, the null hypothesis would be

$$H_0 : \beta_{PrimEnrol} = \beta_{SecEnrol} = \beta_{TerEnrol} = \beta_{Inf.Mort.} = \beta_{Tot.En./Capita} = 0$$

The model stated in Equation C.4 which is the unrestricted model is run and the RSS_{UR} is reported. Then the same model is run without the education, health capital and energy variables and the RSS_R is reported.

The results obtained are:

RSS_{UR}= 0.307532983

RSS_R= 0.333826576

$m = 5$

$k = 11$

$n = 534$

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)} = \frac{(0.333826576 - 0.307532983)/5}{0.307532983/(534-11)} = 8.94 > 3.1100$$

$$F_\alpha(5, 523) \approx 3.1100$$

Since the F value is greater than the critical value at 1% level of significance, then, the null hypothesis can be rejected.

Chapter 3

The Effect of Oil and Stock Price Volatility on Firm Level Investment: The Case of UK Firms

3.1 Introduction

Firms encounter enormous uncertainty about future situations influencing their costs, demand and profitability. This uncertainty may emerge from purely economic shocks such as productivity and tastes, or policy shocks such as monetary and fiscal innovations. In an ideal situation where information is perfect and the future is certain, profit maximizing firms are able to decide on the optimum number of projects. In practice, however, for firms to decide the suitable number and amounts of investments is usually very complicated, and this can lead to either over or under investment. The role of future conditions is predominantly remarkable when firms must make a decision on precious irreversible investment such as producing a new good, selling in a new market or embracing a technology. In these cases, firms may choose to wait for present conditions to be adequately good or for uncertainty about future conditions to be sufficiently low before they invest.

Economic theory and existing literature is yet to present a clear-cut conclusion on the sign of the investment-uncertainty relationship. On the one hand, Hartman (1972) and Abel (1983) conclude that investment decisions are influenced positively by uncertainty, especially, when the marginal earning of capital is a convex function of stochastic variables. On the other hand, Pindyck (1988) assumes an asymmetric adjustment cost function of capital and presents a negative relationship between investment and uncertainty.

There are two types of uncertainty that might affect the firms' investment decisions. The source of uncertainty could be idiosyncratic, that is firm specific and uncorrelated to the overall market; or macroeconomic uncertainty, that is economy wide-risks that are exogenous to the operation of the firm and difficult to hedge against. Studies propose that both idiosyncratic and macroeconomic uncertainty have a significant impact in setting the optimal level of firms' investment. Bo (2002) finds that idiosyncratic demand uncertainty is more important in explaining firm investment than total uncertainty that mixes idiosyncratic uncertainty with other sources of uncertainty. In contrast, Caballero and Pindyck (1996) demonstrate that aggregate (industrial-wide) uncertainty is more important than idiosyncratic uncertainty for the industry equilibrium investment. Baum et al. (2008), who use a panel of U.S. firms, find that increases in firm-specific and capital asset pricing model (CAPM)-based measures affect investment spending significantly and negatively, while market-based uncertainty affects it positively.

One of the major sources of uncertainty is oil prices. Among the prices of various sources of energy, the price of oil is probably the most important (Chardon, 2007). Crude oil represents the largest share of global energy demand, and it is expected to be the controlling source of energy for at least the next 20 years, overriding coal, natural gas, renewable energy sources and nuclear energy (Energy Information Administration (EIA), 2006). At the national economic level, oil price volatility is used as a guide for U.S. monetary policy and possibly serving as an important indicator variable (Serletis and Kemp, 1998). Therefore, a large number of studies have explored the macroeconomic effects of oil price changes. Empirical and theoretical studies generally find that oil price increases negatively affect macroeconomic activities (Hamilton, 1983, 1996, 2003, Mork, 1989, Mork et al., 1994, Jiménez-Rodríguez and Sanchez, 2005, Jimenez-Rodriguez, 2009). Kilian (2008) argues that increases in energy prices receive attention not only because of negative consequences on real economic activities, but also because energy prices are comparatively volatile in contrast with prices of other goods, considered to be exogenous to the domestic economy, and due to the relative inelasticity in the demand for energy.

In comparison with the work done on the impact of energy or oil prices on aggregate economies, relatively few empirical studies have explored the impact of oil or energy prices on investment decisions at the industry or firm level. Authors who have paid attention to the effect of oil price shocks at the industry level are Jiménez-Rodríguez (2008) who investigates the pattern of output responses to an oil price shock in six different industries including France, Germany, Italy, Spain, the UK, and the US. Other studies such as Lee and Ni (2002), Kilian and Park (2009) and Herrera (2008) have focused on US industries. While Lee and Ni (2002) analyzed the impact of oil price shocks on output in manufacturing industries, Kilian and Park (2009) and Herrera (2008) investigated the effects on industry-level stock returns and on industry-level inventory-sales, respectively.

Regarding firm level studies, Bernanke (1983) illustrates that it is optimal for firms to defer irreversible investment expenses when they encounter increased uncertainty about future oil prices. In addition, Mohn and Misund (2009), Ratti et al. (2011), Yoon and Ratti (2011), Henriques and Sadorsky (2011) and Lee et al. (2011) study the effect of energy/oil price volatility on firms' investment. While Yoon and Ratti (2011), Henriques and Sadorsky (2011) and Lee et al. (2011) analyze the impact of oil price volatility on the investment of non-financial U.S. firms; Ratti et al. (2011) and Mohn and Misund (2009) examine the relationship on non-financial firms in 15 European countries and on 115 international oil and gas companies, respectively. Although Ratti et al. (2011) estimate their model using data from 15 European countries including the United Kingdom, they investigate the effect of the relative price of energy not the uncertainty on firm level investment. A noticeable gap in the literature is that previous empirical studies have concentrated on non-financial and manufacturing firms and focused on U.S. companies. Therefore, in this chapter, a Q model of investment is augmented with measures of industry specific uncertainty that is proxied by oil price volatility. The impact of oil price volatility on investment is investigated by dividing the UK firms into financial and non-financial firms. In addition, this chapter investigates the non-linear relationship between firm investment and oil price volatility.[16]

Another source of uncertainty that is of no less importance in comparison to oil price volatility, is market instability. The relationship between stock market prices and firm investment has been investigated for a long time, but it remains an open question whether the stock market has actual consequences. Empirical evidence of the information function of the stock market in setting investment spending is mixed. Morck et al. (1990) examine aggregate and firm level data and deduce that the stock market may not simply be a sideshow (has no effect on real economic activity), but neither is it very central. In contrast, Barro (1990) using aggregate data, reports a significant autonomous role to the stock market. In favor of that, Chen et al. (2007) employ firm level data and conclude that the stock market supplies firms with useful information.

The stock market fulfills three tasks at the firm level. First, it is a provenance of financing investment. When managers think that the stock of their company is overvalued, they may decide that it is the perfect time to proceed into equity-fund raising. Second, the stock market is an incentive for corporate governance. The remuneration of firm managers is linked to the performance of stock market, therefore, the stock market may affect the investment decisions that are taken by firm managers, which ultimately influences firm investment. Third, the stock market transfers information to firm managers concerning the quality of their investment decisions. This chapter considers the relationship between stock price volatility and

[16]Using a large panel of non-financial U.S. companies, Henriques and Sadorsky (2011) examine the U shape relationship between oil price uncertainty and investment.

UK firm investment. Generally, the significant results obtained from the empirical work of this chapter show that the UK stock market can predict investment because they transmit useful information to managers that help in making investment decisions.

The estimation results obtained from the robust two-step GMM show that investment decisions are affected significantly by both industry specific and financial market uncertainty. There is a negative relationship between industry specific uncertainty and investment spending, whereas financial market uncertainty affects investment positively.

The rest of the chapter is organized as follows. Section 3.2 presents a review of the theoretical background and empirical studies on investment and uncertainty. The model employed is outlined in section 3.3. Section 3.4 summarizes the estimation technique that has been followed. A detailed tour of the data set is the subject of section 3.5. Empirical work and results are presented and discussed in section 3.6, before some concluding remarks that are displayed in section 3.7.

3.2 Theoretical Background and Literature Review

3.2.1 Irreversibility and the ability to wait

Economics defines investment as the act of sustaining an instant cost in the anticipation of future rewards. According to Dixit and Pindyck (1994), most investment decisions comprise three different features. First, the investment is partially or fully irreversible which means that the initial cost of investment cannot be recovered once it is installed. Second, there is uncertainty over the future remunerations from the investment. Third, the action of investment can be deferred to get more information about the future. These three features interact to determine the optimal decisions for investors.

For a firm to decide whether to invest in a new factory or not with the presence of uncertainty over future market conditions, economics books generally apply a simple rule to solve such problems. First, calculate the present value of the anticipated flow of profits generated by this investment. Then, calculate the present value of the flow of expenses required. The difference between the two, which is the net present value (NPV) of the investment determines whether to invest or not. The green light for investment is when the NPV is greater than zero. The NPV rule is the foundation for the neoclassical theory of investment which depends on the standard incremental approach of the economist: invest until the value of an extra unit of capital is just equal to its cost. The neoclassical theory of investment was based on the assumption that the future is certain.

Much of the theoretical and empirical literature on the economics of investment depends on this principle. For example, Jorgenson (1963) matches the per period value of the marginal product of a unit with the equivalent per period cost. The other formula, due to Tobin (1969), contrasts the capitalized value of the marginal investment to its purchase cost. This ratio, that is called Tobin's Q, determines the investment decisions. If Q exceeds 1, the investment should go ahead, however, if Q is less than 1, the existing capital should be reduced and the investment should not be undertaken. The optimal rate of growth or contraction is when the marginal cost of adjustment is equal to its benefits. In all of this, the implied principle is the basic NPV rule.

Unfortunately, this basic principle is based on some assumptions that are often neglected. In particular, it assumes that either the investment is reversible (it can by some means be withdrawn and the expenses retrieved when the market conditions are getting worse), or, if the investment is irreversible, it is a now or never offer. While some investments meet these conditions, most of them do not. Irreversibility and the prospect of deferment are very remarkable characteristics of most investment in actuality. It has been shown that the capability to defer an irreversible investment expenditure can thoroughly affect the decision to invest. This leads to the need for a different approach to analyzing investment decisions other than the simple NPV rule.

The new research on investment insists on the fact that the firm has opportunities to invest and must decide the most suitable way to utilize these opportunities. A firm with an opportunity to invest is holding an option similar to a financial call option that it has the right to buy an asset at some future time of its choice. Therefore, when a firm undertakes irreversible investment expenditure, it practices its option to invest. It concedes the possibility of looking forward to get more information that might affect the desirability or timing of the expenditure. This missing option value is an opportunity cost that must be added to the cost of the investment. Studies have shown that this cost of investment can be huge and the investment decision makers that ignore this cost can be excessively in error. In addition, this opportunity cost is crucial to uncertainty over the future value of the investment. This may help to clarify the failure of neoclassical investment theory in providing perfect empirical models of investment behaviour.

Being aware that an investment opportunity is similar to a financial call option helps in understanding the decisive role that uncertainty plays in investment timing. In the case of the financial call option, the more volatile is the stock price on which the option is written, the more worthwhile is the option and the greater is the incentive to wait and keep the option rather than killing it. This is the same with the capital investment opportunity. The more the uncertainty over the prospective profitability of the investment, the greater the value of the opportunity and the greater the motivation to wait and keep the option rather than exercising it by investing now. Uncertainty plays a role in the traditional NPV rule where nondiversifiable uncertainty enters the risk premium, which is added to the discount rate that is used in calculating present values. But in the case of the options of investment, uncertainty has a more central role. A slight increase in uncertainty might cause a remarkable postponement for some investments (such as those that involve the exercising of options like the construction of a factory), and a substantial acceleration for others (such as those that create options or expose information like R & D programs). Real options theory is used by Dixit and Pindyck (1994) to show that when investment is irreversible, an increase in uncertainty leads to an increase in the option value of postponement which delays investment decisions.

Hartman (1972) and Abel (1983) develop theoretical models that anticipate a positive impact of uncertainty on investment. However, they assume constant returns to scale technology, risk neutrality and perfect competition. With these assumptions, anticipated profits present a convex function of future prices. Therefore, an increment in uncertainty about future prices will cause greater expected future profits which will increase the number of investments with positive NPV. However, Caballero (1991) demonstrates that the results obtained using these models are highly conditional on the assumptions of perfect competition and constant returns to scale technology. Therefore, introducing an adequate amount of imperfect competition or reducing returns to scale (decreasing marginal return to capital assumption) is sufficient to produce a non-convex profits function which leads to an undetermined relationship between uncertainty and investment. These insights into the behaviour of investors encouraged a great number of studies at the aggregate, industry and firm level which seek to subject the connection between investment and uncertainty and the impacts of irreversibility on investment timing, to empirical investigation.

According to a survey by Carruth et al. (2000), who review the growing body of investment-uncertainty literature, increased uncertainty, at both aggregate and disaggregate levels, causes lower investment rates. This implies that there is evidence of an irreversibility effect, under which higher uncertainty increases the value of the call option to postpone investments. Moreover, panel data techniques have also triggered a variety of empirical studies, most of which are supportive of the negative relationship between uncertainty and investment (Bond et al., 2005). On the other hand, Sarkar (2000) points out that the probability of investing would increase as uncertainty increases and thereby has a positive impact on investment.

It is clear that uncertainty can take many forms. Firms may be uncertain about wages and future prices, or about future productivity. The origin of uncertainty may be changes in consumer's tastes, technology, or institutions. Carruth et al. (2000) reviewed eight firm level empirical studies, which employ different uncertainty measures and reach different conclusions about the investment-uncertainty relationship. Four of them including Campa (1993), who employs the volatility of the exchange rate, Huizinga (1993), who uses the volatility of real wages, output prices and material prices, Ghosal and Loungani (1996) with output prices volatility and Guiso and Parigi (1999) with the utilization of firm's insight about future product demand, conclude that firm's investment is influenced negatively by uncertainty. The other listed four studies comprising Goldberg (1993) and Campa and Goldberg (1995) who employ exchange rate volatility, Leahy and Whited (1996) who utilize forecast of return variance and Driver et al. (1996) using market share turbulence, obtain either a weak or insignificant impact of uncertainty on investment.

Economic theory proposes that both types of uncertainty (idiosyncratic and macroeconomic) compete in defining the optimal level of firm's investment. For example, Caballero and Pindyck (1996) conclude that aggregate uncertainty (industry-wide) has a larger impact on industry equilibrium investment than idiosyncratic uncertainty (firm-level). Conversely, Bo (2002) argues that idiosyncratic uncertainty is more important in explaining firm investment than total uncertainty, which mixes idiosyncratic uncertainty with other sources of uncertainty. Baum et al. (2008) investigate the impact of firms' stock returns uncertainty and market uncertainty on the investment of a panel of US firms. They find a negative and significant impact of firm specific uncertainty on investment, whereas, market based uncertainty has a positive impact on investment.

Empirical studies on the investment-uncertainty relationship include Price (1996), who investigates the effect of the manufacturing output uncertainty and finds that uncertainty has a large and significant effect on both the rate of adjustment to, and the steady state level of, investment. Beaudry et al. (2001) investigate the impact of macroeconomic uncertainty (measured by inflation uncertainty) on investment expenditures and find that it has a significant negative impact on investment. Likewise, Bloom et al. (2007) indicate that in periods of high uncertainty, firms become more cautious and hence, considerably decrease their investment. Rashid (2011) scrutinizes the responsiveness of investment to two types of uncertainty employing a large panel of UK private manufacturing firms. Particularly, he tests the effect of financial market volatility (macroeconomic uncertainty) measured by the return of treasury bill rates, as well as idiosyncratic uncertainty proxied by sales volatility. His results suggest that both financial market and idiosyncratic uncertainty affect investment negatively and significantly.

3.2.2 Oil Price Volatility and Investment

It is documented in the literature that shocks to oil prices affect the real economy. Hamilton (1983), Mork (1989), Lee et al. (1995) and Jimenez-Rodriguez (2009), among others, assert the negative impact of oil price increases on real US GDP. Oil prices may affect economic activity through several different channels, or transmission mechanisms. The real balances and monetary policy channel posits that oil price increases lead to increases in the overall level of prices, thereby reducing real money balances held by households and firms and ultimately aggregate demand. Lee et al. (2001), Cunado and Pérez de Gracia (2005) and Cologni and Manera (2008), among others, report similar findings of a negative relationship between oil price uncertainty and the aggregate economy for other countries. Bernanke's (1983) study presents one of the foremost research that indicates that it is better for firms facing high uncertainty about the oil price to postpone irreversible investment expenditures. High oil price uncertainty causes a rise in the option value of waiting to invest and hence, the inducement to invest decreases. He argues that such uncertainty about the return to investment at the firm level may create cyclical fluctuations in aggregate investment. Oil price volatility may influence investment decisions through the channel of increasing the uncertainty behind energy input, which has an effect on the marginal product of capital (Pindyck, 1991). Uri (1980) presents an econometric examination of the role of the change in energy prices on US aggregate and industrial level investment. His results show that the price of energy is an important factor in adequately explaining investment decisions .

The fluctuation in the oil price is an essential subject to investigate due to its importance for the production side of the economy. Oil is a substantial input in the production of most goods and services. While a large number of firms do not use crude oil per se, they do employ its products, such as heating oil and gasoline, which are all extracted from crude oil. This has motivated researchers to investigate the effect of oil price volatility on firm level investment decisions. Mohn and Misund (2009) employ a panel of 115 international oil and gas companies to scrutinize the influence of oil price volatility on investment expenditure. They utilize two proxies for uncertainty, macroeconomic uncertainty and industry-specific uncertainty measured by stock price and oil price volatility, respectively. The estimated models suggest that macroeconomic uncertainty affects investment negatively whereas industry-specific uncertainty has a stimulating impact. With the aid of an error correction model of capital adjustment, Yoon and Ratti (2011) examine the effect of energy price uncertainty on a very large panel of U.S. manufacturing firms. They conclude that higher energy price uncertainty makes the firms more cautious by decreasing the reactivity of investment to sales growth. Henriques and Sadorsky (2011) investigate how oil price volatility affects the strategic investment decisions of a large panel of non-financial publicly traded U.S. companies. They employ the Q model of investment and augment it with cash flow and oil price volatility. Their empirical results show that there is a U shaped relationship between oil price volatility and firm investment. Lee et al. (2011) examine the effect of real oil price shocks on firm-level investment, both directly and in interaction with firm stock price uncertainty and with firm sales growth. Using a large panel of U.S. manufacturing firms, they conclude that oil price shocks affect firms' investment negatively in interaction with firm stock price uncertainty. The firms that are facing higher uncertainty are affected by oil price volatility more than the firms with less uncertainty. Ratti et al. (2011) utilize a dynamic model of investment, that is based on the Euler equation approach, to investigate the effect of the relative price of energy on firm-level investment. They study the effect using data on non-financial firms in 15 European countries across 25 industries. Results reveal that stabilizing the relative price of energy would help stabilize firm investment and this benefit would increase in smaller and medium sized firms. However, their model does not include uncertainty. We are not aware of previous microeconometric studies of UK firm level data that address the relationship between investment and oil price volatility.

3.2.3 The Stock Market and Investment

The fact that stock returns predict investment is well established. Morck et al. (1990) present four views that can reasonably account for the correlation between stock market returns and the level of investment. The first view, termed the 'passive informant hypothesis', suggests that the market does not paly a significant function in assigning investment funds. It asserts that the mangers of the firm are more informed about the investment opportunities facing the firm compared to the public and researchers. Therefore, the stock market does not supply the manager with useful information that helps in making investment decisions. The market might inform the manager about the market participants thoughts about the firm's investment but that does not affect his decision. Therefore, this sideshow vision of the stock market suggests not only that investor opinion does not influence investment, but also that the manager does not learn anything from the stock market price.

The second theory, called the 'active informant hypothesis', allocates a major role to the stock market. It suggests that stock prices predict investment because they transmit useful information to managers that help in making investment decisions. This information can accurately, or inaccurately, predict future fundamentals. The market can pass on a variety of information that visualizes the intrinsic uncertainty facing a firm, for instance, future demand. In addition, the stock market can expose investor's estimation of the efficiency of the firm's managers and their capability to make adequate investments.

The previous two hypotheses propose that the function of the stock market is to transmit information either to the econometrician, as in the first hypothesis, or to the manager, as in the second case. The remaining two views allocate the stock market a more effective role. It is believed that the stock market plays an important role in helping firms raise capital. According to Fischer and Merton (1985), the valuation that the market specifies to a firm's equity defines the cost of capital to that firm. The higher the valuation, the cheaper is the equity. In an efficient stock market, firms cannot find a specific beneficial time to conduct equity finance. However, when the sentiment of the investor affects the stock market, firms can undertake equity finance when the market overvalues them, which leads to low capital cost.

Finally, the stock market pressure hypothesis suggests that the stock market may affect investment by exerting pressure on managers. The example that is posited by Fischer and Merton (1985) describes the case when the investors dislike oil companies and depreciate the prices of their shares, then for fear of being fired or taken over, oil companies managers might attempt to disinvest and diversify, even if additional investment in oil is advantageous.

In the literature on the information function of the stock market in manager's decisions of investment, as Galeotti and Schiantarelli (1994) note, there are two contradictory clarifications. The classical clarification, such as that of von Furstenberg (1977) and Fischer and Merton (1985), proposes that if the aim of the firm's managers is to maximize the existing shareholders' wealth, then they should comply to the valuation of the market even if the market value diverges from the true value of the firm. The opposed clarification asserts that once one controls for fundamentals like profits and sales, the additional explanatory power of stock prices for corporate investment, while statistically significant, is quite limited in economic terms, both in firm level and aggregate data (Morck et al., 1990, Blanchard et al., 1993, Stein, 1996).

Empirical evidence on the information function of the stock market in determining investment decisions is also mixed. Morck et al. (1990) examine both firm and aggregate level data and draw a conclusion that the stock market may not be a perfect sideshow, but neither is it very central. On the other hand, Barro (1990) employs aggregate data and finds that lagged changes in real stock market prices have a great deal of explanatory power for the growth rate of investment. Using a large panel of COMPUSTAT[17] non-financial firms, Baker et al. (2003) find that the stock market has a stronger impact on the investment of equity-dependent firms (firms that need external equity to finance marginal investments), which implies that the

[17] Compustat is a database of financial, statistical and market information on active and inactive global companies throughout the world.
https://www.capitaliq.com/home/what-we-offer/information-you-need/financials-valuation/compustat-financials.aspx

investment of different firms respond to the stock market differently as a result of their specific financial constraints. Chen et al. (2007) also use an unbalanced panel of COMPUSTAT firms and show that stock prices have a strong positive effect on the sensitivity of corporate investment. Their results suggest that firm managers learn from the private information in the stock price about their own firms' fundamentals and incorporate this information in the corporate investment decisions. Likewise, Baum et al. (2008) who investigate the relationship between uncertainty and investment in US firms, conclude that market based uncertainty has a positive link with investment. In contrast, Rashid (2011) finds that UK private manufacturing firm's investment significantly decreases as financial market uncertainty increases. Wang et al. (2009) investigate the relationship between Chinese firm level investment and the stock market, and find that there is no significant response to stock market valuation due to the little information that is carried by the stock prices about the future operating performance of firms.

3.2.4 Agency theory

Arrow (1971) and Wilson (1968), among others, explored risk sharing between individuals or groups. This literature represented the risk-sharing problem as one that occurs when cooperating parties have different attitudes toward risk. Agency theory expanded this risk-sharing literature to encompass the so-called agency problem. The agency problem usually refers to a conflict of interest between a company's management and the company's stockholders. The manager, acting as the agent for the shareholders, or principals, is supposed to make decisions that will maximize shareholder wealth. However, it is in the manager's own best interest to maximize his own wealth. While it is not possible to eliminate the agency problem completely, the manager can be motivated to act in the shareholders' best interests through incentives such as performance-based compensation, direct influence by shareholders, the threat of firing and the threat of takeovers. Therefore, the main reasons behind the agency problem are information asymmetries and incentive incompatibilities. The managers who are making the decisions of investment are more informed about the NPV of the investments than the higher level managers, owners and shareholders. Managers are stimulated to invest in projects that give them private returns that are higher than that for the organization as a whole. This will lead to over investment at the firm level. Realizing the possibility of agency problems, financial institutions may have less interest to provide loans for the sake of investment. As a result, it will be more complicated and expensive (in the matter of higher costs of equity and debt) for firms to be funded. Financing restrictions can impede firms from issuing profitable opportunities.

