INTERNAL ADJUSTMENT COSTS AND INVESTMENT DECISIONS OF GHANAIAN MANUFACTURING FIRMS

By

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DECLARATION

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

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ABSTRACT

The study aimed to find out how internal adjustment costs influence the investment decisions of Ghanaian manufacturing firms. This was achieved by examining the relationship between the companies' investment-capital ratio and the value of capital (Tobin's *q*). An internal adjustment cost model was adopted and estimated using annual panel data for 11 manufacturing firms listed on the Ghana Stock Exchange (GSE) for the years 2000 to 2012. The model was estimated using the random effect. This implied that unobserved factors common to plants and equipment within the manufacturing industry in any given year had no correlation with the explanatory variable. The findings showed a highly significant positive relationship between the firms' investment-capital ratio and the value of capital at the 5% significance level. This finding supported one of the central predictions of the internal adjustment cost model that investment increases in the value of capital. The internal adjustment cost parameter was also estimated. With this value, the marginal internal adjustment cost associated with a given value of investment-capital ratio was also estimated. Finally, the findings further suggested that the Tobin's *q* is not effective in summarizing all the information the firms require in making their investment decisions. This result and that of earlier researches confirmed that other variables such as output, profits, government investment policies etc. could have independent effects on investment apart from any effects they may have through the Tobin's *q*. The researcher therefore recommended that further studies should be focused on incorporating variables like output, profits, government investment policies – tax, capacity utilization into the internal adjustment cost model.

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Although putting this piece of work together was a herculean task, a lot of knowledge and experience has been acquired at the end of it all. This would not have been possible without the kind support, cooperation and thought provoking questions and contributions from my supervisor.

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I am also grateful to my wife for her support and encouragements throughout my stay on campus.

Special thanks also go to the many authors, publishers as well as companies whose articles, materials and reports I used in this study.

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DEDICATION

This piece of work is dedicated to my wife, Mrs. Rosemond Dede Amankwa, and our lovely daughter, Nhyiraba Nana Yaa Afrane Amankwa.

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LIST OF ABBREVIATIONS

ACI	African Champion Industries
ALU	Aluworks
ARG	Annual Report Ghana
ARIMA	Autoregressive Integrated Moving Average
ARYT	Ayrton Drug Manufacturing
BEN	Benso Oil Palm Plantation
CAM	Camelot Ghana Ltd
CBI	Confederation of British Industries
CEPA	Centre for Economic Policy Analysis
GDP	Gross Domestic Product
GIPC	Ghana Investment Promotion Centre
GMM	Generalized Method of Moments
GSE	Ghana Stock Exchange
KIT	Pioneer Kitchenware Ltd
OECD	Organisation for Economic Co-operation and Development
PZ	PZ Cussons Ghana

SAM	Sam-Woode Ltd
STAR	Starwin Products Ltd
TFP	Total Factor Productivity
UK	United Kingdom
UN	United Nations Organization
UNI	Unilever Ghana Ltd
US	United States of America
WEB	Golden Web Ltd

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

One of the rudiments for growing an economy is investment (Miles & Scott, 2005). Although the level of total investment is important, it seems what is more critical is the combination of private and public investments in a given economy. As per the neoclassical theory of growth, the optimal choice is that the component of public sector investment must decline (Francois & Reinert, 1997). The development of private investment in Ghana has by and large not been impressive (Asante, 2000). Ideological differences on the part of both past and present governments have greatly influenced policy initiatives as well as the development of private investment in the Ghanaian economy (Coutinho & Gallo, 1991 and Frimpong & Marbuah, 2010).

Since Ghana's independence in the late 1950s, the socialist ideology of the government made it difficult to recognize the need to develop indigenous entrepreneurial capability. For this reason, the government did not trust that the private sector had the capacity to propel its industrialization agenda at the rate and speed it actually wanted. Consequently no effort was made to grow the private sector but concentrated attention on expanding public enterprises (Killick, 1978 and Serven & Solimano, 1992).

All through this period, the private sector found it difficult especially to import raw materials, spare parts and equipment. Measures such as exchange controls were used to prevent foreign investors from sending abroad or repatriating their profits. These restrictions, coupled with political turmoil characterized by seizure of people's properties subsequently worsened the censorship and control of private sector activities. The investment climate was worsened to the extent that expressions such as "mistrust" and "harassment" were used to describe the Ghanaian private investment environment (Leechor, 1994 in Asante, 2000, p. 7).