3.2.5 The link between leverage and investment

The effect of debt on firm investment has been discussed. One of the views suggests that the relationship between debt and investment could be negative. The idea, that is raised by Myers (1977), claims that debt overhang leads to an underinvestment problems for the firm that has growth prospects. The underinvestment phenomenon occurs from agency costs between shareholders and debtholders. As a result of debt load, shareholders avoid letting the assets of the firm be diluted by debtholders, consequently, they oppose affording equity capital to carry out new investment. With the assumption that managers of the firm act to the advantage of the shareholders, the managers will sacrifice projects with positive NPV due to the deficiency in capital. Jensen (1986) suggests that the obligation of debt repayment decreases the amount of available free cash flow which will reduce unnecessary investment spending. Other types of negative impact of debt on investment are linked with capital market imperfections. Myers (1984) formulates the pecking order theory of financing, which illustrates that firms' financing comes from three sources, internal funds, debt and new equity. Hence, internal financing is used first; when that is depleted, then debt is issued, and when it is no longer sensible to issue any more debt, equity is issued. This shows that costs of debt financing for investment are more than that of internal funds. Therefore, a firm that has a lower liquidity will encounter higher costs of external capital, which prevents investment.

In contrast, there may be a positive association between debt and firm investment. For instance, Ross (1977) presents the signalling hypothesis of debt financing. He considers managers are issuing debt because they are optimistic about future productivity of the firm.[18] Therefore the debt signalling hypothesis indicates that more debt implies more investment. Grossman and Hart (1982) believe that the stress of bankruptcy as a result of debt payback obligation may motivate managers to work harder and take better investment decisions.

[18] When a company agrees to take on more debt, it is making a commitment to pay interest on the debt. In doing so, it is showing that the company is in a stable financial situation. Conversely, when the amount of future debt is reduced, investors may see this as a sign that the company is unable to make its interest payments and is in a weak financial situation.

3.3 The Model

Tobin's Q theory, which was developed by Tobin (1969), gave rise to one of the most popular empirical models of investment. This model links investment to the ratio Q which will be applied in this chapter to estimate the investment model. Tobin's Q corresponds to the ratio of the market value of the firm's existing shares to the replacement cost of the firm's physical assets. It states that if Q is greater than one, additional investment in the firm would make sense because the profits generated would exceed the cost of the firm's assets. If Q is less than one, the firm would be better off selling its assets instead of trying to put them to use. The idea states that when Q is approximately equal to one, the firm is in equilibrium.

Under the standard neoclassical assumptions about the behavior of the firm, Bond and Van Reenen (2007) showed that the following linear relationship is implied by the Q model of investment:

$$\frac{I_{it}}{K_{it}} = a + \frac{1}{b} Q_{it} + \varepsilon_{it} \tag{3.1}$$

where I_{it} is gross investment of the firm, K_{it} is the firm fixed capital stock, Q_{it} is the ratio of the market value of a firm to the replacement value of the firm's assets and ε_{it} is the error term. In empirical specifications, Equation (3.1) is usually expanded with fixed effects for cross section and time with the addition of other explanatory variables under concern. In this study, supplemental variables are cash flow (cf_{it}), leverage (Lev_{it}), oil price volatility (σ_t^{oil}) and stock price volatility (σ_t^{stock}).

The model will be firstly augmented with measures of oil price (σ_t^{oil}) and stock price (σ_t^{stock}) volatilities each individually as follows:

$$\frac{I_{it}}{K_{it}} = a + \frac{1}{b}\, Q_{it} + \phi\, \sigma_t + \eta_i + \mu_t + \varepsilon_{it} \tag{3.2}$$

where σ_t is a measure of oil or stock price volatility, η_i and μ_t are firm and year fixed effect terms, respectively.

Then the model is estimated with the additional variables such as cash flow (cf_{it}) and leverage (Lev_{it}) as can be seen in the following equation:

$$\frac{I_{it}}{K_{it}} = a + \frac{1}{b}\, Q_{it} + \phi_1\, cf_{it} + \phi_2\, Lev_{it} + \phi_3\, \sigma_t + \eta_i + \mu_t + \varepsilon_{it} \tag{3.3}$$

Fazzari and Petersen (1988, 1993) concluded that the existence of any information asymmetry in the relationship between shareholders/ managers and creditors has consequences for companies that want to access external finance. These authors showed that companies that are financially constrained in terms of their debt capacity tend to use internal finance to a greater extent, measured by company cash flow, to finance their investment than companies that are not constrained in this way. Financing constraints may hinder firms from tracking profitable investment opportunities.

Most of the previous empirical studies that scrutinize the relationship between uncertainty and investment have employed stock returns, exchange rates or sales to model uncertainty. Adjustments in investment spending by firms are anticipated to be influenced by energy price shocks. According to Bernanke (1983) and Pindyck (1991), uncertainty about future oil prices causes firms to postpone irreversible investment decisions. Therefore, the main objective for this chapter is to scrutinize the link between oil price volatility and firm level investment.

With firm level data over a large number of years, the error term ε is likely to be serially correlated. Following Mohn and Misund (2009), the error term ε is assumed to follow an AR(1) process:

$$\varepsilon_{it} = \rho\varepsilon_{i,t-1} + \nu_{it} \tag{3.4}$$

where ν_{it} is white noise.[19] Substituting the equivalent of ε_{it} from Equation (3.3) and the lag of it into Equation (3.4) yields the following dynamic firm investment:

$$\begin{aligned}\frac{I_{it}}{K_{it}} &= a(1-\rho) + \rho(\frac{I_{i,t-1}}{K_{i,t-1}}) + \frac{1}{b}Q_{it} - \frac{\rho}{b}Q_{i,t-1} + \phi_1 cf_{it} - \rho\phi_1 cf_{i,t-1} \\ &+ \phi_2 Lev_{it} - \rho\phi_2 Lev_{i,t-1} + \phi_3\sigma_t - \rho\phi_3\sigma_{t-1} + (1-\rho)\eta_i + \mu_t \\ &- \rho\mu_{t-1} + \nu_{it}\end{aligned} \tag{3.5}$$

For econometric purposes, Equation (3.5) is written as:

$$\begin{aligned}\frac{I_{it}}{K_{it}} &= \beta_0 + \beta_1(\frac{I_{i,t-1}}{K_{i,t-1}}) + \beta_2 Q_{it} + \beta_3 Q_{i,t-1} + \beta_4 cf_{it} + \beta_5 cf_{i,t-1} + \beta_6 Lev_{it} \\ &+ \beta_7 Lev_{i,t-1} + \beta_8\sigma_t + \beta_9\sigma_{t-1} + (1-\rho)\eta_i + \mu_t - \rho\mu_{t-1} + \nu_{it}\end{aligned} \tag{3.6}$$

[19] Serial correlation in the error term is due to the effect of omitted variables which may be themselves serially correlated. A transformation of the model may be able to remove serial correlation in the error, but may not remove the contamination of omitted variables serial correlation. Therefore, this can be solved by finding proper instruments and using the first lag of the dependent variable and the lags of other independent variables will solve this issue. This chapter uses the system GMM methodology that utilizes these instruments. Moreover, no second order serial correlation (AR(2)) in the first difference of the disturbance term should be observed which examines the key identifying assumption that the level of the disturbances term are serially uncorrelated needed for some lagged instruments to be valid and GMM estimates to be consistent Arellano and Bond (1991).

The model in equation (3.6) will be augmented with oil price volatility square to test for the nonlinear relationship between uncertainty and investment.

$$\frac{I_{it}}{K_{it}} = \beta_0 + \beta_1(\frac{I_{i,t-1}}{K_{i,t-1}}) + \beta_2 Q_{it} + \beta_3 Q_{i,t-1} + \beta_4 cf_{it} + \beta_5 cf_{i,t-1} + \beta_6 Lev_{it}$$
$$+ \beta_7 Lev_{i,t-1} + \beta_8 \sigma_t^{oil} + \beta_9 \sigma_{t-1}^{oil} + \beta_{10}(\sigma_t^{oil})^2 + \beta_{11}(\sigma_{t-1}^{oil})^2 + (1-\rho)\eta_i$$
$$+ \mu_t - \rho\mu_{t-1} + \nu_{it} \quad (3.7)$$

While estimating the impact of oil price volatility on firm level investment, equation (3.6) does not allow us to test whether the effects of oil price volatility on investment in oil and gas producer firms is statistically different from that in other non-financial firms. To examine this point, the model in equation (3.6) is augmented so that the variable under study (σ_t^{oil}) can have a different slope over the oil and gas producer firms. Therefore, a dummy variable (oil) is created and set to one if the firm is categorized as an oil and gas producer and zero otherwise. In order to investigate the differential impact of oil price volatility on the oil and gas producer firms, the dummy variable (oil) is interacted with oil price volatility (σ_t^{oil}). Specifically, the following model is estimated:

$$\frac{I_{it}}{K_{it}} = \beta_0 + \beta_1(\frac{I_{i,t-1}}{K_{i,t-1}}) + \beta_2 Q_{it} + \beta_3 Q_{i,t-1} + \beta_4 cf_{it} + \beta_5 cf_{i,t-1} + \beta_6 Lev_{it}$$
$$+ \beta_7 Lev_{i,t-1} + \beta_8 \sigma_t^{oil} + \beta_9 \sigma_{t-1}^{oil} + \beta_{10}(\sigma_t^{oil} \times oil) + \beta_{11}(\sigma_{t-1}^{oil} \times oil)$$
$$+ (1-\rho)\eta_i + \mu_t - \rho\mu_{t-1} + \nu_{it} \quad (3.8)$$

3.4 Estimation Technique

3.4.1 Construction of the oil and stock prices volatility proxies

Oil price volatility is measured based on the generalized autoregressive conditional heteroscedasticity model, GARCH (1, 1) originally proposed by Bollerslev (1986). Hansen and Lunde (2005) try different approaches to measure uncertainty and find that nothing beats a GARCH (1, 1) model. Sadorsky (1999), Radchenko (2005), Yoon and Ratti (2011), Henriques and Sadorsky (2011) and Chen and Hsu (2012) use the GARCH (1, 1) to compute oil price volatility. In addition, stock price volatility is computed using GARCH (1, 1) (Antoniou and Holmes, 1995). Daily oil and stock price returns will be estimated using GARCH (1, 1) model that is formulated as follows:

Mean equation

$$r_t = \mu + \varepsilon_t \quad (3.9)$$

Variance equation

$$h_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}^2 \tag{3.10}$$

where r_t is the daily oil price return, μ is the average return and ϵ_t is the residual returns defined as:

$$\varepsilon_t = h_t z_t \tag{3.11}$$

and z_t is the standardized residual returns where $z_t \sim N(0, 1)$.
h_t^2 is the conditional variance which is considered as the one period ahead forecast variance based on the past information. The conditional variance equation consists of three terms:

- ω: is the constant term, $\omega > 0$
- ε_{t-1}^2: the ARCH term which shows the volatility from the previous period
- h_{t-1}^2: the GARCH term which shows the previous period variance

Equation (3.10) says that the conditional variance of ε at time t depends not only on the squared error term in the previous time period (as in ARCH(1)), however, it also depends on its conditional variance in the previous time period.
For GARCH (1, 1), the constraints $\alpha \geq 0$ and $\beta \geq 0$ are needed to ensure that h_t^2 is strictly positive (Poon, 2005).
Then the annual oil and stock price volatilities h_t are computed as the average of the daily conditional variance:

$$\sigma_t = GARCH_t = \frac{1}{D} \sum_{t=1}^{D} \hat{h}_t^2 \tag{3.12}$$

where $\hat{h}_t^2$ is the fitted value from the GARCH (1, 1) model.

When estimating stock market volatility, day of the week patterns have been examined comprehensively in different markets. Cross (1973), Rogalski (1984) and Aggarwal and Rivoli (1989) state that the distribution of stocks returns differ according to the day of the week. To address this issue, the mean equation of the stock price return is augmented with five daily dummy variables from Monday to Friday. In addition, it is possible that the conditional standard deviation, as a proxy for risk, can affect stock market returns.

Some of the studies in the literature propose the inclusion of some exogenous variables into the GARCH specification. For example, Berument and Kiymaz (2001) and Kiymaz and Berument (2003) allow some exogenous variables to affect volatility of stock market returns by allowing the constant term of conditional variance equation to change for each day of the week. Therefore, the following model is considered to investigate the day of the week effect in both return and volatility equations:

$$\begin{aligned} r_t^{stock} &= \alpha_M D_{Mt} + \alpha_T D_{Tt} + \alpha_W D_{Wt} + \alpha_H D_{Ht} + \alpha_F D_{Ft} + \lambda h_t \\ &+ \theta_1 r_{t-2}^{stock} + \phi_1 \varepsilon_{t-2} + \varepsilon_t \end{aligned} \tag{3.13}$$

$$h_t^2 = V_M D_{Mt} + V_T D_{Tt} + V_W D_{Wt} + V_H D_{Ht} + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}^2 \tag{3.14}$$

where D_M, D_T, D_W, D_H, and D_F are dummy variables for the day of the week from Monday to Friday. h_t is the conditional standard deviation of the return on the market portfolio.

3.4.2 Estimation Procedure

The empirical models presented in Equations (3.6), (3.7) and (3.8) contain η_i, that is the unobservable time invariant firm fixed effects which may be correlated with the other regressors in the model. Therefore, the ordinary least squares method is not suitable for estimating the above models and will yield biased results. OLS estimation assumes that all the explanatory variables are exogenous which may not be the case in investment models. In addition, the correlation between the lagged dependent variable $(I/K)_{t-1}$ and η_i results into inconsistent estimates. The standard solution for the endogeneity problem in a dynamic panel data model is the utilization of exogenous variables that are not correlated with the error term to instrument other endogenous variables. However, it is very difficult to find independent instrumental variables (IV) for this type of firm data study. In addition, since the IV technique neither uses all the related moment conditions, nor accounts for the differenced structure of the error term, the estimates are not efficient.

Arellano and Bond (1991) proposed that the generalized method of moments (GMM) controls for these problems. It utilizes more instruments acquired by employing the orthogonal terms that occur between the error term ν_{it} and the lagged dependent variable. Therefore, GMM takes advantage of all the linear moment restrictions assigned by the model. Although the Arellano and Bond GMM specification of the first differences is preferable over other methods, recent research demonstrates that the difference GMM has the problem of weak instruments. First-differencing of the variables yields a loss of information across cross-section units and exacerbates the biases of measurement error. Arellano and Bover (1995) argue that the lack of information regarding the parameters of the levels of the variables under concern causes a loss of a major part of the total variation in the data. Therefore, they propose the utilization of instruments in first differences for the level equation in addition to the employment of instruments in levels for the first differenced equations. Blundell and Bond (1998) show that the extended GMM estimator by Arellano and Bover (1995) offers spectacular efficiency gains in situations where the first differenced GMM estimator performs poorly. In particular, this is obvious when the estimated coefficient on the lagged dependent variable is close to unity and when the ratio of the variance of unobservable time invariant firm fixed effects to the variance of residuals [variance(η_i)/variance($\nu_{i,t}$)] increases over time. Furthermore, Blundell and Bond (1998) state that combining the lagged first-differenced and lagged levels instruments into the instrument set reduces the finite sample bias by utilizing the supplementary moment conditions from level equations. In addition, they demonstrate that the instruments utilized in the first differenced estimator comprise slight information about the endogenous variables in first differences and the lagged first differences are informative instruments for the endogenous variables in levels. This will result in capturing the variations between firms' characteristics in addition to controlling for individual heterogeneity. Therefore the system version of the GMM estimator (Arellano and Bover, 1995, Blundell and Bond, 1998) is applied.

To describe the GMM estimation method, consider the linear regression model

$$y = X\beta + u \quad u \sim (0, \Omega) \tag{3.15}$$

with X $(N \times K)$ and define an instruments matrix Z $(N \times l)$ where $l \geq$ K.

The l instruments produce a set of l moments

$$g_i(\beta) = Z_i' u_i = Z_i'(y_i - x_i\beta), \quad i = 1, N \tag{3.16}$$

where each g_i is an l vector. Each of the l moment equations is considered as a sample moment, which could be estimated by averaging over N:

$$\bar{g}(\beta) = \frac{1}{N}\sum_{i=1}^{N} Z_i(y_i - x_i\beta) = \frac{1}{N}Z'u \tag{3.17}$$

An estimate that solves $\bar{g}(\hat{\beta}_{GMM}) = 0$ will be chosen by the GMM approach.

Since the GMM estimator uses all l instruments, weighting matrix is employed so that $\hat{\beta}_{GMM}$ is chosen to let $\bar{g}(\beta_{GMM})$ as close to zero as possible.

With $l >$ K, not all l moment conditions can be completely fulfilled. Therefore, as an attempt to improve the efficiency of the estimator, a criterion function that weights them properly is used. The GMM estimator minimizes the criterion:

$$J(\hat{\beta}_{GMM}) = N\bar{g}(\hat{\beta}_{GMM})'W\bar{g}(\hat{\beta}_{GMM}) \tag{3.18}$$

W is an $l \times l$ symmetric weighting matrix.

As a result the GMM estimator of an overidentifyied equation:

$$\hat{\beta}_{GMM} = (X'ZWZ'X)^{-1}X'ZWZ'y \tag{3.19}$$

The optimal weighting matrix according to Hansen (1982), chooses $W = S^{-1}$ where S is the covariance matrix of the moment conditions

$$S = E[Z'uu'Z] = \lim_{N \to \infty} N^{-1}[Z'\Omega Z] \tag{3.20}$$

Thus the GMM estimator in this case is

$$\begin{aligned} \hat{\beta}_{GMM} &= (X'Z\hat{S}^{-1}Z'X)^{-1}(X'Z\hat{S}^{-1}Z'y) \\ &= [X'(Z'\Omega Z)^{-1}Z'X]^{-1}[X'Z(Z'\Omega Z)^{-1}Zy] \end{aligned} \tag{3.21}$$

When applying the system GMM, there is no well-determined procedure to select the best instrument set which may cause the problem of many instruments. This problem can be solved by utilizing the J test of overidentification restrictions (Hansen, 1982) to evaluate the credibility of the instruments employed in the estimation process. The J test statistic tests the null hypothesis that the model is valid.[20] However, the authenticity of the instruments is only asserted if the residuals do not manifest second-order serial correlation. Non-rejection of first order serial correlation is as predicted and does not affect the validity of the differenced equations.

3.5 Data and Statistics

3.5.1 Sample Selection and Variable Construction

The data employed in this chapter are obtained from the Worldscope Database published by Thomson Reuters which is the financial industry's premier source of detailed financial statement data and profile data on public companies domiciled

[20] Arellano and Bond (1991) recommend the Sargan statistic to test the exogeneity of the instruments as a group, with a null hypothesis of invalidity. However, the Sargan statistic is sensitive to heteroscedasticity and autocorrelation, and tends to over-reject in the presence of any of them. Therefore, the Hansen J statistic is reported following Roodman (2009).

outside of the United States of America. Worldscope provides data in a standardized structure and employs different forms for industrial, banks, insurance and other financial firms in order to foster the comparison of the financial data of firms across different countries, industries and via time. The data utilized for this study are collected from Datastream.

As a start, all the firms listed in the London Stock Exchange are downloaded over the period 1986 to 2011. The longest data period starts from January 1986 which is determined by the availability of daily oil price data. Moreover, the more recent data are available till the year 2011 when the sample was downloaded. The Worldscope Database follows a specific style of classification for the firms. Each company is allocated a general industry classification (GIC), which indicates the company is an industrial (01), utility (02), transportation (03), bank/savings & loan (04), insurance (05) or other financial (06) company. All the firms that are unclassified, are excluded from the sample. Then the data are divided into two samples, non-financial and financial firms where the non-financial firms sample include the industrial, utility and transportation firms, whereas the financial firms sample comprise the bank/savings & loan, insurance and other financial firms. To process the data, and following Yoon and Ratti (2011) and Ratti et al. (2011), firm level data is eliminated if a firm has 3 or less years of continuous data, if there are missing values for investment, capital stock and cash flow. In addition, the outliers in the top and bottom 1% of the data are excluded (Gilchrist and Himmelberg, 1999, Whited, 2006). After this screening procedure, the data set for non-financial firms consists of 2694 firms with 29216 firm years with an average of 9.65 years per firm for the non-financial sample. The financial firms sample includes 416 firms with 4224 firm years with an average of 9.14 years per firm.

Firm investment (I) is measured by capital expenditure (Whited, 2006, Henriques and Sadorsky, 2011, Yoon and Ratti, 2011, Ratti et al., 2011). The capital stock (K) is measured using total assets (Mohn and Misund, 2009, Henriques and Sadorsky, 2011). Following (Rajan and Zingales, 1995, Barclay and Smith Jr, 1995, Julio and Yook, 2012), Tobin's Q is measured as:

$$Q = \frac{book\ value\ of\ assets\ -\ book\ value\ of\ equity\ + market\ value\ of\ equity}{book\ value\ of\ assets}$$

where the book value of assets is the total assets, the book value of equity is the common stock and market value of equity is the market capitalization. Cash flow

(CF) is measured by the funds from operations (according to Thomson Datastream's definitions, it is the cash flow of the company). Leverage is measured using debt to total assets ratio (Baum et al., 2010, Aivazian et al., 2005). To control for any possible heteroscedasticity because of the difference in the size of the firms, investment and cash flow are divided by the total assets and the resulting variables are denoted as I/K and CF/K (Cleary et al., 2007).

Tables 3.1 and 3.2 report means and distributional information for all the variables that are employed in this chapter. The average investment rate for the non-financial firms is slightly higher than that of the financial firms' sample, 5.6% and 3.4%, respectively. Cash flow that demonstrates the internal liquidity of the firm has a mean of 3.9% and 1.7% for the non-financial and financial firms, respectively. However, there are 22.4% to 23.1% negative firm year observations in both samples. Almeida and Campello (2007) suggest eliminating firm-year observation with values of Q in excess of 10 as an attempt to address problems in the measurement of investment opportunities in the raw data. As the maximum value of Tobin's Q in the non-financial firms sample is 12.3 which is close to the proposed cut-off point, this might decrease the prospective measurement error problem. Both samples comprise unlevered firms as well as highly levered firms, especially the non-financial firms sample.

Figure (3.1) shows the change in oil price volatility during the period chosen. In particular, oil price increased in year 1990 due to the Gulf war; in year 1999 because of the concerns about the "millennium bug"[21]; in year 2001 which has the September 11, 2001 terrorist offensive on the World Trade Centre in New York; and finally the year 2008 which show the largest increase in oil price.

3.5.2 Oil and stock price data

This section describes the oil and stock prices data sources and the procedure of generating their volatilities. The time series data for modeling oil price volatility in this chapter is the daily closing prices of the West Texas Intermediate (WTI) oil price contract from the US Energy Information Agency. The annual volatility of the stock price is constructed using daily data of the closing FTSE 100 index from the London stock exchange. These data are running over the period from 2^{nd} January 1986 to 30^{th} December 2011 resulting in total time series observations of

[21] year 2000 software problem

6560 excluding public holidays. Daily oil and stock price returns are calculated as the continuously compounded returns, which are the first difference in logarithm of closing prices of WTI oil price and FTSE 100 index of consecutive days:

$$r_t = log(p_t) - log(p_{t-1}) \tag{3.22}$$

3.5.2.1 Stationarity tests

To investigate whether the daily oil and stock prices and their returns are stationary series, the Augmented Dickey-Fuller (ADF) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test have been applied for both series. The ADF and KPSS tests for the oil and stock prices in level form indicate that they are non-stationary time series. But when applying the same tests for the return series of both prices, the results strongly reject the null hypothesis of a unit root (see Table 3.3). Therefore, it can be concluded that the return series are stationary series.[22]

3.5.2.2 Heteroscedasticity test

Before applying the GARCH methodology, it is essential to examine the residuals for indication of heteroscedasticity. In order to do that, the Lagrange multiplier (LM) test for the presence of ARCH effects proposed by Engle (1982) is applied. The test is carried out by first predicting the residuals from the ordinary least squares regression of the conditional mean equation. This equation might be an autoregressive (AR) process, moving average (MA) process or a combination of AR and MA processes, (ARMA) process. Based on the Akaike information criteria (AIC), for the oil price return series, ARMA (1, 1) is the best model, as it has all its coefficients individually and jointly significant, and the information criterion is minimized. The form of the conditional mean in the ARMA (1, 1) process is as follows:

$$r_t^{oil} = \theta_1 r_{t-1}^{oil} + \varepsilon_t + \phi_1 \varepsilon_{t-1} \tag{3.23}$$

For the stock price return series, ARMA (2, 2) is the best model that is shown in the following form:

$$r_t^{stock} = \theta_1 r_{t-1}^{stock} + \theta_2 r_{t-2}^{stock} + \varepsilon_t + \phi_1 \varepsilon_{t-1} + \phi_2 \varepsilon_{t-2} \tag{3.24}$$

After predicting the residuals e_t the square of the residuals is regressed on a constant

[22] See Appendix A for more explanation of the ADF and KPSS tests.

and p lags as follows:

$$e_t^2 = \beta_0 + \beta_1 e_{t-1}^2 + \ldots + \beta_p e_{t-p}^2 + \nu_t \tag{3.25}$$

The null hypothesis is that there are no ARCH effects:

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_p = 0$$

against the alternative:

$$H_1 : \beta_i > 0 \qquad For\ at\ least\ one\ i = 1, 2, \ldots, p$$

The test statistic for the joint significance of the p-lagged squared residuals equals the number of observations N multiplied by R-squared (NR^2) and is compared with a χ^2(p) distribution. The results of this test are summarized in Table 3.4 . It shows strong evidence for rejecting the null hypothesis for all the lags included. Rejecting the null hypothesis indicates the occurrence of ARCH effects in the residuals series and hence the variances of the oil and stock price return series are not constant.

3.5.2.3 Oil price GARCH (1, 1) model

As described in the data and statistics section when the residuals were examined for the occurrence of heteroscedasticity, the results of ARCH-LM (Autoregressive conditional heteroscedasticity lagrange multiplier) test indicate significant ARCH effects in the residual series. This suggests that the GARCH (1, 1) model can be used to construct the conditional variation in oil price changes. The results of estimating the GARCH model that is stated in Equation (3.10) are reported in Table 3.5.

In the variance equation that is shown in Panel B of Table 3.5, the constant, ARCH term and GARCH term coefficients show a highly significant effect and appear with the expected sign. The significance of the ARCH and GARCH terms gives an evidence that the lagged conditional variance and squared error influence the conditional variance. It can be seen from the table that the sum of the estimated ARCH and GARCH coefficients (persistence coefficient) is less than one, which is needed to maintain a mean reverting variance process (not explosive process). The last panel of the table presents the test statistics of ARCH-LM and it shows no additional ARCH effects since the Chi square test is insignificant which indicates that the variance equation is well defined.

3.5.2.4 Stock price GARCH (1, 1) model

Table 3.6 reports the day of the week effects and stock market volatilities for the FTSE 100 index return. The results in this table are built up by allowing the conditional variance of the returns to change for each day of the week by modeling the conditional variance of return equation as a modified GARCH. This is accomplished to discover the presence of a day of the week effect in volatility. The dummy variable for Fridays is the omitted category. The top panel of the Table shows the day of the week effect results with respect to returns where all the working days dummy variables are included since there is no constant. The estimated coefficients of the days dummy variables are statistically insignificant. The coefficient of the conditional standard deviation of the return equation (risk) is positive and significant at the 10% level. This indicates that investors want to be compensated with higher returns for holding riskier assets.

The diagnostic tests for any remaining GARCH effects show that there are no ARCH effects remaining and this can be noticed from the Chi square probability which appears insignificant. This suggests that the variance equation of stock price return is properly determined.

3.6 Empirical Work and Results

The empirical analysis begins with predicting oil and stock prices volatility using a GARCH(1, 1) model. Once the predicted volatility is available, the impact of oil and stock price volatility is investigated using the system GMM technique with the two samples of firms, non-financial and financial.

3.6.1 Impact of oil price volatility on non-financial firms investment

The investigation starts by estimating an augmented Q model of investment. Particularly, the investment ratio is regressed on the lag of the investment ratio, Q ratio and the measure of oil price volatility as presented in equation (3.2) which is viewed as the baseline model. Next, the impact of oil price volatility is examined with the addition of cash flow and leverage ratios. In addition, the existence of a non linear relationship between oil price uncertainty and investment is tested.

The market instability impact on investment is explored by estimating the model in equation (3.2), but with a different measure of uncertainty. The stock price volatility is employed in addition to the cash flow and leverage measures as in equation (3.6).

Table 3.7 presents the robust two-step GMM estimation results for four Tobin's Q investment models with different specifications that examine the impact of oil price volatility on the investment of the non-financial UK firms. As this methodology utilizes both levels and first difference equations in estimation, it takes off the firm fixed effects term. Following previous empirical work, different specifications including the lagged value of investment to total assets ratio, the contemporaneous and lagged values of Q ratio, the contemporaneous and lagged values of cash flow to total assets ratio, the contemporaneous and lagged values of total debt to total assets ratio are incorporated in investment model. Year dummies are also included in order to control for business cycle effects on investment. Models I and II estimate the impacts of oil price volatility on investment with different specifications. Models III and IV test the non linear relationship between oil price uncertainty and investment with the inclusion of leverage variable in model IV.

The validity of the system-GMM results relies on the veracity of instruments employed for the first-differenced equations as well as the level equations, it is advantageous, primarily, to debate the results of the diagnostic tests. The estimates of the Hansen J-statistics and the second autocorrelation test of Arellano-Bond AR(2) and their p-values are reported in Panel B of Table 3.7. The J-test is a χ^2 distribution under the null hypothesis that the instruments are uncorrelated with the error term (valid instruments and overidentification restrictions are valid). The four models estimates show that the validity of over-identifying restrictions cannot be rejected. The Arellano Bond test statistics suggest 1st order autocorrelation in the residuals of the differenced equation, as expected, but 2nd order autocorrelation does not exist. Overall, the diagnostic tests emphasize the suitability of the instruments employed in system-GMM.

Panel A of Table 3.7 shows that the lagged investment to total assets ratio appears significant and positively related to the current investment ratio in all models. This reveals that there is significant and continual impact of firm's investment expenditures. This relation is in agreement with the studies of Baum et al. (2008), Mohn and Misund (2009) and Henriques and Sadorsky (2011) who also state that there is a positive relation between the contemporaneous and the lag of investment to total assets ratio.

According to the results obtained, the Q ratio does not contribute significantly in explaining investment rates. The estimated parameters are statistically insignificant, with one exception, in the fourth model of Table 3.7. These results suggest that the Q ratio is a weak indicator for investment. This is in agreement with some previous studies such as Mohn and Misund (2009), and Henriques and Sadorsky (2011). On the other hand, Bo (2002) who investigate the impact of idiosyncratic uncertainty and Baum et al. (2008) who examine the effect of firms' stock returns uncertainty and market uncertainty on the investment, find a significant relationship between Q variable and investment.

Compatible with agency theory, there is a lot of empirical evidence that confirms the positive relationship between cash flows and investment. This supports the Free-cash-flow Hypothesis, initiated by Jensen (1986), who proposed that because managers maximize private benefits originated from scale-based proceeds and do not have to endure all the risks in overinvestment, they are highly induced to spend free cash flow on investments with negative NPV when they can charge internal funds more than the amount substantial for profitable opportunities. As a result of the restrictions on managers, they will not finance externally when the internal funds are not adequate. However, when the internal funds are abundant, managers will consume them to invest as much as possible, and accordingly investment is positively correlated with cash flow.

In model IV of Table 3.7, the estimate on the contemporaneous total debt to total assets ratio appears significant and positive which indicates a positive association between firm's loans and investment. This positive relationship suggests that firms that do use debt in their capital structure invest comparatively more. The obtained result is in agreement with Bo (2007) and Rashid (2011), who suggest a positive effect of debt on investment. This argument proposes that the debt markets that perform perfectly would encourage the firms to raise their investment spending.

The estimates regarding the influences of uncertainty denote that the coefficient on oil price volatility is negative and significant in all models. By looking into Models I and II of Table 3.7, it can be seen that the impact of lagged oil price volatility is negative and highly significant in comparison to the current oil price volatility which is significant at 10% and 5% level of significance in both models, respectively. In particular, the results of Models I and II show that an increment of one standard deviation in lagged oil price volatility leads to an average reduction in investment by 0.042 and 0.031 standard deviations, respectively.[23]

Models III and IV test the non-linear relationship between oil price volatility and investment. The results demonstrate that the relationship between investment and oil price volatility is a U shaped. This relationship is robust among the two models with different specifications, which emphasizes the predictions from the literature of strategic growth options. In periods of high uncertainty, there will be an increase in the option value of waiting to invest as it is more beneficial to delay investment till the uncertainty is settled. Therefore, investment in the current period is postponed. When reaching a specific point, however, more increments in uncertainty cause an increment in investment due to the increase in the value of the precautionary strategic impacts of not growing the firm in comparison to the option value of waiting to invest. Based on this, the results obtained characterize the volatility of oil price as an essential macroeconomic uncertainty variable that may minimize the investment level of the firm over some time due to the domination of the option value of waiting to decrease uncertainty. When the inversion point is attained , investment starts to rise due to the domination of strategic growth option value. Inversion points for the contemporaneous impacts are quite comparable among the two models and spread from 15.74% to 16.05%. This implies that for values of annual oil price volatility that are less than the inversion point, a rise in oil price volatility decreases investment. Once the inflection point is reached, an increase in oil price volatility increases investment. The attained results are consistent with Henriques and Sadorsky (2011), who were the first to investigate the non-linear relationship between oil price volatility and investment of a large panel of US firms and find that there is a U shaped relationship.

[23] Standardized regression coefficients (beta coefficients, beta weights) refer to how many standard deviations a dependent variable will change, per standard deviation change in the predictor variable. Standardization of the coefficient is usually done when the variables are measured in different units of measurement. Standardized regression coefficients can be calculated in two ways, with both leading to the same result. One possibility is first to calculate the regression coefficients by using unstandardized variables and then multiply them by the ratio between the standard deviation of the respective independent variable and the standard deviation of the dependent variable:

$$\mathbf{B}_i = \hat{\beta}_i (s_i / s_y)$$

where $\mathbf{B}_i$ is the standardized regression coefficient, β_i is the regression coefficient, s_i ands_y are the standard deviations of the respective independent variable and dependent variable, respectively.

This U shaped relationship is compatible with the conjecture from the strategic growth options literature. It illustrates that for companies that do not have monopolistic control of investment opportunities, and where product markets are not perfectly competitive, then they have two option value effects. They can either choose the option of waiting for the uncertainty to stabilize or an option to augment the business (Kulatilaka and Perotti, 1998). In the case of uncertainty, firms often defer investment until more information is available. Not investing, which retards the potential of obtaining market share or growing the firm, may let another competitor to grab the opportunity. As a result, these two impacts lead to a U shape relationship between investment and uncertainty.

3.6.2 Impact of stock price volatility on non-financial firms investment

Table 3.8 reports the results of the relationship between firm investment and stock price volatility in three models with different specifications. The non-financial firms sample is employed in these estimations. The coefficients of the lagged investment to total assets ratio, Q-ratio, cash flow and leverage variables are almost having the same impact after adding the stock price volatility in to the model. Equation (3.2) is estimated with serial correlation in the error term. The volatility measure is substituted with stock price volatility that was predicted using GARCH(1, 1) model. The results of this estimation are presented in Model I which show a highly significant and positive effect of the contemporaneous stock price volatility on firm investment.

When the cash flow and leverage measures are added to the model (Model II), the impact of the current stock price volatility remains positive and significant but with lower impact in comparison to the estimates of Model I. More precisely, an increase of one standard deviation in the stock price volatility causes an increase in investment by 0.069 standard deviations on average which is lower than that obtained from Model I which gives a rise of 0.127 standard deviations as a result of one standard deviation increase in stock price volatility.

The positive correlation between stock price and investment decisions may be attributed to the managers who incorporate the new information that they get from the stock prices in their investment. Baker et al. (2003) have shown that the sensitivity of investment to price increases in the level of capital constraints faced by the firm. The idea is that financing constraints prevent firms from pursuing their optimal investment plans and that an increase in stock price may ease these constraints and thus enable firms to increase investments.

The positive linkage between investment and stock price volatility is not changed when both measures of volatility are simultaneously introduced in Model III of Table 3.8. Moreover, the negative impact of oil price volatility on firm investment remains. The point estimates indicate that the behaviour of firm's investment is more sensible to stock price volatility as the value of the coefficient of stock price volatility is greater in terms of absolute value in contrast to the coefficient of oil price volatility. In addition, the coefficients of the current and lagged measures of both types of uncertainties appear statistically significant with their expected signs. The acquired results of the stock price volatility impact are different than the results of Lee et al. (2011) who investigate the effect of oil price shocks both directly and in interaction with firm stock price volatility. Their results show a negative association between firm stock price volatility and investment. However, if the stock market is efficient, the stock price will reasonably reflect the marginal product of capital. Because firms make investment decisions on the basis of whether the stock market assessment of standing real capital assets beats their replacement cost, there should be a positive association between firm investment and the stock price (Wang et al., 2009).

3.6.3 Impact of oil and stock price volatility on non-financial firms investment excluding oil and gas firms

The models of Tables 3.7 and 3.8 are replicated with the sample of non-financial firms, excluding oil and gas firms, to examine the robustness of the results obtained. The results for these non-financial firms, are summarized in Table 3.9.

The coefficients of the lagged investment to total assets ratio, Q-ratio, cash flow and leverage variables are almost analogous to that presented in Tables 3.7 and 3.8, in respect of their signs, significance and magnitudes.

By comparing the estimates of oil price volatility impacts on firm investment (presented in Models I, II and II) with that of Models II, II and IV of Table 3.7, it can be seen that oil price volatility has a persistent negative effect on the firm investment. In addition, there is a U shaped relationship between oil price volatility and firm investment.

Models IV and V present the impact of stock price volatility which can be compared with Models II and III of Table 3.8. Although the point estimates show that the marginal effect of stock price volatility has increased, the statistical significance of the effects remains robust.

3.6.4 Differential impact of oil price volatility on oil and gas firms

Although the results of Tables 3.7 and 3.9 provide strong evidence for the existing negative relationship between oil price volatility and firm investment, these results do not allow us to explain whether the impact of oil price volatility differs for the oil and gas firms' investment. To test the differential effect of being an oil and gas firm on investment, an *oil* dummy is generated and set equal to one if the firm is classified as oil and gas firm or zero otherwise, in the non-financial firms sample. This dummy is interacted with the oil price volatility measure and the model presented in Equation (3.8) is estimated.

The results of estimating Equation (3.8) are reported in Table 3.10. Two models are estimated with the addition of an interaction term of oil price volatility and the *oil* dummy. It can be seen that the coefficients of the lagged investment to total assets ratio, Q-ratio, cash flow and leverage terms are significant with the expected signs. The coefficients of the contemporaneous and lagged oil price volatility are negative and statistically significant. However, the coefficient of the interaction term ($\sigma_t^{oil} \times oil$) appears positive and has a significant impact. Particularly, with an increase of one standard deviation in annual oil price volatility, the investment to total assets ratio of oil and gas firms increases by $(-0.041 + 0.084 = 0.043)$ standard deviations compared to a decrease of (-0.041) in the investment to total assets ratio of the other non-financial firms. This results in a positive and statistically significant impact of oil price volatility on the investment of oil and gas firms. These results are in line with Mohn and Misund (2009) who conclude that the oil price uncertainty has a stimulating effect on the investment of a panel of 115 international oil and gas companies.

3.6.5 Impact of oil and stock price volatility on financial firms investment

The effects of oil and stock price volatility are investigated using the financial firms sample to compare the impact of the uncertainty with that on the non-financial firms. The results are presented in Table (3.11). As reported before, the Q ratio does not contribute significantly in explaining the investment rates as the coefficients of this variable appear insignificant. All the models show a positive and significant impact of cash flow on investment.

Model I presents a significant negative impact of the lagged oil price volatility on investment. Specifically, an increase of one standard deviation in the lagged oil price volatility will reduce investment by 0.040 standard deviations on average. It is surprising to find that the investment expenditures of the financial firms that are not directly affected by oil prices also are sensitive to oil price changes. This may be because their main customers are impacted by oil price changes. Changing oil prices may create uncertainty about the future path of the price of energy, causing consumers to postpone irreversible purchases of consumer durable. Or, even when purchase decisions are reversible, consumption may fall in response to energy price shocks as consumers increase their precautionary savings (Kilian, 2008).

Models II and III test the nonlinear relationship between oil price volatility and investment. It can be noticed that the coefficient of the squared oil price volatility is positive and significant which indicates that a U shaped relationship exists between oil price volatility and investment. Inflection points of the current impact range between 16.63% and 17.36%.

When stock price volatility is added to the model as in Model IV, it appears positive an affects the firms' investment expenditure significantly. This positive impact of stock price volatility remains when both type of uncertainties are jointly introduced in Model V.

3.7 Conclusion

This chapter empirically investigates the association between firms' investment expenditure and two types of uncertainty, namely industry-specific uncertainty measured by oil price volatility and financial market instability proxied by stock price volatility. Unlike the previous empirical studies that investigated this topic on mainly non-financial firms of US, this chapter concentrates on the impact of both type of uncertainty on the investment of non-financial and financial UK firms over the period between 1986 to 2011.

The key findings of the analysis is that both forms of uncertainty have a significant impact on the investment of non-financial and financial firms' investment. While the oil price volatility has a negative effect, the stock price volatility influence the investment behaviour positively. It is surprising to get a significant relationship between oil price uncertainty and financial firms' investment, perhaps because their main customers are impacted by oil price changes. Furthermore, oil and gas firms' investment is significantly and positively affected by oil price volatility.

Empirical results show that the investment and oil price volatility relationship is more complicated, there exists a U shaped association. This U shaped relationship is compatible with the conjecture from the strategic growth options literature. It illustrates that for companies that do not have monopolistic control of investment opportunities, and where product markets are not perfectly competitive, then they have two option value effects. They can either choose the option of waiting for the uncertainty to stabilize or an option to augment the business (Kulatilaka and Perotti, 1998). In the case of uncertainty, firms often defer investment until more information is available. Not investing, which retards the potential of obtaining market share or growing the firm, may let another competitor to grab the opportunity. As a result, these two impacts lead to a U shape relationship between investment and uncertainty.

The results imply that stability in oil prices would help stabilize firm-level investment. Moreover, the stock market is efficient and reflects the marginal product of capital. For policy implications, the results recommend that policy makers should take into consideration the relationship between uncertainty and investment at the time of planning monetary and fiscal policies because these decisions are important for overall economic performance of any economy. The obtained results show a significant positive impact of debt on investment, therefore an efficient debt market, especially for small scale borrowing would promote firm level investment.

It is noteworthy to point out that the applied empirical strategy masks the potential heterogeneity across the same panel firms. Given the obtained findings and recent research on the relationship between oil price uncertainty and firm investment behavior, further exploration along these lines while taking into account firms heterogeneity could shed considerable light on this relationship.

Table 3.1: Non-financial firms descriptive statistics

	Non-financial firms						
	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
(I/K)	0.056	0.059	0	0.016	0.039	0.074	0.387
Tobin's Q	2.096	1.303	0.450	1.364	1.720	2.321	12.358
(CF/K)	0.039	0.182	-1.635	0.012	0.077	0.127	0.360
(Lev)	0.182	0.218	0	0.026	0.146	0.267	7.070
$(\sigma)^{oil}$	1.29E-04	7.07E-05	4.32E-05	7.54E-05	1.03E-04	1.67E-04	3.41E-04
$(\sigma)^{stock}$	2.50E-05	1.92E-05	7.64E-06	1.31E-05	1.95E-05	3.23E-05	9.37E-05
Total observations	29216	29216	29216	29216	29216	29216	29216

Notes: (I/K) = capital expenditure to total assets ratio, Tobin's Q = market value to book value of assets ratio, (CF/K) = cash flow to total assets ratio, (Lev) = total debt to total assets ratio, $(\sigma)^{oil}$ = oil price volatility and $(\sigma)^{stock}$ = stock price volatility.

Table 3.2: Financial firms descriptive statistics

	Financial firms						
	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
(I/K)	0.034	0.062	0	6.94E-04	0.006	0.039	0.404
Tobin's Q	1.500	0.580	0.489	1.149	1.350	1.620	6.157
(CF/K)	0.017	0.09	-0.852	0.002	0.017	0.041	0.31
(Lev)	0.232	0.229	0	0.011	0.181	0.400	0.963
$(\sigma)^{oil}$	1.29E-04	7.10E-05	4.32E-05	7.54e-05	1.03E-04	1.67E-04	3.41E-04
$(\sigma)^{stock}$	2.52E-05	1.93E-05	7.64E-06	1.31E-05	1.95E-05	3.23E-05	9.37e-05
Total observations	4224	4224	4224	4224	4224	4224	4224

Notes: (I/K) = capital expenditure to total assets ratio, Tobin's Q = market value to book value of assets ratio, (CF/K) = cash flow to total assets ratio, (Lev) = total debt to total assets ratio, $(\sigma)^{oil}$ = oil price volatility and $(\sigma)^{stock}$ = stock price volatility.

Table 3.3: Results of ADF unit root test for the oil and stock price and their return series

Variable	**A**DF test				**K**PSS test			
	Constant		Constant & Trend		Constant		Constant & Trend	
Log oil price	-1.137	(1)	-3.576**	(1)	100***	(4)	19.6***	(4)
Oil price return	-49.407***	(2)	-49.416***	(2)	0.099	(4)	0.0192	(4)
Log stock price	-2.217	(7)	-1.916	(7)	87.3***	(4)	19.9***	(4)
Stock price return	-32.130***	(6)	-32.165***	(6)	0.165	(4)	0.0361	(4)

Notes: $***$ and $**$ denote statistical significance at 1% and 5%, respectively. The figures given in parentheses are number of lags.

Table 3.4: ARCH-LM test for residuals of oil and stock prices returns

	ARCH-LM Test	
	Oil Price	Stock Price
ARCH-LM statistic (NR^2)	263.417	1077.768
Prob. Chi-square(4)	0.0000	0.0000

Table 3.5: Estimation results of GARCH (1, 1) model

Variable	Oil price return		Stock price return	
	Coef.	Std. Err.	Coef.	Std. Err.
	Panel A: Mean Equation			
AR(1)	0.852***	0.051	-0.859***	0.126
MA(1)	-0.879***	0.046	0.846***	0.132
Constant	1.514E-04**	7.7E-05	1.784E-04***	4.72E-05
	Panel B: Variance Equation			
ω (constant)	1.30E-06***	1.75E-07	2.41E-07***	3.80E-08
α (arch 1)	0.093***	0.004	0.084***	0.006
β (garch 1)	0.901***	0.005	0.906***	0.006
$\alpha + \beta$	0.994		0.990	
Log likelihood	21072.09		24825.41	
	Panel C: ARCH-LM Test for heteroscedasticity			
ARCH-LM test statistics (NR^2)	6.93		5.57	
Prob. Chi-square (8)	0.5444		0.6954	

Notes: $***$, $**$ and $*$ denote statistical significance at 1%, 5% and 10%, respectively.