During this period, the output elasticity of public investment grew much higher than that of private investment. As a consequence, the share of private investment to Gross Domestic Product (GDP) declined considerably from 7.9% in 1970 to 4.0% in 1973, increased slightly to 6.9% in 1974 and dropped incessantly to 3.3% in 1978 and even further to 2.6% in 1982 which obviously was suboptimal. For this reason, successive governments have had to put measures in place to boost investor confidence. As part of the measures to make Ghana an attractive investment destination, the Investment Decree (NRCD 141) and the Investment Policy Decree (NRCD 329) of 1973 and 1975 respectively, were introduced to encourage and attract both local and foreign investors. The implementation was however short-lived (Abosi, 2008 and Asante, 2000).

Due to the failure of the above policies, the Investment Code of 1981 (Act 437) was introduced in 1981. Within this Code was a proviso to set up an investment centre to serve as a "one stop-shopping centre" to enable all would-be indigenous and foreign investors to access all necessary information. Although the law was never passed, it actually served as a good omen to encourage investment into key sectors of the economy primarily mining and agriculture (Asante, 2000). Recognizing the investment prospects the Code possessed, it was revised under the Ghana Investment Promotion Centre (GIPC) Act of 1994 to place more emphasis, encourage and promote private sector investment. The frequent changes or reviews of these codes clearly show the poor level of commitment that is usually attached to the implementation of such policy instruments (Abosi, 2008).

In spite of the challenges, the codes by and large allowed investors to enjoy accelerated depreciation allowances, tax holidays, exemption from import duties on machinery and equipment, investment allowances, reduction of corporate taxes, financial system liberalisation as well as arrangements for profit repatriation. The main objective of these policies has been to create an enabling environment for local and foreign investors to operate so as to reap the benefits associated with it especially by Ghanaians. These benefits may include the transfer of capital, advanced technology, human capital formation and creation of a more competitive business environment (Asante, 2000 and Abosi, 2008).

The introduction and implementation of some of these measures seemed to have made some gains since the share of private investment to the Gross Domestic Product (GDP) between 1985 and 1988 shot up at an average of 7.1%. It reached its highest of 8.5% in 1989, dropped to 7.5% in 1990 and increased to 8.1% in 1992 confirming Francois & Reinert's (1997) view that the output elasticity of private investment changed for the better in the 1990s.

Aside these policy interventions, there is another factor associated with private investment that has become an issue of concern. This is the concept of internal adjustment costs. When firms undertake fixed investments like plant and equipment, they are unable to use them immediately (uninstalled capital) until they are properly installed. In the process of installing the capital, they incur certain additional costs which are independent of the purchase price of the asset and these additional costs are termed as internal adjustment costs of capital (Sala-i-Martin, 2005).

But this study examines the adjustment costs of Ghanaian manufacturing firms. The reason is that, these firms engage in the direct production of goods. Manufacturing as used in this study refers to producing goods that are necessary for modern life from raw materials. There are three main processes involved in virtually all manufacturing: assembly, extraction, and alteration. Assembly is the combination of parts to make a product; for example, when a manufacturer puts together parts such as engines, wings and fuselage. Extraction is the process of removing one or more components from raw materials, such as obtaining gasoline from crude oil. Alteration is modifying or moulding raw materials into a final product - for example, sawing trees into lumber (Brookstein, 2013).

Therefore, the manufacturing firms being referred to in this study comprise firms that engage in one or all of the three processes characterizing manufacturing mentioned above. Additionally, these firms are listed on the Ghana Stock Exchange (GSE).

1.2 Statement of the Research Problem

There is sizeable research on investment and investment adjustment costs especially those that are internal to the firm. Whenever demand goes up suddenly, firms usually earn economic rent until they are able to increase capital and labour inputs. While doing so, many studies viz. Mussa (1977), Galeotti (1990), Hamermesh and Pfann (1996), Hall (2004) among others have all shown that due to increasing marginal internal costs of adjustment, firms are unable to expand their output as much as they actually wish to.