Table 3.6: Day of the week effect in stock price return and volatility equations

Variable	Coefficient	Std. Error
Monday	-2.670E-04	1.880E-04
Tuesday	-8.870E-06	1.670E-04
Wednesday	-4.650E-05	1.720E-04
Thursday	-1.140E-04	1.710E-04
Friday	5.630E-05	1.770E-04
Risk (Std. deviation)	0.072*	0.040
AR(2)	-0.778***	0.111
MA(2)	0.762***	0.115
ω (constant)	1.18E-06**	5.06E-07
α (arch 1)	0.083***	0.006
β (garch 1)	0.907***	0.006
Monday	-9.460E-07	8.120E-07
Tuesday	-2.110E-06**	7.300E-07
Wednesday	-4.00E-07	7.73E-07
Thursday	-1.23E-06	9.31E-07
Diagnostic tests for remaining GARCH effects		
$\alpha + \beta$	0.989	
Log likelihood	24834.92	
ARCH-LM test statistics (NR^2)	6.447	
Prob. Chi-square (8)	0.5972	

$***$, $**$ and $*$ denote statistical significance at 1%, 5% and 10%, respectively.

Table 3.7: The impact of oil price volatility on firm level investment

Panel A: Determinants of investment, dependent variable $(I/K)_{it}$								
Regressors	Model I		Model II		Model III		Model IV	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
$(I/K)_{i,t-1}$	0.784	(0.146)***	0.751	(0.123)***	0.265	(0.154)*	0.242	(0.074)***
$(Q)_{it}$	-0.001	(0.006)	-0.007	(0.005)	0.007	(0.007)	0.005	(0.002)***
$(Q)_{i,t-1}$	-0.001	(0.003)	0.003	(0.003)	-0.004	(0.007)	-0.004	(0.004)
$(CF/K)_{it}$			0.071	(0.037)*	0.193	(0.104)*	0.036	(0.013)***
$(CF/K)_{i,t-1}$			-0.032	(0.024)	-0.066	(0.069)	-0.019	(0.034)
$(Lev)_{it}$							0.030	(0.012)***
$(Lev)_{i,t-1}$							-0.037	(0.023)
$(\sigma)_t^{oil}$	-0.026	(0.015)*	-0.025	(0.011)**	-0.535	(0.306)*	-0.353	(0.196)*
$(\sigma)_{t-1}^{oil}$	-0.035	(0.009)***	-0.026	(0.010)***	-0.756	(0.938)	-0.804	(0.532)
$(\sigma_t^{oil})^2$					0.017	(0.009)**	0.011	(0.006)**
$(\sigma_{t-1}^{oil})^2$					0.021	(0.028)	0.023	(0.016)
Constant	0.018	(0.006)***	0.022	(0.004)***	0.097	(0.055)*	0.097	(0.039)**
Panel B: Diagnostic tests								
J-test	17.04		42.03		9.80		27.20	
J, p-value	0.383		0.426		0.832		0.346	
AR(2)	1.55		1.58		-0.64		-1.47	
AR(2), p-value	0.120		0.114		0.520		0.142	
firm-year	25995		25995		25995		25995	

Notes: Statistically significant different from zero at: *10, **5, and ***1 percent levels, respectively. All models include time dummy variables (not reported here). Heteroscedasticity consistent standard errors are given in the parentheses. J-test is Hansen (1982) test of overidentifying, asymptotically distributed as χ^2-test under the null instrument validity and AR(2) is the Arellano and Bond (1991) test for autocorrelation in residuals.

Table 3.8: The impact of stock price volatility on firm level investment

Panel A: Determinants of investment, dependent variable $(I/K)_{it}$						
Regressors	Model I		Model II		Model III	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
$(I/K)_{i,t-1}$	0.194	(0.147)	0.223	(0.080)***	0.650	(0.133)***
$(Q)_{it}$	0.017	(0.008)**	0.006	(0.005)	-0.005	(0.005)
$(Q)_{i,t-1}$	-0.004	(0.004)	0.001	(0.002)	0.011	(0.005)**
$(CF/K)_{it}$			0.022	(0.010)**	0.102	(0.048)**
$(CF/K)_{i,t-1}$			0.032	(0.026)	-0.044	(0.036)
$(Lev)_{it}$			0.035	(0.017)**	0.106	(0.057)*
$(Lev)_{i,t-1}$			-0.035	(0.029)	-0.055	(0.042)
$(\sigma)_t^{oil}$					-0.189	(0.095)**
$(\sigma)_{t-1}^{oil}$					-0.065	(0.028)**
$(\sigma)_t^{stock}$	0.390	(0.135)***	0.211	(0.106)**	0.366	(0.205)*
$(\sigma)_{t-1}^{stock}$	-0.062	(0.037)	-0.049	(0.031)	0.465	(0.237)**
Constant	-0.007	(0.011)	0.008	(0.008)	-0.008	(0.010)
Panel B: Diagnostic tests						
J-test	20.96		24.18		24.94	
J, p-value	0.138		0.149		0.770	
AR(2)	-1.21		-1.45		1.47	
AR(2), p-value	0.225		0.147		0.141	
firm-year	25995		25995		25995	

Notes: Statistically significant different from zero at: *10, **5, and ***1 percent levels, respectively. All models include time dummy variables (not reported here). Heteroscedasticity consistent standard errors are given in the parentheses. J-test is Hansen (1982) test of overidentifying, asymptotically distributed as χ^2-test under the null instrument validity and AR(2) is the Arellano and Bond (1991) test for autocorrelation in residuals.

Table 3.9: The impact of oil and stock price volatilities on firm level investment / without oil

Panel A: Determinants of investment, dependent variable $(I/K)_{it}$										
Regressors	Model I		Model II		Model III		Model IV		Model V	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
$(I/K)_{i,t-1}$	0.686	(0.126)***	0.172	(0.132)	0.203	(0.083)**	0.173	(0.101)*	0.624	(0.154)***
$(Q)_{it}$	-0.007	(0.005)	0.009	(0.009)	0.008	(0.006)	0.004	(0.005)	-0.0002	(0.004)
$(Q)_{i,t-1}$	0.003	(0.003)	-0.0003	(0.007)	-0.006	(0.006)	0.001	(0.004)	0.008	(0.004)**
$(CF/K)_{it}$	0.067	(0.037)*	0.165	(0.092)*	0.142	(0.077)*	0.023	(0.009)***	0.026	(0.014)*
$(CF/K)_{i,t-1}$	-0.028	(0.023)	-0.023	(0.066)	-0.068	(0.055)	0.029	(0.023)	0.009	(0.025)
$(Lev)_{it}$					0.050	(0.022)**	0.032	(0.016)**	0.099	(0.047)**
$(Lev)_{i,t-1}$					-0.052	(0.035)	-0.033	(0.025)	-0.035	(0.029)
$(\sigma)_t^{oil}$	-0.026	(0.011)**	-0.451	(0.273)*	-0.426	(0.237)*			-0.231	(0.093)**
$(\sigma)_{t-1}^{oil}$	-0.025	(0.009)***	-0.566	(0.913)	-0.689	(0.769)			-0.073	(0.029)***
$(\sigma_t^{oil})^2$			0.015	(0.008)*	0.014	(0.007)**				
$(\sigma_{t-1}^{oil})^2$			0.016	(0.027)	0.019	(0.023)				
$(\sigma)_t^{stock}$							0.223	(0.124)*	0.482	(0.196)**
$(\sigma)_{t-1}^{stock}$							-0.060	(0.037)	0.529	(0.233)**
Constant	0.023	(0.004)***	0.072	(0.050)	0.091	(0.048)*	0.012	(0.008)	-0.012	(0.009)
Panel B: Diagnostic tests										
J-test	43.06		12.26		15.41		19.02		28.61	
J, p-value	0.383		0.659		0.752		0.213		0.485	
AR(2)	1.47		-1.53		-1.25		-1.51		1.29	
AR(2), p-value	0.142		0.126		0.212		0.132		0.198	
firm-year	25362		25362		25362		25362		25362	

Notes: Statistically significant different from zero at: *10, **5, and ***1 percent levels, respectively. All models include time dummy variables (not reported here). Heteroscedasticity consistent standard errors are given in the parentheses. J-test is Hansen (1982) test of overidentifying, asymptotically distributed as χ^2-test under the null instrument validity and AR(2) is the Arellano and Bond (1991) test for autocorrelation in residuals.

Table 3.10: The impact of oil price volatility on oil and gas firm level investment

Panel A: Determinants of investment				
Regressors	Model I		Model II	
	Coef.	Std. Error	Coef.	Std. Error
$(I/K)_{i,t-1}$	0.452	(0.156)***	0.569	(0.098)***
$(Q)_{it}$	0.004	(0.002)***	0.003	(0.001)***
$(Q)_{i,t-1}$	-0.003	(0.004)	-0.0001	(0.002)
$(CF/K)_{it}$	0.013	(0.007)*	0.024	(0.008)***
$(CF/K)_{i,t-1}$	0.016	(0.017)	-0.005	(0.014)
$(Lev)_{it}$			0.046	(0.026)*
$(Lev)_{i,t-1}$			-0.031	(0.022)
$(\sigma)_t^{oil}$	-0.041	(0.023)*	-0.048	(0.021)**
$(\sigma)_{t-1}^{oil}$	-0.024	(0.010)**	-0.021	(0.010)**
$(\sigma)_t^{oil} \times oil$	0.084	(0.044)**	0.080	(0.037)**
$(\sigma)_{t-1}^{oil} \times oil$	-0.009	(0.008)	-0.012	(0.008)
Constant	0.021	(0.005)***	0.011	(0.003)***
Panel B: Diagnostic tests				
J-test	21.01		18.59	
J, p-value	0.336		0.417	
AR(2)	-0.61		0.19	
AR(2), p-value	0.541		0.849	
firm-year	25995		25995	

$***$, $**$ and $*$ denote statistical significance at 1%, 5% and 10%, respectively.

Table 3.11: The impact of oil and stock price volatilities on firm level investment / Financial firms

Panel A: Determinants of investment, dependent variable $(I/K)_{it}$

Regressors	Model I		Model II		Model III		Model IV		Model V	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
$(I/K)_{i,t-1}$	0.601	(0.174)***	0.269	(0.057)	0.364	(0.178)**	0.312	(0.067)***	0.315	(0.076)***
$(Q)_{it}$	0.010	(0.008)	-0.003	(0.028)	-0.001	(0.016)	-0.009	(0.009)	-0.009	(0.009)
$(Q)_{i,t-1}$	-0.009	(0.013)	0.008	(0.013)	0.0004	(0.008)	0.038	(0.013)***	0.029	(0.012)**
$(CF/K)_{it}$	0.033	(0.016)**	0.103	(0.060)*	0.041	(0.020)**	-0.034	(0.025)	-0.033	(0.025)
$(CF/K)_{i,t-1}$	-0.131	(0.090)	-0.020	(0.023)	-0.030	(0.078)	0.093	(0.043)**	0.091	(0.044)**
$(Lev)_{it}$					0.160	(0.093)*	-0.199	(0.125)	-0.193	(0.120)
$(Lev)_{i,t-1}$					-0.152	(0.104)	0.391	(0.131)***	0.324	(0.110)***
$(\sigma)_t^{oil}$	0.003	(0.022)	-0.865	(0.461)*	-0.868	(0.451)**			0.048	(0.051)
$(\sigma)_{t-1}^{oil}$	-0.035	(0.018)**	0.823	(1.306)	1.108	(1.103)			-0.062	(0.023)***
$(\sigma_t^{oil})^2$			0.026	(0.013)**	0.025	(0.013)*				
$(\sigma_{t-1}^{oil})^2$			-0.026	(0.040)	-0.035	(0.033)				
$(\sigma)_t^{stock}$							0.084	(0.049)*	-0.081	(0.124)
$(\sigma)_{t-1}^{stock}$							0.277	(0.131)**	0.280	(0.138)**
Constant	0.010	(0.010)	0.013	(0.061)	0.005	(0.066)	-0.076	(0.019)***	-0.044	(0.138)**

Panel B: Diagnostic tests

	Model I	Model II	Model III	Model IV	Model V
J-test	10.90	4.40	18.52	16.51	22.59
J, p-value	0.619	0.623	0.819	0.283	0.163
AR(2)	1.50	1.03	0.84	1.33	1.33
AR(2), p-value	0.133	0.305	0.400	0.184	0.183
firm-year	3795	3795	3795	3795	3795

Notes: Statistically significant different from zero at: *10, **5, and ***1 percent levels, respectively. All models include time dummy variables (not reported here). Heteroscedasticity consistent standard errors are given in the parentheses. J-test is Hansen (1982) test of overidentifying, asymptotically distributed as χ^2-test under the null instrument validity and AR(2) is the Arellano and Bond (1991) test for autocorrelation in residuals.

Figure 3.1: WTI oil price volatility

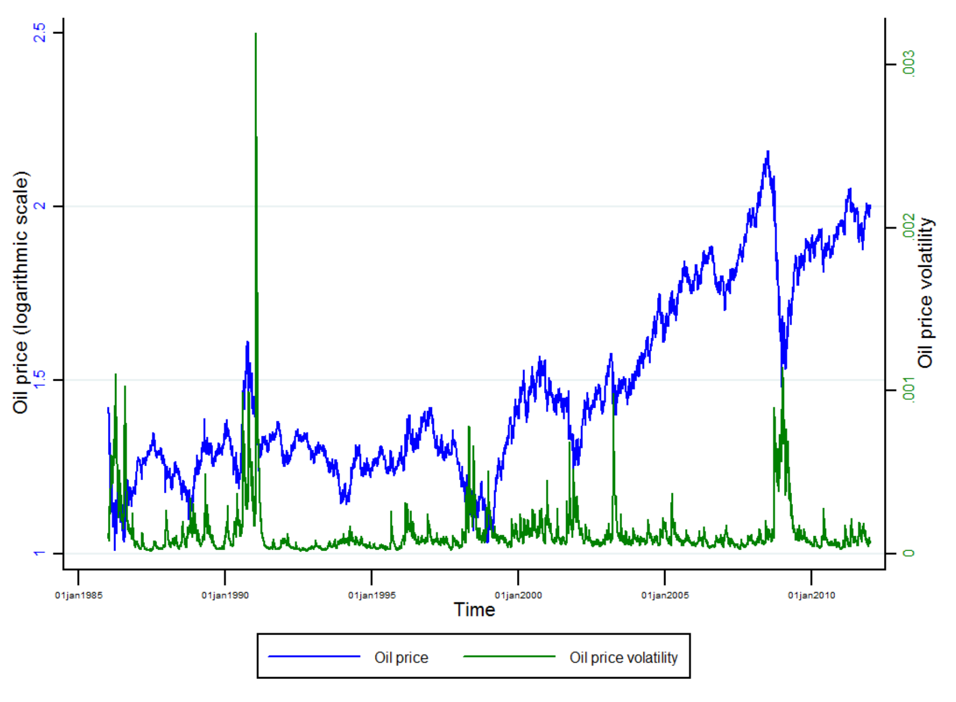
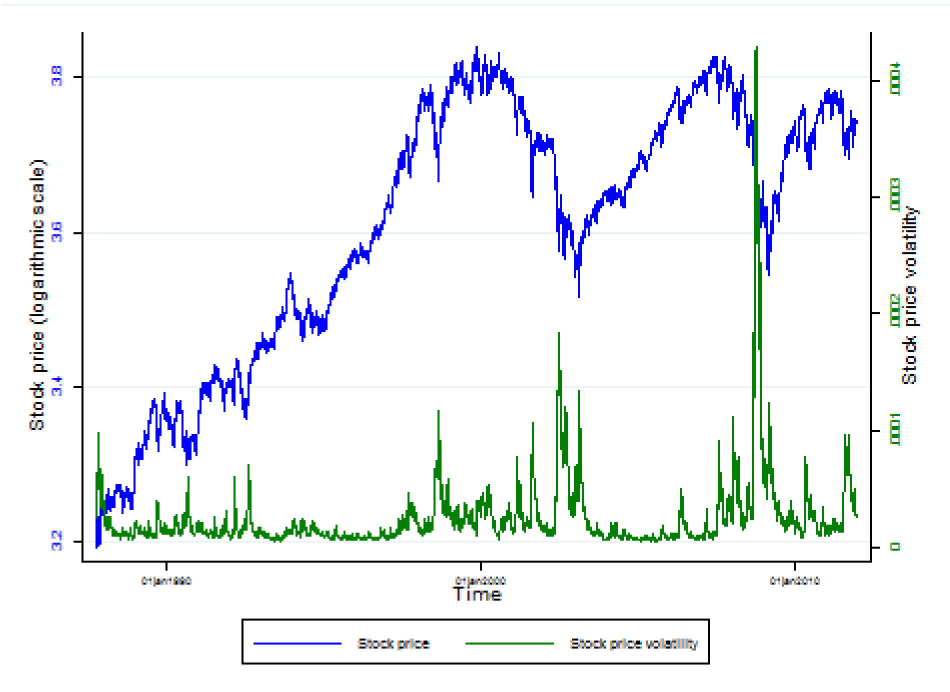


Figure 3.2: FTSE 100 stock price volatility



Appendix A: Stationarity Tests

Augmented Dickey Fuller unit root test

The ADF test tests the null hypothesis that a time series y_t is $I(1)$ against the alternative that it is $I(0)$, assuming that the dynamics in the data have an ARMA structure. The ADF test is based on estimating the test regression

$$y_t = \alpha + \beta t + \phi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t \tag{A.1}$$

where α is a constant, β the coefficient on a time trend . The p lagged difference terms, Δy_{t-j}, are used to approximate the ARMA structure of the errors, and the value of p is set so that the error ε_t is serially uncorrelated. The error term is also assumed to be homoskedastic. Imposing the constraints $\alpha = 0$ and $\beta = 0$ corresponds to modelling a random walk and using the constraint $\beta = 0$ corresponds to modelling a random walk with a drift. Consequently, there are three main versions of the test.

By including lags of the order p the ADF formulation allows for higher-order autoregressive processes. This means that the lag length p has to be determined when applying the test. One possible approach is to test down from high orders and examine the t-values on coefficients. An alternative approach is to examine information criteria such as the Akaike information criterion and Bayesian information criterion.

The unit root test is then carried out under the null hypothesis $\phi = 0$ against the alternative hypothesis of $\phi < 0$.

Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test

The ADF unit root test is for the null hypothesis that a time series y_t is $I(1)$. Stationarity tests, on the other hand, are for the null that y_t is $I(0)$. The most commonly used stationarity test, the KPSS test, is due to Kwiatkowski et al. (1992). They derive their test by starting with the model:

$$y_t = \acute{\beta}\mathbf{D_t} + \mu_t + u_t \tag{A.2}$$

$$\mu_t = \mu_{t-1} + \varepsilon_t \quad \varepsilon_t \sim (0, \sigma_\varepsilon^2) \tag{A.3}$$

where $\mathbf{D}_t$ contains deterministic components (constant or constant plus time trend), u_t is I_0 and may be heteroskedastic. Notice that μ_t is a pure random walk with innovation variance σ_ε^2. The null hypothesis that y_t is $I(0)$ is formulated as H_0 : $\sigma_\varepsilon^2 = 0$, which implies that μ_t is a constant.

Chapter 4

The Effect of Oil Price Shocks on Asset Prices: Evidence from UK firms

4.1 Introduction

The stock market plays a significant role in the global economy. Traditionally, the stock market has been considered as an essential signal for an economy, where a large drop in stock prices may indicate a future recession, while a large increase in stock prices may suggest future economic growth. This view might be backed up by the debate that present stock prices should demonstrate expected future growth of firms' earnings. Therefore, stock markets may influence the economy by affecting consumers' wealth or through affecting the confidence level of both businesses and investors. As the stock market consists of the largest firms' shares, therefore, it is treated as a signal for the nations economy and industrial production. As a consequence, the important role of the stock market has created a considerable field of research on the link between macroeconomic factors and stock returns.

Theoretical models have been built to explain the behaviour of stock returns and realize the components that affect it. Sharpe (1964) and Lintner (1965), each individually, develop the Capital Asset Pricing Model (CAPM) that suggests that the rate of return is determined by market risk. Although this model is supported by early studies such as Black et al. (1972) and Fama and MacBeth (1973), its shortcomings of disregarding the role of other macroeconomic factors have been the issue of debate. Consequently, the Arbitrage Pricing Theory (APT) of Ross (1976) aims to demonstrate the scope of asset returns in terms of multi-factor model.

With the admittance that other variables, especially macroeconomic variables, may influence stock prices, this has induced a large number of empirical studies in the spirit of arbitrage pricing theory. These studies were done using different types of macroeconomic factors such as: industrial production, interest rate, inflation rate, exchange rate and money supply most of which are usually unanticipated (the future behaviour of these variables is not anticipated by decision makers) as stated in Chen et al. (1986).

One of the key factor inputs and a major source of energy is crude oil which prices have swung considerably in the last decades that granted it a highly empirical attention. The linkage between oil price changes and stock returns can be illustrated by the equity valuation model. According to Huang et al. (1996), the equity price at any time corresponds to the expected value of future discounted cash flows. Since oil is an essential factor in the production process, any change in oil price potentially influences cash flows. As a consequence, an increase in the oil price, which, due to the lack of perfect substitution between the input components of production, will lead to a rise in production expenses. Increase in production costs decay cash flows and reduce stock prices. Moreover, hikes in oil prices affect the discount rate that is employed in equity valuation. An increase in oil prices is a signal of inflation that the central bank usually controls by increasing interest rates. This rise in interest rates may switch investor preferences to bonds instead of stocks, which dampens the price of stocks.

Although understanding the relationship between stock returns and changes in the oil price is essential for energy planning policy, investors portfolio diversification and other economic matters, it is only recently that researchers have investigated this relationship. There are a number of studies that scrutinize the role of oil prices in determining stock returns, most of which concentrate on aggregate level data (for example, Jones and Kaul, 1996, Huang et al., 1996, Sadorsky, 1999, Basher and Sadorsky, 2006, Park and Ratti, 2008, Apergis and Miller, 2009, Kilian and Park, 2009). The overall conclusion from these studies is that the impact of rising oil prices differs from one economy to the other depending on the reliance of the country on oil products. In order to show the heterogeneity between the stocks of the different sectors in an economy, researchers started to examine the impact of changes in oil prices on the stock returns of specific sectors and subsectors, arguing that the distinct industry circumstances may have different effects on its returns as a result of changes in oil prices. Most of the studies have been done on the oil and gas industry and transportation industry (for example, Sadorsky, 2001, Hammoudeh et al., 2004, El-Sharif et al., 2005, Boyer and Filion, 2007, Nandha and Brooks, 2009, Mohanty and Nandha, 2011a, Aggarwal et al., 2012, Mohanty et al., 2013). In general, they find that oil prices influence different sectors in different ways. For example, the energy industry exhibits a strong positive association with increases in oil price, while other oil consuming industries show significant negative association with oil prices.

Since the different sectors have distinct market structures, the returns of the firms in the different sectors are affected variously by the changes in oil prices. As a result, some studies attempt to investigate this relationship at the firm level. The sensitivity of London quoted oil company stocks to oil prices is examined by Manning (1991) and the impact on 29 oil companies that are listed on the New York Stock Exchange is investigated by Al-Mudhaf and Goodwin (1993) in which they both find a positive and significant response. More recently, Lanza et al. (2005) examined the effectiveness of oil prices in determining the stock returns of six international oil companies. Mohanty and Nandha (2011b) employ the Fama and French-Carhart (1997) four factor asset pricing model to investigate the exposure of 16 US transportation companies to oil price risk. Among the small number of studies that have been done on firm level stock returns and their response to oil shocks, UK firms have received very little attention. Therefore, as an attempt to fill this gap in the literature, this chapter investigates the impact of oil price changes and volatility on the monthly stock returns of 25 UK firms from three different sectors (transportation, travel and leisure, and oil and gas) from the period 1998:1 to 2012:12. These firms are specifically chosen due to the availability of long historical data and as they form two different sides of the market, consumers and producers of crude oil. It is important to consider the impact of oil prices at the firm level for the benefit of investors when investing in oil-sensitive stocks.

A generalized autoregressive conditional heteroscedasticity GARCH(q, p) model is conducted with two measures of oil price risks, the change in oil price and conditional volatility of oil price. The results reveal that the extent of the exposure of UK transportation and travel and leisure firms is generally negative (negative coefficients on oil price return) but it is particularly significant for a number of firms including delivery services, travel and tourism, and airlines. However, oil price risk exposures of UK oil and gas companies are generally positive and significant.

In addition, the sensitivity of firms' stock returns might be asymmetric; where the response to increases in the oil price may differ from that to falls in the oil price as stated in the studies that are done at the aggregate and sectoral level (for example, Park and Ratti, 2008, Arouri, 2011). Therefore, two different specifications of asymmetric measures are used to scrutinize this impact: increases and decreases in the change in oil price and hikes and drops in oil price volatility. The findings show that some firms show strong evidence of asymmetry in the reaction of stock returns to changes in the price of oil; these comprise travel and tourism, airlines, and integrated oil and gas firms.

The final contribution that this chapter presents is the investigation of oil price risk exposure during global recession. The results document that oil price risk exposures vary over time. In particular, the global recession of 2008 has significantly contributed to the oil price risk exposure of travel and tourism and integrated oil and gas firms.

The structure of the remaining parts of the chapter is as follows. The theoretical background of the asset pricing model and the related empirical literature is documented in section 4.2. Section 4.3 illustrates the applied methodology that will be adopted; followed by the data used in section 4.4. The results are presented in section 4.5 and the chapter is summarized in section 4.6.

4.2 Theoretical Background and Literature Review

The capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) augments the model of portfolio selection developed by Markowitz (1959). In Markowitz's model, an investor is assumed to be risk averse and aims to maximize his financial investments by considering not only the average return on his portfolio, but also its risk measured by the variance. Correspondingly, investors select a portfolio that is efficient in both, mean and variance, in a way that the portfolios maximize the anticipated return, given the variance, and minimize the anticipated variance given expected return.

Sharpe (1964) and Lintner (1965) append two assumptions to the Markowitz (1959) model to establish a portfolio that is efficient in mean and variance. The first assumption is complete agreement, which states that all investors know the true joint distribution of asset payoffs. The second assumption is risk-free rate borrowing and lending, which is equal for all investors and does not change with the amount borrowed or lent. An essential effect of the complete agreement assumption is that all agents have the same efficient frontier; this leads to the separation theorem, which states that regardless of all investors' initial wealth and priorities for risk, they construct their best portfolios by holding collections of risk-free assets and market portfolio. The market portfolio is the portfolio that includes all risky assets available in the world financial market, with each asset weighted in proportion to its total presence in the market.

The market portfolio is hence the effective portfolio held by all investors who do not borrow or lend at the risk-free rate. They only vary in their weight in the total portfolio. Thus, at the market equilibrium:

$$E(R_{it}) = R_{ft} + \beta_i[E(R_{Mt}) - R_{ft}] \tag{4.1}$$

where R_{it} is the return of the asset, R_{ft} is the return on risk-free assets and R_{Mt} is the return on the market. The expected return of asset i is a combination of the return on risk-free assets, and risk premium where the risk premium is the product of the market risk premium and the beta (β_i) coefficient of the asset. The crucial parameter of this model is the beta which measures the sensitivity of the asset's return to variation in the market return.

The assumption of unrestrained risk-free borrowing and lending might be an impractical assumption. Black (1972) evolves another version of the CAPM that does not assume the existence of a riskless asset, but rather obtains the same result (that the market portfolio is mean variance efficient) by allowing for unrestricted short sales of risky assets. In this version, each individual can hold a different portfolio of risky assets. It considers all assets as risky. Rather than depending on the presence of a riskless asset, all that is required is the existence of an asset whose returns are uncorrelated with those of the market portfolio (a zero-beta portfolio). The final equation for this model is:

$$E(R_{it}) = E(R_{zt}) + \beta_i[E(R_{Mt}) - E(R_{zt})] \tag{4.2}$$

where $E(R_{zt})$ is the expected return of the zero-beta portfolio.

The only difference between the Sharpe-Lintner and Black versions of the CAPM is their opinions about the expected return on assets that is uncorrelated with the market, $E(R_{zt})$. The Sharpe-Lintner version, $E(R_{zt})$ should be the riskless interest rate, R_{ft}, and the premium per unit of beta is $E(R_{Mt}) - R_{ft}$. In comparison, Black suggests that $E(R_{zt})$ should be less than the expected market return such that the premium for beta is positive.

The appropriateness of the CAPM has been supported by a number of empirical studies such as Black et al. (1972) and Fama and MacBeth (1973). However, its shortcomings have been the subject of intensive debate, for example, the implication of the mean-variance model's beta to estimate the stock return and the poor market proxy by utilizing the mean-variance efficient concept.

As a consequence of a number of deficiencies in the CAPM, Arbitrage Pricing Theory (APT) was developed by Ross (1976). APT attempts to illustrate the frame of asset returns based on a multifactor model. APT is built on a number of assumptions that can be split into two main groups. The first group involves the general assumptions of the CAPM pertaining to the efficiency of the market, the attitude of investors, and the unlimited risk-free rate borrowing. The second group comprises the key assumption of the Ross (1976) model that distinct economic factors influence the financial assets returns. These factors can be allocated into two categories: the common factors that affect all financial assets and the specific factors that influence one or more assets or industries.

In the essence of Ross (1976) APT, Fama and French (1993) show that the return premia associated with size and book-to-market ratio are compensation for risk, as described in the APT. In their model, they introduce two additional non-market risk factors such as 'small minus big' (SMB) which is the return on a portfolio of small stocks less the return on a portfolio of large stocks and 'high minus low' (HML) that is the return on a portfolio of high book-to market value stocks less the return on a portfolio of low book-to-market value stocks.

Based on this, Fama and French (1993, 1996) introduce a three-factor model for expected returns:

$$E(R_{it}) - R_{ft} = \beta_M[E(R_{Mt}) - E(R_{zt})] + \beta_1 SMB_t + \beta_2 HML_t \tag{4.3}$$

Fama and French (1993, 1996) find that the model picks out a lot of the difference in average return for portfolios composed on size, book-to-market equity and other price ratios that weaken the CAPM. In addition, Fama and French (1998) indicate that an international version of the model operates better than the international CAPM in explaining the high average returns on the country value portfolios for stocks from 13 main markets.

Due to the inability of the three-factor model to explain cross-sectional variation in momentum-sorted portfolio returns (Fama and French, 1996),[24] Carhart (1997) suggests adding a momentum factor (the difference between the returns on various portfolios of short term winners and losers) to the three factor model.[25]

[24] Momentum is the acceleration rate of a security's price or volume.

[25] Jegadeesh and Titman (1993) show that there is substantial evidence that indicates that stocks that perform the best (worst) over a three to 12 month period tend to continue to perform well (poorly) over the subsequent three to 12 months. Momentum trading strategies that exploit this phenomenon have been consistently profitable in the United States and in most developed markets.

With the increasing acceptance that pricing factors other than the market portfolio, especially macroeconomic factors, should also be included, this has led to further improvements, prominently in the form of the arbitrage theory. With this multifactor specification as a starting point, a growing number of empirical studies have examined whether macroeconomic variables specify a source of consistent asset price risk at the market and industry level. Examples of the employed macroeconomic variables other than market portfolio are: industrial production, inflation, term structure, money supply, gold prices, interest rates, and foreign exchange rate (for example Poon and Taylor, 1991, Antoniou et al., 1998, Faff and Chan, 1998, Dinenis and Staikouras, 1998, Elyasiani and Mansur, 1998, Ryan and Worthington, 2004, Erdem et al., 2005, among others).

As oil prices have fluctuated wildly in recent decades, it seems sensible to extend the literature with research on the impact of these prices on stock market return. The theoretical framework for how increasing oil prices influence stock prices is set out in Huang et al. (1996). An increase in the price of oil, which, in the absence of the effects of entire substitution between the components of production, increases the cost of operating a business. As such, higher expected business costs, reduces cash flow. Since stock prices are discounted values of expected cash flows, therefore, a reduction in the cash flow causes a similar change in stock prices. The impact on a particular stock price would rely on whether the company is a net consumer or producer of oil. In addition, a change in oil prices affect stock returns through the discount rate. The expected discount rate consists of a combination of the expected inflation rate and expected real interest rate, both of which may be affected by the price of oil. Since oil is a commodity, rising oil prices are often indicative of inflationary pressures (Kilian and Lewis, 2011). Therefore, an increase in the expected inflation rate will cause the same change in discount rate, thus, a reduction in stock returns.

In contrast to the bulk of work examining the relationship between oil price shocks and macroeconomic variables, there have been fewer studies investigating the exposure of equity returns to oil price changes. Several studies examine the effect of oil price risk on the aggregate stock market. There is no general consensus about the relationship between stock prices returns and returns on the price of oil among economists. On one hand, Chen et al. (1986) and Hamao (1988) find that the oil price is not a significant factor in the stock market of the US and Japan, respectively. Sadorsky (1999) and Kaneko and Lee (1995), on the other hand, show that changes in oil prices play a significant role in the US and Japanese stock market returns, respectively. Apergis and Miller (2009), Basher and Sadorsky (2006), Driesprong et al. (2008), Jones and Kaul (1996), Kilian and Park (2009) and Park and Ratti (2008), among others, have also investigated the oil price risk exposure of equity markets at the aggregate level with distinct results. For example, Apergis and Miller (2009) conclude that international stock market returns do not react in a considerable way to oil market shocks, whereas Basher and Sadorsky (2006) find strong evidence that stock price returns of emerging markets respond significantly to oil price risk.

Several studies have looked at the impact of oil price changes on the stocks of individual sectors. Most of these studies at the industry level focus on the US oil and gas industry (Hammoudeh et al., 2004, Mohanty et al., 2013, Mohanty and Nandha, 2011a), Canadian oil and gas sector (Sadorsky, 2001, Boyer and Filion, 2007), the UK oil and gas industry (El-Sharif et al., 2005), the US transportation industry (Aggarwal et al., 2012), and the US travel and leisure industry (Mohanty et al., 2014). Gogineni (2010) investigates the effect of changes in oil prices on the stock returns of a wide array of the US industries. He finds in addition to the stock returns of industries that depend heavily on oil, stock returns of some industries that use little oil are also sensitive to oil price changes. Using a sample of 13 US industries, Elyasiani et al. (2011) examine the impact of oil returns and volatility on excess stock returns and return volatilities.[26] They find that nine of the 13 sectors analyzed show a statistically significant relationship between oil return and industry excess returns. In addition, oil-consumer industries are more likely to be influenced by changes in oil returns volatility than those of the oil return itself. Nandha and Faff (2008) analyse 35 DataStream global industry indices and find that an increase in oil prices has a negative impact on equity returns for all sectors except mining, and oil and gas industries. Nandha and Brooks (2009) examine the role of oil prices in explaining transport sector equity returns in 38 countries across the world and find significant roles in the countries falling within the developed, Euro area and G7 countries. However, there appears to be no such evidence of a significant role for oil for other country groupings (Asia Pacific, Emerging and Latin America). El-Sharif

[26] The 13 industry sectors are: coal mining, electric and gas services, oil and gas extraction, building, chemical, petroleum refining, rubber and plastic products, metal, industrial and commercial machinery, transportation equipment, air transportation, depository institutions, and insurance.

et al. (2005) find evidence of a positive and significant relationship between oil prices and equity values in the oil and gas sector of the UK. However, UK evidence of the oil price sensitivity of non-oil and gas sectors is weak. McSweeney and Worthington (2008) examine the impact of crude oil prices on Australian industry stock returns and conclude that oil prices are an important determinant of returns in the banking, energy, materials, retailing and transportation industries. With the aid of 12 European sector indices, Arouri (2011) investigates their responses to oil price changes and concludes that the strength of the association between these variables varies across sectors.

Very few studies have looked at the impact of oil price changes on individual firms. For instance, Manning (1991) analyzes the reaction of London-quoted oil company stocks to oil price changes over the period from 1986 to 1988 using weekly data. He finds a positive and significant relationship between oil price changes and stock returns of oil companies and concludes that the response to an increase in oil price is more significant for oil firms that are only involved in exploration than those of integrated oil firms.[27] A firm-specific study by Al-Mudhaf and Goodwin (1993) examines the returns from 29 oil companies listed on the New York Stock Exchange. Their findings suggest a positive impact of oil price shocks on actual returns for firms with significant assets in domestic oil production. Using multivariate co-integration techniques and a vector error-correction model, Lanza et al. (2005) examine the long-run financial determinants of the stock prices of six major oil companies: Bp (UK), Chevron-Texaco (US), Eni (Italy), Exxon-Mobil (US), Royal Dutch Shell (The Netherlands/UK), and Total-Fina-Elf (France). They find a significant oil risk premium. Jin and Jorion (2006) investigate the relationship between stock return sensitivity of 119 US oil and gas producers to commodity prices over the period 1998 to 2001. They find that oil and gas prices have a significant positive effect on firm value. Using Fama-French-Carharts four-factor asset pricing model, augmented with the oil price and interest rate, Mohanty and Nandha (2011a) estimate oil price risk exposures of 40 US oil and gas sector. They find that oil price risk exposures vary considerably over time and across firms, in addition to industry subsectors. As an extension to their previous study, Mohanty and Nandha (2011b) employ the same methodology to investigate the relation between oil price movements and US transportation companies' stock returns. Their results suggest that oil price exposures of firms in the US transportation sector vary across firms

[27]Integrated oil and gas companies are business entities that take part in the exploration, production, refinement and distribution of oil and gas.

and over time. Most of the previously mentioned studies are applied on the US sectoral industries or individual firms, and very few studies are implemented on UK industrial sectors. As an attempt to fill this gap in the literature, the present chapter investigates the impact of oil price return on the stock returns of 25 UK firms from the industrial transportation, travel and leisure and oil and gas sectors.

Due to the significant impact of oil price changes on the different economic variables, many researchers have used different estimation procedures and data to test this relationship. More recently, the assertion has shifted to the asymmetry of the effect of oil price shocks on economic activities. It has been documented that oil price increases have a greater effect on the macroeconomic aggregates than decreases in oil price. Evidence of this asymmetric influence has been shown in many studies, such as Mork (1989), Cuñado and Pérez de Gracia (2003), and Park and Ratti (2008), among others for different countries. With the utilization of US data, Hamilton (2003) outlines that the significant role of non-linear oil price increases is more considerable in describing US output growth than non-linear oil price decreases. Contrary to this argument, Kilian (2008) presents little evidence for the asymmetric response of investment expenditures to the positive and negative oil price shocks. At the sectoral level, Arouri (2011) utilizes three non-linear specifications (asymmetric, scaled and net specifications) to test for asymmetric reaction of sectoral returns to oil shocks. He finds strong evidence of asymmetry in the response of stock returns to changes in the price of oil for some sectors. Scholtens and Yurtsever (2012) analyse the relationship between oil price shocks and 38 European industries and confirm that there are asymmetric effects but most of the time and in most industries these asymmetries are not statistically significant.

4.3 Empirical Methodology

The three-factor asset pricing model proposed by Fama and French (1993) (hereafter FF) has become a familiar asset pricing model and has been excessively utilized in the empirical finance literature. Recent studies investigate the prevalent empirical success of FF models and put forward evidence that the book-to-market factor, which is the difference between a portfolio of high book-to-market stocks and one of low book-to-market stocks (HML) and size factor, which is the difference between a small cap portfolio and a large cap portfolio (SMB) are connected with a number of macroeconomic fundamentals.[28] Aretz et al. (2005) propose that the FF-Carhart (1997) model which considers a momentum factor, outlines macroeconomic risk exposures in a parsimonious way. While the FF-Carhart (1997) model accounts for ordinary macroeconomic risk (systematic risk factors for the aggregate stock market), it may not express commodity price risk such as oil price risk at the industry or firm level.

The major concern of this study is to determine whether the crude oil price return and its volatility provide supplemental information beyond the generally accepted return generating factors such as FF-Carhart's (1997) factors, in describing industry and company stock returns. Therefore, the company excess stock return is estimated using the four factor FF-Carhart's (1997) model to investigate the sensitivity of the company stock returns to oil prices. In addition, tests for non-linearity in the relationship between oil price and stock price returns are conducted.

4.3.1 Firm returns and oil price changes

Following Narayan and Sharma (2011), Arouri (2011) and Elyasiani et al. (2011), the FF-Carhart's (1997) model that will be used to examine whether the firm stock returns are sensitive to oil price changes takes the following form:

$$\begin{aligned} R_{it} &= \beta_0 + \beta_m\, RM_t + \beta_1\, SMB_t + \beta_2\, HML_t + \beta_3\, Mom_t + \beta_{oil}\, Roil_t + \varepsilon_{it} \\ \varepsilon &\rightarrow N(0, h_{it}) \\ h_{it}^2 &= \alpha + \sum_{m=1}^{q} \beta_m \times \varepsilon_{i,t-m}^2 + \sum_{n=1}^{p} \gamma_n \times h_{i,t-n}^2 \end{aligned} \tag{4.4}$$

where R_{it} is the monthly return on price index i in excess of the yield of three month UK treasury bills, RM_t is the excess monthly return on the market portfolio, SMB_t is the difference in monthly return between a small cap portfolio and a large cap portfolio, HML_t is the difference in monthly return between a portfolio of high book-to-market stocks and one of low book-to-market stocks, Mom_t is the difference between the equal weighted average of the highest performing firms and the equal weighted average of the lowest performing firms, and $Roil_t$ is the monthly return on the oil price. ε_{it} is the idiosyncratic error term, which is assumed to be normally distributed with zero mean and conditional variance determined by a standard GARCH (q,p) process. Before implementing the GARCH methodology, it

[28] Macroeconomic factors that are correlated with HML and/or SMB involve innovations in real economic growth (Vassalou, 2003, Liew and Vassalou, 2000), default risk (Hahn and Lee, 2006, Vassalou and Xing, 2004), and inflation (Aretz et al., 2010).

is crucial to scrutinize the residuals for signs of heteroscedasticity. Therefore, the Engle (1982) Lagrange multiplier (LM) test is employed to check for the existence of ARCH effects. The test for the existence of ARCH effects is carried out by first predicting the residulas from the ordinary least squares regression of the conditional mean equation. After predicting the residuals e_t, the square of the residuals is regressed on a constant and p lags as follows:

$$e_t^2 = \beta_0 + \beta_1 e_{t-1}^2 + ... + \beta_p e_{t-p}^2 + \nu_t \tag{4.5}$$

The null hypothesis is that there are no ARCH effects:

$$H_0 : \beta_1 = \beta_2 = ... = \beta_p = 0$$

against the alternative:

$$H_1 : \beta_i > 0 \quad \text{For at least one } i = 1, 2, ..., p$$

The test statistic for the joint significance of the p-lagged squared residuals equals the number of observations N multiplied by R-squared (NR^2) and is compared with a $\chi^2(p)$ distribution. The $ARCH - LM$ test results for the firm's stock returns are reported in Table 4.1.

The GARCH(q,p) model treats the non constant volatility in returns and considers the next period's volatility dependent on this period information. The return series are modeled using two equations; mean and variance equations as follows;
Mean equation

$$R_{it} = \mu + \varepsilon_{it}$$

Variance equation

$$h_{it}^2 = \alpha + \sum_{m=1}^{q} \beta_m \times \varepsilon_{i,t-m}^2 + \sum_{n=1}^{p} \gamma_n \times h_{i,t-n}^2$$

The mean equation might be an autoregressive (AR) process, a moving average (MA) process or a combination of both AR or MA processes, (ARMA) process. The model that has the lowest Akaike information criteria (AIC)(Akaike, 1998) combined with significant coefficients for all its components will be the best model; this can vary from firm to another.

The variance equation includes two parts, $\varepsilon_{i,t-m}^2$ which is the ARCH term that presents the volatility from the period and $h_{i,t-n}^2$ that shows the previous period variance. To ensure positive variance, the conditions, $\beta_m \geq 0$ and $\gamma_n \geq 0$ are needed. In addition, to preserve a mean reverting variance process, the sum of both coefficients should be less than one.

For the firms that show no ARCH effects, the Newey and West (1987) estimator that accounts for serial correlation of unknown form in the residuals of a single time series is utilized.

With the existence of heteroscedasticity and/or serial correlation, the OLS estimator is no longer efficient and estimated standard errors are incorrect.

For the case

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$$

$$Var(\hat{\beta}_1) = \sum_{t=1}^{T} \sum_{t'=1}^{T} \frac{x_t \; x_{t'}}{\sum_{s=1}^{T} x_s^2} \; \sigma_{|t-t'|}$$

To estimate $Var(\hat{\beta}_1)$, $\sigma_{|t-t'|}$ should be replaced with an estimate $e_t e_{t'}$, however, there are too many covariances to estimate. Therefore, Newey and West (1987) suggests a way to simplify it. Instead of estimating all the covariances, they propose estimating only the most important covariances, where observations are more correlated to each other the more they are close to each other (for example, $Cov(\varepsilon_{11:2008}, \varepsilon_{12:2008}) > Cov(\varepsilon_{11:2008}, \varepsilon_{12:2010})$). Hence, $\sigma_{|t-t'|}$ approaches zero as $|t - t'|$ becomes larger.

To estimate Newey and West standard errors, the distance $|t - t'|$ after which $\sigma_{|t-t'|}$ can be ignored, should be judged. Therefore, the first step is to specify a lag, L and follow the assumption $\sigma_{|t-t'|} \approx 0$ for all $\sigma_{|t-t'|} > L$. $L = 4$, $L = 8$ and $L = 12$ are typical choices. The estimator replaces $\sigma_{|t-t'|}$ with $e_t e_{t'}$ if $|t - t'| \leq L$ and replaces $\sigma_{|t-t'|}$ with zero if $|t - t'| > L$.

So to correct for serial correlation and heteroscedasticity, the Newey and West estimated standard error is used:

$$s.e(\hat{\beta}_1) = \sqrt{\sum_{t=1}^{T} \sum_{t'=t-L}^{t+L} \frac{x_t \; x_{t'}}{\sum_{s=1}^{T} x_s^2} \; e_t e_{t'}}$$

4.3.2 Asymmetric response to oil shocks

Some research has found an asymmetric impact of oil price changes on the macroeconomy. That is oil price hikes have a negative impact on gross domestic product, but falls in the oil price do not necessarily have a positive impact on output and not necessarily of the same degree (Mork, 1989, Mork et al., 1994). There is, however, contradictory evidence of asymmetric effects of oil prices in financial markets. Basher and Sadorsky (2006) find that oil price changes produce asymmetric effects while Park and Ratti (2008), Nandha and Faff (2008) and Cong et al. (2008) do not find this.

To test for asymmetry in the reaction of UK firm returns to oil price shocks, Park and Ratti's (2008) method is followed where two specifications are estimated of non-linear measures of oil price changes on stock returns: an *asymmetric specification* (Mork, 1989, Hamilton, 2003), and a *scaled specification* (Lee et al., 1995, Cologni and Manera, 2009).

4.3.2.1 Asymmetric specification

In this specification, hikes and drops in the oil price are differentiated according to the following:

$$\begin{aligned} Roil_p^+ &= max[0, Roil_t] \\ Roil_n^- &= min[0, Roil_t] \end{aligned}$$

where $Roil_t$ is the return on the price of oil at time t and $Roil_p^+$ ($Roil_n^-$) is the positive (negative) oil price change at time t. $Roil_p^+$($Roil_n^-$) assumes positive(negative) values each time variations are positive (negative) and zero otherwise.

To examine the asymmetric effects of oil price fluctuations, equation (4.4) is rewritten to include the nonlinear measures of oil price changes: $Roil_p^+$, and $Roil_n^-$ besides the other factors. The exposure to rises in oil price is tested to see if it is different from the exposure to oil price drops. Following Basher and Sadorsky (2006), Nandha and Faff (2008), Sadorsky (2008), and Arouri (2011), $Roil_p^+$ and $Roil_n^-$ are included in the model to help test these effects:

$$\begin{aligned} R_{it} &= \beta_0 + \beta_m\, RM_t + \beta_1\, SMB_t + \beta_2\, HML_t + \beta_3\, Mom_t + \beta_{oil}^+\, Roil_p^+ \\ &\quad + \beta_{oil}^-\, Roil_n^- + \varepsilon_{it} \\ &\varepsilon \rightarrow N(0, h_{it}) \\ h_{it}^2 &= \alpha + \sum_{m=1}^{q} \beta_m \times \varepsilon_{i,t-m}^2 + \sum_{n=1}^{p} \gamma_n \times h_{i,t-n}^2 \end{aligned} \tag{4.6}$$

Therefore, β_{oil}^+ and β_{oil}^- are the coefficients that show the impacts of increases and decreases in oil price, respectively. If β_{oil}^+ and β_{oil}^- are not statistically different from zero, then the contention of asymmetry has no support. The null hypothesis that $\beta^{+}_{oil} = \beta^{-}_{oil}$ is also tested.

4.3.2.2 Scaled specification

This specification takes into consideration the volatility of oil prices. The main expectations is that increases in oil price after a long period of stability in price, may have larger impacts on stock returns than those that are simply corrections to greater decreases in oil price during the previous month. The measure of oil price volatility is based on a generalized autoregressive conditional heteroscedasticity process of order one, GARCH(1, 1) that was first proposed by Bollerslev (1986). Hansen and Lunde (2005) argue that the best volatility models do not provide a significantly better forecast than the GARCH(1,1) model. Following Lee et al. (1995), Jiménez-Rodríguez and Sanchez (2005) and Arouri (2011) we estimate a GARCH(1, 1) model to predict oil price volatility. Daily oil price returns will be estimated using ARMA(1,1)-GARCH(1, 1) model that is stated as the following:

$$\begin{aligned} Roil_t &= \gamma_0 + \gamma_1 Roil_{t-1} + \xi_t + \gamma_2 \xi_{t-1} \\ \xi_t &\rightarrow N(0, \sigma_t) \\ \sigma_t^2 &= \lambda_0 + \phi_1 \xi_{t-1}^2 + \varphi_1 \sigma_{t-1}^2 \end{aligned} \tag{4.7}$$

The monthly oil price volatilities ($Voil$) are computed as the average of the daily conditional volatilities

$$Voil = \frac{1}{D} \sum_{t=1}^{D} \hat{\sigma}_t^2$$

Then, the scaled oil price increase ($Voil_p^+$) and the scaled oil price decrease ($Voil_n^-$) are computed using the following:

$$\begin{aligned} Voil_p^+ &= max[0, \hat{\xi}_t / \sqrt{Voil_t}] \\ Voil_n^- &= min[0, \hat{\xi}_t / \sqrt{Voil_t}] \end{aligned}$$

Then the model can be estimated using the following equation:

$$\begin{aligned} R_{it} &= \beta_0 + \beta_m\, RM_t + \beta_1\, SMB_t + \beta_2\, HML_t + \beta_3\, Mom_t + \beta^{+}_{Voil}\, Voil_p^+ \\ &\quad + \beta^{-}_{Voil}\, Voil_n^- + \varepsilon_{it} \\ \varepsilon &\rightarrow N(0, h_{it}) \\ h_{it}^2 &= \alpha + \sum_{m=1}^{q} \beta_m \times \varepsilon_{i,t-m}^2 + \sum_{n=1}^{p} \gamma_n \times h_{i,t-n}^2 \end{aligned} \tag{4.8}$$

The same hypothesis as in the previous section will be tested here, using the coefficients β^{+}_{Voil} and β^{-}_{Voil}.

4.3.3 Effects of oil shocks and recessions on UK firms

The official declaration of UK in recession was in January 2009. It was announced by the Office for National Statistics (ONS) when the initiazl estimation of UK GDP indicated a reduction of 1.5% in the last quarter of 2008 preceded by a fall of 0.6% in the previous quarter. These figures showed that the famous definition of a recession - two successive quarters of declining economic growth had been met. ONS figures indicated a fall in the UK GDP by 2.4% in the first quarter of 2009 in comparison to the last quarter of 2008. The second quarter of 2009 showed another reduction in GDP by 0.7%, resulting in an overall drop in the level of GDP by 5.5% compared to the second quarter of 2008 (Vaitilingam, 2010).

In order to investigate the impact of oil price returns on the UK firm's stock returns during the global economic recession of 2008, equation (4.4) is augmented with a dummy variable. The dummy variable D_1 which equals 1 during the global recession from December 2007 to June 2009. This dummy variable is interacted with the change in oil price variable *Roil* as follows:

$$
\begin{aligned}
R_{it} = \beta_0 + \beta_D D_1 + \beta_m\, RM_t + \beta_1\, SMB_t + \beta_2\, HML_t + \beta_3\, Mom_t \\
+ \beta_{oil}\, Roil_t + \phi_1 D_1 Roil_t + \varepsilon_{it}
\end{aligned}
\tag{4.9}
$$

4.4 Data

To investigate the relationship between UK firms' stock returns and oil price changes, monthly data from 1998:01 to 2012:12 are employed. Monthly price indices for all the UK active firms are downloaded from the Worldscope Database published by Thomson Reuters. To start with, the data availability of all the transportation, travel and leisure and oil and gas producers companies are examined. The list is narrowed to include as many companies with sufficiently long data period as possible. As a result, the final sample comprises 25 UK companies that have relatively long histories (see Table A4.1).[29] The transportation industry is then grouped into subsectors that include transportation services (six firms) and delivery services (one firm). The travel & leisure sector is divided into subsectors, too. Travel & tourism (four firms) and airlines (two firms). Finally, the oil & gas producer companies are distributed into exploration & production (nine firms) and integrated oil & gas (three firms).

[29] These firms are specifically chosen due to the availability of long historical data and as they form two different sides of the oil market, consumers and producers of crude oil.

As is customary in the financial literature, returns R_{it} are computed as $R_{i,t} = [ln(I_{i,t}) - ln(I_{i,t-1})]$, where $I_{i,t}$ is the price index of firm i at time t in excess of the yield of three month UK Treasury Bills (i.e. equivalent to the risk free rate R_{ft}, see section 4.2). Stock market returns RM_t is the monthly market portfolio excess return on month t, measured as the return on the FTSE ALL Share Index minus the return on three month UK Treasury Bills; the market return is a proxy for changes in aggregate economic wealth that affect risk premia and expected returns (Fama and French, 1989, Ferson and Harvey, 1991). SMB_t is the difference in monthly return between a small cap portfolio and a large cap portfolio, HML_t is the difference in monthly return between a portfolio of high book-to-market stocks and one of low book-to-market stocks, Mom_t is the return on a zero investment portfolio long on winner and short on loser stocks. The data on the four FF-Carhart factors are from the University of Exeter Business School website.[30]

Regarding the oil prices, monthly prices of the West Texas Intermediate (WTI), expressed in US \$/barrel terms from the US Energy Information Agency. The exchange rate between the US \$ and the UK £ is used to convert the oil price into £ and the consumer price index CPI of UK is employed to adjust the nominal (dollar) price of oil.[31] Monthly returns of oil price are then calculated as the logarithmic difference of oil prices.

To predetermine the integration order of the stock prices, two unit root tests are applied; the Augmented Dickey and Fuller (1979) (ADF) and Kwiatkowski et al. (1992) (KPSS) tests both with a constant and a constant and a trend. The ADF test is setup on the unit root null hypothesis whereas the KPSS test is based on a null hypothesis of stationary time series. The obtained results of both tests are reported in Table 4.2. The ADF and KPSS tests with both specifications (constant and constant and trend) are applied on the level as well as the difference stock prices.[32] It can be observed from the reported results in Table 4.2 that the level prices have a unit root. For the ADF test, we cannot reject the null hypothesis of unit root in addition to the results of KPSS test that are significant which states that the null hypothesis of stationarity can be rejected. In contrast, the results of the first difference variables show significant ADF test results which means rejection

[30]The test portfolios and factors underlying the paper of Gregory et al. (2013) are found on `http://xfi.exeter.ac.uk/researchandpublications/portfoliosandfactors/index.php`.

[31]Lee et al. (1995), Jiménez-Rodríguez and Sanchez (2005) and Park and Ratti (2008) use the real price of oil.

[32]See Appendix A for more explanation of ADF and KPSS tests.

of the null hypothesis of unit root whereas the KPSS test results are insignificant which denote that the stationary null hypothesis cannot be rejected. Therefore, the price index series display a unit root, which show an integration of order one. The first difference series appear stationary as anticipated. Descriptive statistics for all firm returns' series (first difference) are summarized in Table 4.3. The other variables' descriptive statistics including oil price returns are reported in Table 4.4.

4.5 Empirical Work and Results

The empirical investigation starts with examining the sensitivity of firms' stock returns to oil price changes using FF-Carhart's (1997) model. In addition, the asymmetry in the reaction of UK firms' stock returns to oil price shocks is examined using two specifications of non-linear measures of oil price changes. Finally, the impact of oil shocks and recessions on the UK firms is explored.

4.5.1 Sensitivity of stock returns to oil price changes

The exposure of the chosen sample stock returns to oil price changes is scrutinized for each firm severally as an attempt to extend the perception to the link between oil price changes and firms' stock returns. In particular, FF- Carhart's (1997) model is augmented with the change in oil price to examine its effect on each firm's stock returns as stated in equation (4.4).

Table 4.5 presents the results of model (4.4) that are obtained by applying either GARCH(1, 1) for the firms with high ARCH effects in their stock returns, or the Newey and West (1987) estimator for the firms that fail to reject the null hypothesis of no ARCH effects. The firms are reported in groups according to their sector and subsector classifications.

As can be seen from the third column of Table 4.5, market return coefficients are positive and significant for 20 out of 25 firms. Most of the significant coefficients are less than 1, which indicate that the asset's price is less volatile than the market. The BBA Aviation transportation service company and Easyjet airlines company have market coefficients of greater than 1; offering the possibility of a higher rate of return, but also posing more risk (Sadorsky, 2001).

The fourth column of Table 4.5 presents the coefficients of the SMB factor which accounts for the spread in returns between small and large-sized firms. The SMB coefficients for most of the firms are positive and significant at the 5% level of significance, except for BP company, with negative and significant SMB coefficient. This is in line with the findings of Fama and French (1996) and Drew et al. (2003), who detect that small firms tend to have positive slopes on SMB. However, big firms tend to have diminishing positive or negative slopes on SMB, which indicates that they covary more with other large stocks than with small returns stocks.

Only 15 out of 25 firms have a significant positive slope of HML as can be seen from the fifth column of Table 4.5. Prior research has found that distressed stocks or industries tend to have positive loadings on HML and thus higher future returns while strong firms or industries have negative loadings on HML and lower future returns (Fama and French, 1995). Regarding the momentum variable *Mom*, most of the firms show insignificant response to it.

The main focus of this study is to investigate the relationship between oil price changes and stock returns of individual firms. Column seven of Table 4.5 demonstrates the oil price returns' coefficients (*Roil*). At first glimpse of the transportation services subsector, it can be noticed that oil price swings have no significant impact on stock returns for most of the firms in this subsector. However, an attentive testing of the obtained results indicates that two firms are having significant exposure to oil price risk. Braemar shipping services and Clarkson firms have a significant positive exposure at 10% and 5% level, respectively. Hence, a rise in the price of oil probably has a significant positive influence on stock returns in these two companies. This may be because; firstly, since these two companies are marine transportation, they are generally more fuel efficient; second, shipping companies gain a major fraction of their earnings by participating in ocean transportation of crude oil and petroleum outputs, so a rise in oil price that is joined with a growth in the overall demand for marine shipping of crude oil may cause an increase in the earnings of these firms. Finally, some companies utilize financial derivatives to hedge against increasing oil prices through the purchase of crude oil futures during periods when the price of oil is on a rising trend that would yield gains for the shipping company. The obtained results are in line with Mohanty and Nandha (2011b) who find a positive and significant oil price coefficient for the US marine transportation sector. Most of the other transportation firms that show insignificant exposure to oil price risk run different types of activities. For example, Sutton Harbour Holdings is the parent of a number of wholly owned subsidiary companies that comprise property and regeneration, marina, fisheries and Plymouth City Airport which was closed in 2011.[33] On top of that, their reports show that they usually hedge 100% of fuel requirements at improving rates to secure budgets.[34] Therefore, oil price fluctuations have insignificant impact. Moreover, the delivery services subsector shows a significant and negative relationship between oil price return and stock returns. For instance, the UK mail group stock returns are affected negatively by the change in oil price. In particular, an increase of 1% in returns of oil price causes a reduction in their stock returns by 0.164%.

The travel and leisure sector includes two of the main subsectors, travel and tourism and airlines. Surprisingly, oil price returns have a weakly significant and negative impact on the stock returns of National Express and Stagecoach Group from the travel and tourism subsector, where an increase of 1% in the price of oil reduces the stock returns of both of them by 0.107% and 0.129%, respectively. These two groups are of the most leading public transport groups who consume 222 and 370 million litres of fuel per year, respectively.[35] However, both groups have hedging contracts to help dilute the effect of jumps in oil prices. On one hand, National Express group announced in mid 2010 that they are fully hedged for 2010 at an average of 39 pence per litre, about 90% hedged for 2011 at 41 pence and 35% hedged for 2012 at 42 pence, which will decrease their exposure to changes in oil price.[36] Two years later, they announce that they are fully hedged for the year 2013 at 48 pence per litre.[37] On the other hand, Stagecoach group is employing a hi-tech echo-driving system, to help decrease the consumption of fuel. Regarding the other airlines sector, the same negative impact is found on its stock returns. However, Easyjet company's stock returns are influenced more significantly by an increase in oil price when compared to Dart group company. Similar to the previously mentioned travel and leisure groups, Dart group's fuel price risk exposure is

[33] http://www.suttonharbourholdings.co.uk/about-us/what-we-do

[34] http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aCNsiIDLJKOU

[35] http://www.stagecoach.com/media/insight-features/planning-for-a-different-energy-future.aspx
http://www.rttnews.com/1346064/national-express-expects-progress-in-h1-normalized-pre-tax-p
aspx

[36] http://www.nationalexpressgroup.com/media/corporatenews.aspx?newsyear=2010&newsitem=18

[37] http://www.nationalexpressgroup.com/media/corporatenews.aspx?newsyear=2012&newsitem=680

maintained by forward hedging against any unexpected rise in the price of oil.[38] In one of the recent analysis reports, Easyjet states that although the firm hedges as best it can to prevent or dilute the risk of oil price, fuel cost remains a large risk. The firm's operating income dropped by 47% in the year 2009 as fuel costs rised by 67%.[39]

The last panel of Table 4.5 displays the results for the oil and gas producers sector. This sector is composed of two subsectors, exploration and production and integrated oil and gas where the first subsector includes nine firms and the other includes three firms. Seven out of nine exploration and production firms show a positive and significant exposure to oil risk at the 5% and 1% levels of significance. All the three integrated oil and gas firms are significantly and positively influenced by the changes in oil price. Similar to the results of El-Sharif et al. (2005), who investigate the relationship between the price of crude oil and equity values in the UK oil and gas sector, this study concludes that there is a positive relationship between oil price changes and oil and gas equity returns. Another result worth mentioning is that the oil price return has a greater impact on producers than on integrated firms. This result is consistent with that of Boyer and Filion (2007).

When the FF-Carhart (1997) model is augmented with oil price volatility instead of oil price return as in Model (4.4), the transportation sector firms show no significant response to it except Sutton Harbour Holdings as can be seen from Table 4.6. The seventh column that is headed with *Voil* presents the coefficients of oil price volatility. Sutton Harbour Holdings company reacts negatively to the oil price volatility. This result may be imputed to the operating of the regional airline Air Southwest which was subsequently sold at the end of 2010 due to unsustainable losses.[40] Similarly, National Express as a travel and leisure company shows a negative and significant reaction to oil price volatility.

In the oil and gas producers sector, only Fortune Oil company and Sterling Energy company respond significantly and negatively to oil price volatility. Fortune Oil company concentrates mainly on investments and operations in oil and gas supply and infrastructure projects in China whereas Sterling Energy company is interested in potential explorations projects in Africa (Cameroon, Madagascar and

[38] http://www.dartgroup.co.uk/report_and_accounts_2013/business_and_financial_review/

[39] http://analysisreport.morningstar.com/stock/research?t=EZJ&region=gbr&culture=en-US&productcode=MLE

[40] http://www.suttonharbourholdings.co.uk/about-us/our-business

Somaliland). At the end of 2013, Sterling Energy company's report stated that one of the risks that the group's business faces is the volatility of oil price that affects its revenues and reserves.[41]

4.5.2 Asymmetric response of UK firms to oil shocks

One of the estimation techniques to examine the impact of oil price returns on the firms' equity returns is to investigate its asymmetric effect where increases and decreases in both, oil price returns and its volatility, are included as distinct variables.

Estimation results of the non linear models which are stated in Equations (4.6) and (4.8), are presented in Table 4.7. The second and third columns show the coefficients for increases and decreases in oil price. Tests on the following null hypotheses (a and b) for each firm's stock returns are reported in the fourth and fifth column of the same table.

$$(a) \quad H_{0a} : \beta^{+}_{oil} = \beta^{-}_{oil} = 0 \qquad H_{1a} : \beta^{+}_{oil} \neq \beta^{-}_{oil} \neq 0$$

$$(b) \quad H_{0b} : \beta^{+}_{oil} = \beta^{-}_{oil} \qquad H_{1b} : \beta^{+}_{oil} \neq \beta^{-}_{oil}$$

The first panel shows the results of the firms from the transportation sector. The outcome of the Wald tests indicate that the hypothesis $\beta^{+}_{oil} = \beta^{-}_{oil} = 0$ is rejected only for Clarkson company at the 5% level of significance. This result is in line with that obtained from Table 4.5, which emphasizes the importance of the effect of oil price changes on the stock returns of this company.

Travel and leisure sector results are presented in the second panel. National Express company (one of the travel and tourism companies), reacts to the changes in oil price asymmetrically. This can be deduced from the significant results of Wald tests which suggest that the null hypotheses $\beta^{+}_{oil} = \beta^{-}_{oil} = 0$ and $\beta^{+}_{oil} = \beta^{-}_{oil}$ are rejected at 1% level. These findings might give confirmation for the relationship between oil price changes and the group's stock returns. The hikes in oil price have a significant negative impact, whereas a fall in the price of oil has a significant positive effect on the returns of National Express group. When comparing this result with the weakly significant impact of oil price changes that was obtained in Table 4.5, it can be argued that the group's stock returns react differently and significantly to the increases and decreases in oil price. Similarly, both of the null hypotheses are rejected

[41] http://www.sterlingenergyuk.com/pdf/financial-reports/ReportandFinancialStatements2013.pdf

at 5% level for the Stagecoach group. The obtained results provide evidence that the stock returns of this firm respond negatively to increases in oil price but show no response to oil price dropping. One more rejection for the two hypotheses is for the impact of the hikes and drops in oil price on the Dart group's stock returns. Drops in oil price affect it negatively but no significant impact of the rises in oil price. The negative impact of the drop in oil price might be attributed to the hedging strategy that they imply to protect from high energy costs, but also might deprive them from enjoying lower costs when the crude price falls.

The oil and gas producers sector results demonstrate that the first hypothesis ($\beta^+_{oil} = \beta^-_{oil} = 0$) is rejected for 10 out of 12 firms, usually at the 1% level. These outcomes assert the findings of Table 4.5, which show the important role for oil price changes in determining the stock price returns of this sector's firms. The BP integrated oil and gas company is the one and only exception which shows a rejection for the second hypothesis ($\beta^+_{oil} = \beta^-_{oil}$), as well. This result leads to an asymmetric reaction of the BP stock returns to a change in oil price, where it respond positively to an increase in oil price, but no significant reaction to drops in oil price.

The results of the second scaled specification are reported in the sixth column and beyond of Table 4.7. The hypotheses $\beta^+_{Voil} = \beta^-_{Voil} = 0$ and $\beta^+_{Voil}\ \beta =^-_{Voil}$ are rejected for Sutton Harbour Holdings company which asserts the result obtained in Table 4.6. The stock returns react negatively and significantly to decreases in oil price volatility but no response to the increases.

The hypothesis $\beta^+_{Voil} = \beta^-_{Voil} = 0$ is rejected for National Express, Fortune Oil and Sterling Energy companies, which emphasizes the prominence of oil price shocks. These results are in line with that stated in Table 4.6. Although the results of Table 4.6 do not show any significant response to oil price volatility from Premier Oil, Tullow Oil and BG Group companies, however, the results that are displayed in Table 4.7 illustrate that the stock returns of the previously mentioned companies react positively to increases in oil price volatility and do not respond to decreases in its volatility. This outcome is confirmed by the rejection of both hypotheses; $\beta^+_{Voil} = \beta^-_{Voil} = 0$ and $\beta^+_{Voil} = \beta^-_{Voil}$, for these firms.[42]

[42]Model (4.4) is augmented with both oil price change and oil price volatility, but no significant change in the coefficients obtained. Similarly, the asymmetric effect is examined using both specifications, but no noticeable change in coefficients nor in hypotheses tests. Therefore, these results are not reported here.

4.5.3 Reactivity of Stock returns to oil price shocks during recessions

In this section, the effect of the global recession on the stock returns of the sectors' firms is investigated.[43] In order to examine this effect, a dummy variable (D_1) is generated that equals one in the period from December 2007 to June 2009 to show the period of the global recession following Mohanty et al. (2014).[44] This dummy is interacted with the oil price return ($Roil_t$). The augmented model is presented in Equation (4.9) and the results are reported in Table 4.8.

In general, the results of the transportation industry stock returns show insignificant reaction to the high oil prices in recession time. However, Ocean Wilsons Holdings' stock returns are affected positively during the recession period as can be seen from the fourth column of Table 4.8. Ocean Wilsons Holdings firms is a marine transportation that provides support services to the oil and gas industry. In addition, this type of transportation uses financial derivatives to hedge against increases in oil price.[45]

Travel and leisure firms, specifically the travel and tourism subsector firms present a significant positive response to the change in oil prices over the time of recession. This can be observed from the results of Go-ahead group, National express and Stagecoach group. For example, National express overall response to the change in oil price is positive ($-0.144 + 0.441 = 0.297\%$). The positive response can be attributed to the hedging strategy that these firms follow to decrease the impact of the increase in oil prices.

For the oil and gas producers sector, only two firms, namely BP and Royal dutch shell, from the integrated oil and gas subsector show significant reaction to the oil price changes while recession. Unexpectedly, their response appears to be negative. This may be explained through the role of this type of firm. Integrated companies split their different processes into two streams: upstream, which involve all exploration and production efforts; and downstream, that is limited to the improvement and marketing activities. During the periods of oil price increases, these companies

[43] Mohanty et al. (2014) scrutinize the impact of the change in oil prices on the travel and leisure sector returns over three different US recessions

[44] http://www.huffingtonpost.com/2009/07/16/imf-predicts-end-of-globa_n_236690.html
https://www.imf.org/external/pubs/ft/fandd/2009/03/basics.htm
https://www.businesscycle.com/pdf/trackrecord/0808ICO_Overall.pdf

[45] http://www.oceanwilsons.bm/news-item?item=971107138033562

may have lower profit margins due to having greater downstream than upstream capability.

4.6 Conclusion

This chapter empirically investigates the relationship between oil price shocks and the equity returns of 25 UK firms. Contrary to other empirical studies that investigate the oil price exposure of stock returns at the aggregate and sectoral levels (and in most of the cases using the US data), this study explores this relationship at the firm level, specifically, transportation, travel and leisure and oil and gas sectors' firms over the period from 1998m01 to 2012m12. The sample is chosen on the basis of the availability of long historical data and as they form two different sides of the oil market, consumers and producers of crude oil. The oil price exposure of the firms' returns is examined using FF-Carhart (1997) four factor asset pricing model that is augmented with oil price risk using two measures, oil price change and oil price volatility.

Contrary to what was expected, most of the stock returns of the transportation sector's firms show insignificant exposure to oil price risk, except two firms from the transportation services subsector. These two firms are marine transportation, which are fuel efficient, usually participate in ocean transportation of crude oil and petroleum outputs, and hedge against the rise in oil price . Therefore, the exposure of this type of company to the oil price is positive and significant. Similarly, hedging contracts help dilute the negative effect of jumps in oil prices on the returns of travel and tourism and airlines subsectors firms. Comparably, most of the oil and gas firms respond positively to the change in oil price. However, oil price returns have a greater impact on exploration and production firms than on integrated firms.

In addition, the asymmetric response of the firms' returns is examined using two different measures, increases and decreases in oil price, and hikes and drops in oil price volatility. It has been found that some firms show asymmetric response to theses measures, including travel and tourism, airlines and integrated oil and gas firms.

The obtained results might be of interest to researchers, regulators and investors. Investors who wish to invest in oil price-sensitive stocks, should choose oil and gas and marine transportation stocks when the prices are high and choose travel and tourism and airlines stocks when the oil prices are expected to drop. Moreover, hedging minimizes the responsiveness of the firms' stock returns to the changes in oil prices. As the firms' returns have different distinct sensitivities to oil price changes, diversifying between stocks in the investors' portfolios, particularly holding some assets with affirmative response to oil price shocks, may help reducing the impact of the change in oil prices. Investors should consider any forthcoming rises or drops in oil price and try to stabilize their portfolios accordingly.

Table 4.1: ARCH-LM test for residuals of firm's stock returns

Company	ARCH-LM statistic (NR^2)	Prob. Chi-square(4)
	Transportation	
Transportation Services		
BBA AVIATION	10.757	0.029
BRAEMAR SHIPPING SVS.	1.101	0.894
CLARKSON	10.033	0.039
FISHER(JAMES) & SONS	12.869	0.012
OCEAN WILSONS HOLDINGS	1.117	0.892
SUTTON HARBOUR HDG.	10.037	0.039
Delivery Services		
UK MAIL GROUP	6.819	0.009
	Travel & Liesure	
Travel & Tourism		
FIRST GROUP	6.632	0.157
GO-AHEAD GROUP	0.506	0.973
NATIONAL EXPRESS	26.66	0.000
STAGECOACH GROUP	16.233	0.003
Airlines		
DART GROUP	44.401	0.000
EASYJET	5.332	0.255
	Oil & Gas Producers	
Exploration & Production		
AMERISUR RESOURCES	3.101	0.541
CAIRN ENERGY	9.406	0.052
FORTUNE OIL	4.579	0.333
JKX OIL & GAS	27.397	0.000
NORTHERN PETROLEUM	13.93	0.008
PREMIER OIL	0.101	0.751
SOCO INTERNATIONAL	13.453	0.009
STERLING ENERGY	1.044	0.903
TULLOW OIL	12.198	0.016
Integrated Oil & Gas		
BG GROUP	1.373	0.849
BP	5.275	0.022
ROYAL DUTCH SHELL B	3.937	0.415

Table 4.2: Unit root tests

Firm	Levels				First difference			
	ADF		KPSS		ADF		KPSS	
	Const.	*Const. + Trend*	*Const.*	*Const. + Trend*	*Const.*	*Const. + Trend*	*Const.*	*Const. + Trend*
Transportation								
Transportation Services								
BBA AVIATION	-1.861	-2.304	0.834***	0.0795	-13.983***	-13.953***	0.074	0.052
BRAEMAR SHIPPING SVS.	-1.557	-2.474	0.962***	0.122*	-12.629***	-12.593***	0.082	0.080
CLARKSON	-1.061	-1.680	1.210***	0.241***	-11.626***	-11.602***	0.097	0.070
FISHER(JAMES) & SONS	-0.333	-2.275	1.220***	0.221***	-12.758***	-12.753***	0.144	0.138
OCEAN WILSONS HOLDINGS	-0.389	-1.182	1.280***	0.156**	-12.399***	-12.367***	0.165	0.155**
SUTTON HARBOUR HDG.	-1.053	-0.861	0.317	0.270***	-13.236***	-13.307***	0.251	0.108
Delivery Services								
UK MAIL GROUP	-2.661	-2.740	0.371*	0.130*	-11.357***	-11.332***	0.062	0.059
Travel & Liesure								
Travel & Tourism								
FIRST GROUP	-1.918	-1.675	0.297	0.163**	-12.868***	-12.923***	0.179	0.064
GO-AHEAD GROUP	-1.832	-1.766	0.866***	0.200**	-12.420***	-12.425***	0.116	0.056
NATIONAL EXPRESS	-1.578	-2.152	0.455*	0.124*	-11.921***	-11.899***	0.079	0.046
STAGECOACH GROUP	-1.278	-1.887	0.515**	0.202**	-12.651***	-12.683***	0.152	0.056
Airlines								
DART GROUP	-1.805	-1.880	0.092	0.052	-12.038***	-12.010***	0.055	0.051
EASYJET	-1.572	-2.083	0.312	0.074	-10.643***	-10.671***	0.116	0.059
Oil & Gas Producers								
Exploration & Production								
AMERISUR RESOURCES	-0.904	-1.745	0.616**	0.185**	-12.850***	-12.888***	0.169	0.041
CAIRN ENERGY	-0.623	-2.352	1.250***	0.171**	-12.247***	-12.216***	0.144	0.143
FORTUNE OIL	-1.643	-3.316	0.760***	0.140*	-14.443***	-14.586***	0.275	0.113
JKX OIL & GAS	-0.815	-0.556	1.050***	0.220***	-11.800	-11.788***	0.219	0.195**
NORTHERN PETROLEUM	-1.643	-3.095	0.957***	0.168**	-14.948***	-14.939***	0.218	0.188**

Table 4.2 – Continued

	Levels				First difference			
	ADF		KPSS		ADF		KPSS	
Firm	*Const.*	*Const. + Trend*	*Const.*	*Const. + Trend*	*Const.*	*Const. + Trend*	*Const.*	*Const. + Trend*
PREMIER OIL	-0.535	-3.589**	1.240***	0.129*	-12.357***	-12.377***	0.246	0.188**
SOCO INTERNATIONAL	-0.571	-2.617	1.180***	0.181**	-11.823***	-11.817***	0.139	0.131
STERLING ENERGY	-1.537	-1.795	0.803***	0.200**	-12.071***	-12.046***	0.118	0.120
TULLOW OIL	-0.262	-3.467	1.290***	0.225***	-16.528***	-16.595***	0.278	0.168
Integrated Oil & Gas								
BG GROUP	-0.971	-2.209	1.320***	0.180**	-15.617***	-15.584***	0.147	0.130
BP	-3.496***	-3.627	0.154	0.122*	-14.775***	-14.777***	0.145	0.053
ROYAL DUTCH SHELL B	-2.747*	-3.342*	0.535**	0.092	-15.057***	-15.015***	0.061	0.047

Notes: This Table presents unit root tests results for the log of price index (level) and difference log of price index series for 25 firms from the UK transportation, travel and leisure, and oil and gas producers sectors. ADF presents Augmented Dickey and Fuller (1979) and KPSS presents Kwiatkowski et al. (1992) tests. ***, **, and * indicate a statistical significance of 1%, 5% and 10%, respectively.

Table 4.3: Firms Returns Descriptive Statistics

Firm	**Mean**	**Std. Dev.**	**Min**	**Max**	**Skewness**	**p-value**	**Kurtosis**	**p-value**
				Transportation				
Transportation Services								
BBA AVIATION	-0.006	0.108	-0.332	0.257	-0.390	0.032	3.393	0.224
BRAEMAR SHIPPING SVS.	-0.001	0.099	-0.464	0.357	-0.419	0.021	6.242	0.000
CLARKSON	0.010	0.109	-0.371	0.303	-0.374	0.039	4.644	0.002
FISHER(JAMES) & SONS	0.007	0.092	-0.397	0.325	-0.399	0.028	5.641	0.0001
OCEAN WILSONS HOLDINGS	0.009	0.089	-0.478	0.190	-0.770	0.0001	6.854	0.000
SUTTON HARBOUR HDG.	-0.004	0.095	-0.332	0.303	-0.288	0.107	5.431	0.0001
Delivery Services								
UK MAIL GROUP	-0.006	0.124	-0.783	0.252	-2.126	0.000	12.705	0.000
				Travel & Liesure				
Travel & Tourism								
FIRST GROUP	-0.003	0.097	-0.417	0.317	-0.343	0.057	5.203	0.0003
GO-AHEAD GROUP	0.002	0.091	-0.379	0.255	-0.836	0.000	5.488	0.0001
NATIONAL EXPRESS	-0.006	0.108	-0.455	0.456	-0.691	0.0003	7.469	0.000
STAGECOACH GROUP	0.0005	0.140	-0.548	0.674	0.000	0.011	1.800	0.000
Airlines								
DART GROUP	0.003	0.131	-0.529	0.487	-0.055	0.754	6.012	0.000
EASYJET	0.003	0.125	-0.500	0.356	-0.856	0.0001	4.813	0.003
				Oil & Gas Producers				
Exploration & Production								
AMERISUR RESOURCES	0.008	0.199	-0.816	0.677	-0.053	0.762	4.434	0.005
CAIRN ENERGY	0.006	0.133	-0.522	0.385	-0.530	0.004	4.811	0.001
FORTUNE OIL	-0.004	0.154	-0.643	0.545	0.221	0.214	5.326	0.0002

Table 4.3 – Continued

Firm	**Mean**	**Std. Dev.**	**Min**	**Max**	**Skewness**	**p-value**	**Kurtosis**	**p-value**
JKX OIL & GAS	-0.0005	0.152	-0.624	0.470	-0.359	0.047	5.097	0.0004
NORTHERN PETROLEUM	-0.008	0.214	-0.626	1.151	0.745	0.0001	7.874	0.000
PREMIER OIL	0.003	0.118	-0.387	0.313	-0.415	0.023	4.225	0.010
SOCO INTERNATIONAL	0.004	0.141	-0.796	0.370	-1.046	0.000	8.349	0.000
STERLING ENERGY	-0.027	0.166	-0.765	0.412	-0.868	0.000	6.559	0.000
TULLOW OIL	0.009	0.134	-0.538	0.366	-0.784	0.0001	5.848	0.000
Integrated Oil & Gas								
BG GROUP	0.006	0.079	-0.444	0.186	-1.221	0.000	8.742	0.000
BP	-0.003	0.076	-0.382	0.212	-0.760	0.0001	5.728	0.0001
ROYAL DUTCH SHELL B	-0.001	0.072	-0.170	0.274	0.338	0.060	3.783	0.052

Table 4.4: **Descriptive statistics for the other factors**

Variable	Mean	Std. Dev.	Min	Max	Skewness	p-value	Kurtosis	p-value	observations
RM	0.002	0.043	-0.136	0.099	-0.669	0.0005	3.601	0.104	180
SMB	0.002	0.036	-0.114	0.165	0.038	0.831	5.400	0.0002	180
HML	0.003	0.040	-0.185	0.122	-0.519	0.005	7.923	0.000	180
Mom	0.007	0.055	-0.274	0.138	-1.129	0.000	7.109	0.000	180
Roil	0.004	0.038	-0.144	0.089	-0.822	0.000	4.673	0.002	180

Notes: This Table presents the descriptive statistics of all explanatory variables. RM is the monthly market portfolio excess return, SMB is the difference in monthly return between a small cap portfolio and a large cap portfolio, HML is the difference in monthly return between a portfolio of high book-to-market stocks and one of low book-to-market stocks, Mom is the difference between the equal weighted average of the highest performing firms and the equal weighted average of the lowest performing firms and Roil is the monthly return on the oil price.

Table 4.5: Response of UK firms to changes in oil price

Firm	**Constant**	**RM**	**SMB**	**HML**	**Mom**	**Roil**	**ARCH**	**GARCH**	R^2
				Transportation					
Transportation Services									
BBA AVIATION	-0.010	1.103	1.095	0.286	-0.155	-0.038	0.234	0.637	
	(0.004)**	(0.128)***	(0.147)***	(0.138)**	(0.106)	(0.057)	(0.128)	(0.185)***	
BRAEMAR SHIPPING SVS.	-0.006	0.513	0.412	0.334	0.219	0.143			0.1038
	(0.007)	(0.166)***	(0.263)	(0.185)*	(0.175)	(0.086)*			
CLARKSON	0.007	0.681	0.531	0.464	0.161	0.218	0.130	0.742	
	(0.008)	(0.194)***	(0.218)**	(0.244)*	(0.172)	(0.089)**	(0.078)*	(0.156)***	
FISHER(JAMES) & SONS	0.008	0.310	0.732	0.392	0.038	0.004	0.366	0.438	
	(0.006)	(0.128)**	(0.168)***	(0.217)*	(0.139)	(0.065)	(0.107)***	(0.109)***	
OCEAN WILSONS HOLDINGS	0.006	0.277	0.940	0.292	0.041	-0.011			0.1800
	(0.006)	(0.159)*	(0.234)***	(0.189)	(0.136)	(0.0178)			
SUTTON HARBOUR HDG.	-0.008	0.410	0.909	0.519	0.243	0.020	0.356	0.406	
	(0.006)	(0.132)***	(0.180)***	(0.182)***	(0.138)*	(0.070)	(0.162)**	(0.205)**	
Delivery Services									
UK MAIL GROUP	0.002	0.535	0.498	-0.186	0.140	-0.164	0.827		
	(0.009)	(0.163)***	(0.197)**	0.246)	(0.204)	(0.083)**	(0.0205)***		
				Travel & Liesure					
Travel & Tourism									
FIRST GROUP	-0.008	0.224	0.466	0.619	0.088	0.108			0.1043
	(0.007)	(0.150)	(0.158)***	(0.233)***	(0.133)	(0.087)			
GO-AHEAD GROUP	-0.004	0.135	0.846	0.524	0.243	0.081			0.1420
	(0.007)	(0.172)	(0.161)***	(0.236)**	(0.132)*	(0.109)			
NATIONAL EXPRESS	0.004	0.294	0.734	0.325	-0.008	-0.107	0.527	0.445	
	(0.005)	(0.128)**	(0.149)***	(0.153)**	(0.114)	(0.060)*	(0.206)***	(0.115)***	
STAGECOACH GROUP	0.001	0.748	0.821	0.157	0.252	-0.129	0.284	0.696	
	(0.006)	(0.146)***	(0.189)***	(0.205)	(0.162)	(0.072)*	(0.143)**	(0.132)***	

Table 4.5 – Continued

Firm	Constant	RM	SMB	HML	Mom	Roil	ARCH	GARCH	R^2
Airlines									
DART GROUP	0.004	0.494	0.933	0.142	0.0005	-0.171	0.189	0.704	
	(0.009)	(0.171)***	(0.264)***	(0.279)	(0.222)	(0.096)*	(0.097)**	(0.142)***	
EASYJET	-0.001	1.117	1.209	-0.286	0.240	-0.242			0.2556
	(0.011)	(0.312)***	(0.382)***	(0.347)	(0.224)	(0.123)**			
Oil & Gas Producers									
Exploration & Production									
AMERISUR RESOURCES	0.001	0.958	0.959	0.113	0.352	0.140			0.0859
	(0.014)	(0.356)***	(0.420)**	(0.339)	(0.343)	(0.178)			
CAIRN ENERGY	-0.011	0.718	0.924	0.648	0.397	0.427	0.172	0.769	
	(0.009)	(0.215)***	(0.218)***	(0.245)***	(0.205)**	(0.088)***	(0.068)**	(0.095)***	
FORTUNE OIL	-0.015	0.513	1.028	0.833	0.492	0.403			0.1651
	(0.010)	(0.225)**	(0.340)***	(0.352)**	(0.290)*	(0.132)***			
JKX OIL & GAS	-0.007	0.029	0.922	0.413	0.363	0.321	0.460		
	(0.011)	(0.236)	(0.294)***	(0.335)	(0.208)*	(0.131)**	(0.211)**		
NORTHERN PETROLEUM	-0.018	0.490	1.508	0.560	0.204	0.423	0.630		
	(0.012)	(0.340)	(0.459)***	(0.315)*	(0.258)	(0.131)***	(0.149)***		
PREMIER OIL	-0.007	0.537	0.986	0.970	0.227	0.322			0.2813
	(0.008)	(0.189)***	(0.209)***	(0.220)***	(0.183)	(0.117)***			
SOCO INTERNATIONAL	0.011	0.435	0.433	0.052	0.030	0.153	0.232	0.587	
	(0.011)	(0.245)*	(0.304)	(0.267)	(0.172)	(0.132)	(0.104)**	(0.175)***	
STERLING ENERGY	-0.030	0.418	0.625	0.200	-0.345	0.318			0.1021
	(0.012)**	(0.260)	(0.272)**	(0.441)	(0.328)	(0.149)**			
TULLOW OIL	0.001	0.746	0.366	0.374	0.678	0.337	0.361	0.461	
	(0.006)	(0.158)***	(0.234)	(0.180)**	(0.143)***	(0.083)***	(0.129)***	(0.157)***	

Table 4.5 – Continued

Firm	**Constant**	**RM**	**SMB**	**HML**	**Mom**	**Roil**	**ARCH**	**GARCH**	R^2
Integrated Oil & Gas									
BG GROUP	0.002	0.510	0.005	0.312	0.123	0.205			0.1457
	(0.005)	(0.131)***	(0.197)	(0.140)**	(0.129)	(0.071)***			
BP	-0.005	0.773	-0.298	0.226	0.138	0.230	0.299		
	(0.003)*	(0.111)***	(0.131)**	(0.104)**	(0.083)*	(0.045)***	(0.072)***		
ROYAL DUTCH SHELL B	-0.005	0.718	-0.072	0.169	0.163	0.226			0.2494
	(0.004)	(0.101)***	(0.152)	(0.108)	(0.132)	(0.095)**			

Notes: This Table presents the estimation results of Equation 4.4 for 25 firms from the UK transportation, travel and leisure, and oil and gas producers sectors. The figures that are stated in parentheses are standard errors that are asymptotically robust to the existence of heteroscedasticity and serial autocorrelation. ***, **, and * indicate a statistical significance of 1%, 5% and 10%, respectively.

Table 4.6: Oil price volatility impact on UK companies

Firm	**Constant**	**RM**	**SMB**	**HML**	**Mom**	**Voil**	**ARCH**	**GARCH**	R^2
				Transportation					
Transportation Services									
BBA AVIATION	-0.018	1.110	1.097	0.309	-0.144	0.111	0.268	0.581	
	(0.007)**	(0.124)***	(0.139)***	(0.133)**	(0.104)	(0.081)	(0.144)*	(0.196)***	
BRAEMAR SHIPPING SVS.	0.010	0.475	0.460	0.280	0.177	-0.229			0.1016
	(0.012)	(0.169)***	(0.261)*	(0.181)	(0.163)	(0.150)			
CLARKSON	0.014	0.797	0.485	0.746	0.223	-0.024	0.229	0.581	
	(0.016)	(0.212)***	(0.233)**	(0.22)***	(0.186)	(0.173)	(0.121)*	(0.211)***	
FISHER(JAMES) & SONS	0.019	0.271	0.699	0.365	0.020	-0.183	0.384	0.433	
	(0.010)**	(0.128)**	(0.163)***	(0.208)*	(0.131)	(0.125)	(0.108)***	(0.103)***	
OCEAN WILSONS HOLDINGS	0.012	0.254	0.930	0.266	0.013	-0.097			0.1841
	(0.010)	(0.150)*	(0.221)***	(0.189)	(0.132)	(0.138)			
SUTTON HARBOUR HDG.	0.008	0.412	0.887	0.465	0.218	-0.230	0.425	0.387	
	(0.009)	(0.126)***	(0.177)***	(0.168)***	(0.138)	(0.117)**	(0.173)**	(0.177)**	
Delivery Services									
UK MAIL GROUP	-0.004	0.505	0.490	-0.199	0.095	0.051	0.760		
	(0.012)	(0.164)***	(0.196)**	(0.242)	(0.201)	(0.122)	(0.192)***		
				Travel & Liesure					
Travel & Tourism									
FIRST GROUP	0.008	0.221	0.472	0.574	0.082	-0.222			0.1058
	((0.014)	(0.146)	(0.149)***	(0.228)**	(0.146)	(0.184)			
GO-AHEAD GROUP	0.0004	0.131	0.874	0.512	0.241	-0.061			0.1378
	(0.012)	(0.171)	(0.154)***	(0.232)**	(0.134)*	(0.174)			
NATIONAL EXPRESS	0.019	0.474	0.593	0.248	-0.117	-0.356	0.985		
	(0.007)***	(0.109)***	(0.118)***	(0.118)**	(0.128)	(0.048)***	(0.218)***		
STAGECOACH GROUP	0.018	0.531	0.805	0.128	0.174	-0.257	0.273	0.706	
	(0.011)	(0.164)***	(0.210)***	(0.226)	(0.175)	(0.164)	(0.122)**	(0.117)***	

Table 4.6 – Continued

Firm	Constant	RM	SMB	HML	Mom	Voil	ARCH	GARCH	R^2
Airlines									
DART GROUP	-0.021	0.516	0.831	0.202	0.077	0.377	0.190	0.709	
	(0.018)	(0.165)***	(0.259)***	(0.288	(0.231)	(0.250)	(0.094)**	(0.136)***	
EASYJET	-0.006	1.093	1.109	-0.225	0.200	0.077			0.2338
	(0.016)	(0.327)***	(0.364)***	(0.360)	(0.254)	(0.146)			
Oil & Gas Producers									
Exploration & Production									
AMERISUR RESOURCES	0.020	0.869	1.030	0.038	0.256	-0.276			0.0849
	(0.024)	(0.346)**	(0.421)**	(0.351)	(0.360)	(0.217)			
CAIRN ENERGY	0.004	0.598	1.153	0.607	0.385	-0.204	0.120	0.798	
	(0.018)	(0.219)***	(0.216)***	(0.275)**	(0.213)*	(0.179)	(0.067)*	(0.125)***	
FORTUNE OIL	0.017	0.430	1.186	0.728	0.408	-0.446			0.1385
	(0.016)	(0.222)*	(0.338)***	(0.377)*	(0.297)	(0.192)**			
JKX OIL & GAS	-0.005	0.092	1.144	0.393	0.388	-0.144	0.344		
	(0.028)	(0.261)	(0.291)***	(0.343)	(0.231)*	(0.264)	(0.148)**		
NORTHERN PETROLEUM	0.006	0.404	1.719	0.409	0.068	-0.250	0.606		
	(0.022)	(0.334)	(0.463)***	(0.336)	(0.267)	(0.253)	(0.135)***		
PREMIER OIL	-0.010	0.551	1.149	0.993	0.257	0.066			0.2342
	(0.014)	(0.210)***	(0.237)***	(0.241)***	(0.188)	(0.184)			
SOCO INTERNATIONAL	0.013	0.432	0.477	0.018	0.018	-0.033	0.235	0.571	
	(0.018)	(0.247)*	(0.302)	(0.276)	(0.176)	(0.223)	(0.109)**	(0.189)***	
STERLING ENERGY	0.024	0.339	0.672	0.031	-0.440	-0.753			0.1235
	(0.018)	(0.249)	(0.261)**	(0.434)	(0.298)	(0.204)***			
TULLOW OIL	0.008	0.738	0.604	0.418	0.645	-0.136	0.366	0.459	
	(0.011)	(0.160)***	(0.261)**	(0.190)**	(0.155)***	(0.137)	(140)***	(0.144)***	

Table 4.6 – Continued

Firm	**Constant**	**RM**	**SMB**	**HML**	**Mom**	**Voil**	**ARCH**	**GARCH**	R^2
Integrated Oil & Gas									
BG GROUP	0.002	0.543	0.088	0.328	0.167	0.022			0.1052
	(0.010)	(0.129)***	(0.215)	(0.139)**	(0.139)	(0.146)			
BP	-0.008	0.784	-0.210	0.245	0.172	0.063	0.298		
	(0.006)	(0.122)***	(0.140)	(0.118)**	(0.089)**	(0.079)	(0.078)***		
ROYAL DUTCH SHELL B	-0.004	0.695	0.054	0.166	0.148	-0.008			0.1735
	(0.008)	(0.114)***	(0.165)	(0.119)	(0.129)	(0.100)			

Notes: This Table presents the estimation results of Equation 4.4 (with the change in oil price volatility as a measure for oil price risk) for 25 firms from the UK transportation, travel and leisure, and oil and gas producers sectors. The figures that are stated in parentheses are standard errors that are asymptotically robust to the existence of heteroscedasticity and serial autocorrelation. ***, **, and * indicate a statistical significance of 1%, 5% and 10%, respectively.

Table 4.7: Asymmetric response of UK firms to oil shocks

Firm	Asymmetric Specification (Model 2)				Scaled Specification (Model 4)			
	β^{+}_{oil}	β^{-}_{oil}	$\beta^{+}_{oil} = \beta^{-}_{oil} = 0$	$\beta^{+}_{oil} = \beta^{-}_{oil}$	$\beta^{+}_{V oil}$	$\beta^{-}_{V oil}$	$\beta^{+}_{V oil} = \beta^{-}_{V oil} = 0$	$\beta^{+}_{V oil} = \beta^{-}_{V oil}$
Transportation								
Transportation Services								
BBA AVIATION	-0.056	-0.023	0.47	0.03	0.006	0.117	2.32	0.49
	(0.121)	(0.114)	(0.793)	(0.175)	(0.180)	(0.086)	(0.314)	(0.485)
BRAEMAR SHIPPING SVS.	0.193	0.100	1.76	0.09	-0.157	-0.241	0.58	0.11
	(0.154)	(0.192)	(0.175)	(0.761)	(0.317)	(0.227)	(0.563)	(0744)
CLARKSON	0.164	0.284	**8.56**	0.28	0.060	-0.189	0.95	1.43
	(0.145)	(0.133)**	**(0.014)**	(0.599)	(0.277)	(0.218)	(0.388)	(0.233)
FISHER(JAMES) & SONS	0.079	-0.065	0.49	0.49	-0.195	-0.181	2.14	0.01
	(0.132)	(0.112)	(0.782)	(0.484)	(0.196)	(0.125)	0.344	(0.931)
OCEAN WILSONS HOLDINGS	-0.077	0.047	0.15	0.27	-0.074	-0.101	0.27	0.02
	(0.143)	(0.140)	(0.859)	(0.605)	(0.188)	(0.138)	(0.763)	(0.877)
SUTTON HARBOUR HDG.	-0.042	0.082	0.47	0.34	0.071	-0.205	**5.68**	**2.92**
	(0.132)	(0.120)	(0.790)	(0.558)	(0.180)	(0.107)*	**(0.058)**	**(0.088)**
Delivery Services								
UK MAIL GROUP	-0.336	0.072	3.62	**3.31**	-0.116	0.093	1.74	1.18
	(0.177)**	(0.083)	(0.164)	**(0.069)**	(0.235)	(0.130)	(0.418)	(0.277)
Travel & Liesure								
Travel & Tourism								
FIRST GROUP	0.057	0.154	1.49	0.17	-0.158	-0.233	0.90	0.16
	(0.183)	(0.100)	(0.228)	(0.677)	(0.262)	(0.182)	(0.409)	(0.691)
GO-AHEAD GROUP	-0.006	0.156	0.32	0.36	0.050	-0.079	0.34	0.65
	(0.125)	(0.204)	(0.728)	(0.551)	(0.188)	(0.174)	(0.714)	(0.422)
NATIONAL EXPRESS	-0.451	0.535	**5.56**	**10.56**	-0.587	-0.614	**31.109**	0.023
	(0.196)**	(0.176)***	**(0.005)**	**(0.001)**	(0.185)***	(0.114)***	**(0.000)**	(0.880)
STAGECOACH GROUP	-0.349	0.079	**8.437**	**4.688**	-0.289	-0.101	1.709	1.034
	(0.121)***	(0.122)	**(0.015)**	**(0.030)**	(0.224)	(0.172)	(0.426)	(0.309)

Table 4.7 – Continued

Firm	Asymmetric Specification (Model 2)				Scaled Specification (Model 4)			
	β^+_{oil}	β^-_{oil}	$\beta^+_{oil} = \beta^-_{oil} = 0$	$\beta^+_{oil} = \beta^-_{oil}$	β^+_{Voil}	β^-_{Voil}	$\beta^+_{Voil} = \beta^-_{Voil} = 0$	$\beta^+_{Voil} = \beta^-_{Voil}$
Airlines								
DART GROUP	0.131	-0.456	**5.40**	**3.44**	0.261	0.413	2.50	0.38
	(0.172)	(0.198)**	**(0.067)**	**(0.064)**	(0.306)	(0.263)	(0.286)	(0.536)
EASYJET	-0.460	-0.058	**4.51**	1.56	-0.087	0.100	0.70	0.88
	(0.170)***	(0.219)	**(0.013)**	(0.213)	(0.254)	(0.149)	(0.498)	(0.350)
Oil & Gas Producers								
Exploration & Production								
AMERISUR RESOURCES	-0.134	0.381	0.84	0.86	-0.769	-0.196	2.21	2.47
	(0.352)	(0.298)	(0.432)	(0.355)	(0.366)**	(0.241)	(0.113)	(0.118)
CAIRN ENERGY	0.369	0.526	**31.01**	0.27	0.052	-.223	2.37	0.90
	(0.210)*	(0.138)***	**(0.000)**	(0.602)	(0.325)	(0.174)	(0.307)	0.343)
FORTUNE OIL	0.356	0.444	**4.99**	0.04	-0.121	-0.499	**2.67**	2.10
	(0.291)	(0.214)**	**(0.008)**	(0.838)	(0.243)	(0.219)**	**(0.072)**	(0.149)
JKX OIL & GAS	0.511	0.159	**6.58**	0.71	0.141	-0.217	1.80	0.98
	(0.264)**	(0.230)	**(0.037)**	(0.399)	(0.481)	(0.277)	(0.406)	(0.322)
NORTHERN PETROLEUM	0.523	0.320	**12.01**	0.34	-0.097	-0.286	1.11	0.28
	(0.181)***	(0.261)	**(0.003)**	(0.561)	(0.345)	(0.272)	(0.573)	(0.596)
PREMIER OIL	0.517	0.150	**6.96**	1.02	0.391	0.013	**2.59**	**3.66**
	(0.001)***	(0.232)	**(0.001)**	(0.313)	(0.193)**	(0.196)	**(0.078)**	**(0.057)**
SOCO INTERNATIONAL	0.188	0.122	1.40	0.03	-0.072	-0.020	0.05	0.03
	(0.122)	(0.239)	(0.498)	(0.874)	(0.330)	(0.226)	(0.977)	(0.865)
STERLING ENERGY	0.176	0.442	**3.40**	0.47	-0.543	-0.787	**6.41**	0.74
	(0.291)	(0.193)**	**(0.000)**	(0.493)	(0.271)**	(0.225)***	**(0.002)**	(0.391)
TULLOW OIL	0.254	0.394	**17.81**	0.22	0.553	-0.073	**6.07**	**5.83**
	(0.210)	(0.132)***	**(0.000)**	(0.636)	(0.291)*	(0.137)	**(0.048)**	**(0.016)**

Table 4.7 – Continued

Firm	Asymmetric Specification (Model 2) β^{+}_{oil}	β^{-}_{oil}	$\beta^{+}_{oil} = \beta^{-}_{oil} = 0$	$\beta^{+}_{oil} = \beta^{-}_{oil}$	Scaled Specification (Model 4) β^{+}_{Voil}	β^{-}_{Voil}	$\beta^{+}_{Voil} = \beta^{-}_{Voil} = 0$	$\beta^{+}_{Voil} = \beta^{-}_{Voil}$
Integrated Oil & Gas								
BG GROUP	0.193	0.216	**4.38**	0.01	0.300	-0.024	**3.94**	**7.61**
	(0.114)*	(0.138)	**(0.014)**	(0.912)	(0.155)*	(0.135)	**(0.021)**	**(0.006)**
BP	0.369	0.107	**27.27**	**3.55**	0.164	0.040	2.02	1.14
	(0.097)***	(0.066)	**(0.000)**	**(0.060)**	(0.115)	(0.073)	(0.364)	(0.285)
ROYAL DUTCH SHELL B	0.344	0.122	**3.85**	0.77	0.165	-0.036	1.23	2.23
	(0.154)**	(0.156)	**(0.023)**	(0.382)	(0.131)	(0.121)	(0.296)	(0.138)

Notes: This Table presents the estimation results of Equation 4.6 and Equation 4.8 for 25 firms from the UK transportation, travel and leisure, and oil and gas producers sectors. The figures that are stated in parentheses in the second, third, sixth and seventh columns are standard errors that are asymptotically robust to the existence of heteroscedasticity and serial autocorrelation. The figures that are stated in parentheses in the fourth, fifth, eighth and ninth columns are probabilities. ***, **, and * indicate a statistical significance of 1%, 5% and 10%, respectively.

Table 4.8: **Effects of oil shocks and recessions on UK firms**

Firm	D_1	**Roil**	$D_1 * Roil$
	Transportation		
Transportation Services			
BBA AVIATION	0.004	-0.040	0.016
	(0.011)	(0.068)	(0.133)
BRAEMAR SHIPPING SVS.	-0.002	0.073	0.311
	(0.019)	(0.075)	(0.252)
CLARKSON	-0.012	0.134	0.443
	(0.024)	(0.090)	(0.249)*
FISHER(JAMES) & SONS	-0.027	-0.033	0.179
	(0.017)	(0.073)	(0.143)
OCEAN WILSONS HOLDINGS	-0.012	-0.125	0.369
	(0.016)	(0.088)	(0.176)**
SUTTON HARBOUR HDG.	-0.011	-0.029	0.279
	(0.018)	(0.077)	(0.156)*
Delivery Services			
UK MAIL GROUP	-0.021	-0.192	0.258
	(0.032)	(0.086)**	(0.181)
	Travel & Liesure		
Travel & Tourism			
FIRST GROUP	-0.020	0.127	-0.097
	(0.025)	(0.109)	(0.145)
GO-AHEAD GROUP	-0.026	0.007	0.307
	(0.026)	(0.110)	(0.152)**
NATIONAL EXPRESS	-0.043	-0.144	0.441
	(0.019)**	(0.064)**	(0.163)***
STAGECOACH GROUP	-0.042	-0.034	0.524
	(0.020)**	(0.071)	(0.172)***
Airlines			
DART GROUP	0.035	-0.121	-0.798
	(0.038)	(0.101)	(0.612)
EASYJET	-0.032	-0.213	-0.115
	(0.027)	(0.141)	(0.238)
	Oil & Gas Producers		
Exploration & Production			
AMERISUR RESOURCES	-0.020	0.010	0.546
	(0.033)	(0.198)	(0.343)
CAIRN ENERGY	0.037	0.502	-0.355
	(0.025)	(0.097)***	(0.215)*
FORTUNE OIL	0.037	0.467	-0.256
	(0.028)	(0.140)***	(0.220)
JKX OIL & GAS	-0.021	0.297	0.187
	(0.041)	(0.141)**	(0.269)
NORTHERN PETROLEUM	0.036	0.496	-0.405
	(0.050)	(0.133)***	(0.364)
PREMIER OIL	0.049	0.380	-0.223
	(0.022)**	(0.104)***	(0.244)
SOCO INTERNATIONAL	-0.050	0.255	-0.414
	(0.027)*	(0.132)*	(0.329)
STERLING ENERGY	-0.071	0.252	0.239
	(0.039)*	(0.161)	(0.439)
TULLOW OIL	0.059	0.346	-0.041
	(0.017)***	(0.096)***	(0.175)

Table 4.8 – Continued

Firm	D_1	**Roil**	$D_1 * Roil$
Integrated Oil & Gas			
BG GROUP	0.019	0.257	-0.217
	(0.020)	(0.061)***	(0.180)
BP	0.013	0.322	-0.407
	(0.008)	(0.058)***	(0.112)***
ROYAL DUTCH SHELL B	0.011	0.335	-0.477
	(0.012)	(0.071)***	(0.146)***

Notes: This Table presents the estimation results of Equation 4.9 for 25 firms from the UK transportation, travel and leisure, and oil and gas producers sectors. The figures that are stated in parentheses are standard errors that are asymptotically robust to the existence of heteroscedasticity and serial autocorrelation. ***, **, and * indicate a statistical significance of 1%, 5% and 10%, respectively.

Appendix A: Sample Firms

Table A4.1: Sample Firms

Company	Local Code
Transportation	
Transportation Services	
BBA AVIATION	BBA
BRAEMAR SHIPPING SVS.	BMS
CLARKSON	CKN
FISHER(JAMES) & SONS	FSJ
OCEAN WILSONS HOLDINGS	OCN
SUTTON HARBOUR HDG.	SUH
Delivery Services	
UK MAIL GROUP	UKM
Travel & Liesure	
Travel & Tourism	
FIRST GROUP	FGP
GO-AHEAD GROUP	GOG
NATIONAL EXPRESS	NEX
STAGECOACH GROUP	SGC
Airlines	
DART GROUP	DTG
EASYJET	EZJ
Oil & Gas Producers	
Exploration & Production	
AMERISUR RESOURCES	AMER
CAIRN ENERGY	CNE
FORTUNE OIL	FTO
JKX OIL & GAS	JKX
NORTHERN PETROLEUM	NOP
PREMIER OIL	PMO
SOCO INTERNATIONAL	SIA
STERLING ENERGY	SEY
TULLOW OIL	TLW
Integrated Oil & Gas	
BG GROUP	BG
BP	BP
ROYAL DUTCH SHELL B	RDSB

Chapter 5

Conclusions

A thorough understanding of the forces that drive the growth of nations is a primary precondition for conducting policy recommendations. Aggregate, sectoral and firm levels contribute for the sake of achieving the desired level of development and prosperity despite the fact that most of economic activities are surrounded with various sources of uncertainties. Uncertainties arising from macro level factors appear to have persistent traces on the firm level activities and accordingly on the whole economy. This thesis addresses a variety of topics related to economic development under uncertainty in three different chapters.

5.1 Summary of Findings and policy implications

The major purpose of chapter 2 is to investigate the effects of human capital and energy consumption on economic growth. An augmented neoclassical growth model and a panel data set of 130 countries over the period 1981-2009 is used. In order to examine the impact of human capital, different measures were utilized; stock and flow measures of education capital and infant mortality rate as a proxy for health capital. Moreover, various measures for energy consumption are employed. Most of the studies agree that there is cointegration between energy consumption and economic growth. However, evidence on the direction of causality between these two variables is mixed. Recent studies have sought to illustrate the importance of energy in the production process. Oh and Lee (2004), Lee and Chang (2008), Lee et al. (2008) and Yuan et al. (2008) argue that energy is an essential factor in production and hence contributes positively to growth. Therefore, energy consumption is considered as an input in the production process and hence in the growth model of the second chapter.

The results indicate that secondary education is the most significant level of education which affects economic growth positively. Tertiary education is required to create technology that is more appropriate for the developed countries while secondary education is required to make use of the technology in the work place that is more appropriate in most of the less developed countries. This result might be useful for the policy makers, especially in less developed countries encouraging them to implement compulsory secondary education in order to reach higher standards of living.

The infant mortality rate as a measure of health capital appears to affect economic growth negatively. Therefore, efforts should be increased to reduce infancy deaths. This can be done through many policies such as increasing female literacy, which has been shown to be the best long term investment to achieve the best children's well-being (Sandiford et al., 1995). Moreover, the popularization of child immunizations and exclusive breastfeeding are essential contributors to reduce infant mortality rate, especially in less developed countries.

Economic growth is shown to be positively affected by total primary energy consumption. However, the core of the debate relies on the issue of identifying the economically effective level of energy consumption. Moreover, it is essential to determine whether policy directed to energy efficiency is necessary to bring economic growth to the required level as well as reduce greenhouse gas production and preserve the environment for sustainable development.

Chapter 2 also investigates also the differential impact of human capital and energy consumption in the developed and oil exporting countries. The obtained results reveal no differential effect for education capital in the developed countries which means that the impact on the developed and developing countries is similar. This can be attributed to the sample period (that is running from the 1980's) whereas the significant effect of education on the growth of the developed countries was largely in the 1950's and 1960's period. Furthermore, education capital is more effective and contributes significantly to the growth of the countries that are in the development process. Regarding health capital, it has been found that the infant mortality rate affects developed countries' economic growth differently. However, human capital variables have no differential impact on the growth of oil exporting countries. Most of the existing literature assumes that wealth in natural resource leads to slower economic growth (Sachs and Warner, 1995). One of the channels of transmission from the abundance of natural resource to slow economic growth, that is identified by Gylfason (2001), is education and human capital. Natural capital is considered as the main asset in these countries which tends to lead to neglect of investment in other sources of growth such as human capital accumulation.

Chapter 3 empirically examines the impact of two types of macroeconomic uncertainties on firms' investment expenditures, specifically industry-specific uncertainty measured by oil price volatility and financial market instability determined by stock price volatility. Different from prior studies in this field that mainly scrutinize idiosyncratic and macroeconomic uncertainties on the investment decisions of US non-financial firms, this chapter applies it in a broader way to explore the impact of the different types of macroeconomic uncertainty on the investment of non-financial and financial UK firms for the period 1986-2011.

The key findings obtained from the analysis of Chapter 3 show that both forms of uncertainty significantly affect financial and non-financial firms' investment. Oil price volatility appears to have a negative impact on firms' investment expenditures. In order to reduce oil price risk, companies may choose to buy an oil futures contract that will protect them from the risk that the price will rise. Hedging simply attempts to decrease undesirable and unexpected risk. In contrast, stock market volatility positively influences investment behaviour. This result reflects that firm managers react significantly and positively to stock market valuation when determining investment decisions. Unexpectedly, the results show that financial firm's investment responds negatively to oil price risk, which might be attributed to these companies' main customers who may be influenced by oil price changes. Moreover, oil and gas firms' investment is significantly and positively affected by oil price volatility as anticipated. One of the biggest benefits of high oil prices is that it becomes profitable to extract oil from more sources.

One more objective of chapter 3 is to examine the existence of a nonlinear relationship between oil price volatility and firms' investment. The obtained results show that there exists a U shape relationship. This result is consistent with the predictions from the strategic growth options literature. The literature on strategic growth options emphasizes that when firms do not have monopolistic control over the investment opportunity, and product markets are not perfectly competitive, there are two option value effects, the option of waiting to settle uncertainty and an option to grow the business (Kulatilaka and Perotti, 1998). In the case of uncertainty, firms often defer investment until more information is available. Not investing, which retards the potential of obtaining market share or growing the firm, may allow another competitor to seize the opportunity. These two effects give rise to a U shape relationship between investment and uncertainty.

The outcomes from this chapter suggest that steadiness in oil prices would support firm-level investment. In addition, the stock market appears to be efficient and fully reflects available information. Therefore, the results recommend that policy makers should take into consideration the relationship between uncertainty and investment at the time of planning monetary and fiscal policies. As the results also show that debt influences investment positively, it would be beneficial to enhance investment through small scale borrowing.

The last empirical study of this thesis, Chapter 4, scrutinizes the relationship between oil price risk and equity returns of 25 UK firms. In contrast to the previous empirical studies that explore the effect of oil price risk on equity returns at the aggregate and sectoral levels and most cases employ US data, this chapter attempts to investigate this relationship using UK firm level data, particularly, transportation, travel and leisure and oil and gas sector firms over the period 1998:01 to 2012:12. The availability of long historical data is the basis for choosing this sample with the consideration of having firms that compose two different sides of the oil market, consumers and producers of crude oil. In order to examine this relationship, FF-Carhart's (1997) four factor asset pricing model is utilized. Two measures of oil price risk are used, change in oil price and oil price volatility.

The results were unexpected, most of the transportation sector firms' equity returns appear to have insignificant exposure to oil price risk, except two firms from the transportation services subsector that show a significant positive exposure. The reason behind this is that these two firms are marine transportation which are fuel efficient, usually participating in ocean transportation of crude oil and petroleum outputs, and hedge against the rise in oil prices using future contracts. The other transportation services firms that show insignificant exposure to oil price risk are mostly providing distinct types of services. For example, Fisher (James) & Sons is a leading provider of services such as marine, oil and gas, manufacturing services to the nuclear industry, aerospace industry, and renewable energy services. Therefore, diversifying services reduces the risk inherent in any service and helps overcome oil price risk. Regarding the returns on the equities of travel and tourism and airline subsector firms, the hedging contracts help dilute the negative impact of jumps in oil prices. Comparably, most of the oil and gas firms respond positively to changes in oil price.

This chapter further explores the asymmetric response of the firms' returns to oil price risk. Two specifications of non-linear measures of oil price changes are estimated; an asymmetric specification which differentiates between increases and decreases in oil price, and a scaled specification which distinguishes between hikes and drops in oil price volatility. The key findings from this analysis indicate that some firms show asymmetric response to these specifications, including travel and tourism, airlines and integrated oil and gas firms. The asymmetric response analysis reveals symmetric effects in most cases.

The obtained results should be of interest to researchers, regulators and investors. Investors who wish to invest in oil price-sensitive stocks, should choose oil and gas and marine transportation stocks when the prices are high and choose travel and tourism and airlines stocks when the oil prices are expected to drop. Moreover, hedging minimizes the responsiveness of the firms' stock returns to changes in oil prices. As the firms' returns have different distinct sensitivities to oil price changes, diversifying between stocks in the investors' portfolios, particularly holding some assets with positive response to oil price shocks, may help in reducing the impact of the change in oil prices. Investors should consider any forth coming rises or drops in oil price and try to stabilize their portfolios accordingly.

5.2 Limitations

The empirical analysis employed in this thesis has a number of possible limitations. The credit market constraints may prevent poor families from sending their children to school as they cannot bear their expenses unless schooling is subsidized. Therefore, government expenditure for at least primary education is essential for higher level of school enrollment (Baldacci et al., 2008). Hence, investigating the impact of expenditure per student on economic growth could provide further insight about education capital and growth relationship. Similarly, using health expenditure per capita might explore the health capital growth association. Unfortunately, this type of data is not available for a large enough panel of countries.

Since we are examining the impact of oil price risk on firms' investment decisions in chapter 3, it is useful to examine firms' exposure to external shocks as they differ in the degree of their operation across countries and industries. Firms' exposure to external shocks can be measured by the import costs to total cost ratio or the ratio of exports to total sales. However, import costs and exports data for the used sample firms are not available in the chosen database.

5.3 Future Research Areas

Since the seminal work of Sachs and Warner (1995), the slow economic growth that is brought by the abundance in natural resource is widely assumed. Therefore, as an extension to the human capital and economic growth relationship, it is worth examining the impact of natural resource on human capital accumulation. Moreover, the indirect impact of natural resource abundance on growth can be investigated by including an interaction effect between human capital and natural resource in order to test whether the negative effect on growth decreases with human capital.

It is noteworthy to point out that the applied empirical strategy in chapter 3 masks the potential heterogeneity across the panel of firms. Given the obtained findings and recent research on the relationship between oil price uncertainty and firm investment behavior, further exploration along these lines while taking into account firms heterogeneity could shed considerable light on this relationship. Yoon and Ratti (2011) investigate the impact of oil price uncertainty through the effect of sales growth on firm-level investment and find that this effect is greater at firms in lower energy intensity at the industry level. It will be interesting to test the differential impact of oil price uncertainty according to the energy intensity of the different types of firms. We were not able to do it due to lack of data.

Although the main objective of chapter 4 is to examine the effect of oil price risk on equity returns of oil consumer and producer firms, there are various potential extensions to this chapter. This can be done through adding more firms from the sectors to test the robustness of the obtained results. Moreover, with the application of the same methodology, the impact of other energy measures can be examined such as natural gas.

The empirical studies showed in this thesis investigated three different but related topics. Regardless of the limitations that we have come across, the desired goals behind each topic, the method of treating each case, the unexpected and expected results and their implications on the economies studied, may contribute to the literature in this area.

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