Adjustment costs internal to firms take the form of recruitment and training costs for labour as well as planning and installation costs for capital goods. Capital goods as used here refer to durable goods capable of producing a stream of goods or services over a period (Rutherfold, 2002). At times, highly skilled labour effort otherwise known as human capital is also treated as part of fixed capital. But for the purpose of this study, the researcher was interested in the investment decisions Ghanaian manufacturing firms make that affect fixed capital assets like plant and equipment, machinery, buildings and transport infrastructure because it appears to better describe firm-level investment decisions (Acheampong, 2008 and Romer, 2012).

The addition and installation of new capital tend to shift other inputs away from current production. Also as workers learn by doing with the newly installed capital, it takes time and reduces output. This is what Treadway (1971) referred to as "internal costs of reduced efficiency" (cited in Hamermesh & Pfann, 1996, p. 1267) giving rise to the internal adjustment cost theory.

According to this theory, the additional cost firms incur for acquiring fixed capital assets exceed the purchase price by the marginal internal adjustment costs. Therefore, there is the need for firms to take these additional costs into consideration in making their investment decisions. In this light, the internal adjustment cost theory operates within the framework of the Tobin's q theory of investment (Romer, 2012) which also states that the single most important variable that firms should observe in making their investment decisions is the Tobin's q (Tobin, 1969). This implies that the Tobin's q summarizes all the information firms need in making their investment decisions. As a result, many studies have been conducted in countries like the United Kingdom (UK) and the United States (US) to estimate these marginal internal adjustment costs using the Tobin's q to guide the investment decisions of their manufacturing sector. For instance von Furstenberg (1977) found that each dollar of firms' investment is associated with 3.15 dollars in adjustment costs. In Shapiro's (1986a, 1986b) the marginal cost of a dollar of investment was found to be less than 10 cents. Lichtenberg (1988) also showed that a dollar of expansion investment causes a 35 cent reduction in current output with Galeotti (1990) showing that the incidence of adjustment cost expenditures on total investment expenditures per dollar of investment represents 60% of the unit cost of investment.

The marginal internal adjustment cost that emerges from this theory specifies how much additional costs firms will incur if their present-day investment decisions tend to be wrong in relation to future demand and prices; and therefore have to either lower or increase their investments. Due to the growing importance of the internal adjustment cost concept in guiding investment decisions of firms the world over, this study seek to estimate the marginal internal adjustment of the Ghanaian manufacturing sector and also find out whether indeed, the Tobin's *q* effectively contains all the information relevant to firms' investment decisions or behaviour.

1.3 Objectives of the Study

The study objectives have been categorized into two namely general objective and specific objectives.

1.3.1 General Objective

The general objective of this study is to find out how internal adjustment costs influence the investment decisions of Ghanaian manufacturing firms by examining the relationship between their investment-capital ratio (I/K) and the Tobin's q empirically.

1.3.2 Specific Objectives

To arrive at the general objective, the following specific objectives have been designed to guide the study:

- To estimate the marginal internal adjustment cost associated with a cedi worth of investment in Ghanaian manufacturing firms;
- To assess the effectiveness of the Tobin's q in summarizing all the information relevant to firms' investment decisions or behaviour.

1.4 Research Hypotheses

The following research hypotheses have been formulated to guide the study as well.

Hypothesis One:

H_0: The internal adjustment costs of Ghanaian manufacturing firms do not obey the internal adjustment cost theory;

H_1: The internal adjustment costs of Ghanaian manufacturing firms do obey the internal adjustment cost theory.

Hypothesis Two:

H_0: The Tobin's q does not summarize all information Ghanaian manufacturing firms' require in making their investment decisions;

H$_1$: The Tobin's *q* summarizes all information Ghanaian manufacturing firms' require in making their investment decisions.

1.5 Significance of the Study

Various studies have come out with the significant role that marginal internal adjustment costs play in firms' decisions to invest or disinvest. It is obvious that firms all over the world experience internal adjustment costs in their bid to increase their stock of capital to meet expected demand. However, no such estimate exists to explain the Ghanaian situation and how this impacts on firms in realizing their overall objective of profit maximization.

This study is expected to benefit a number of groups especially stakeholders who are keenly concerned about investment prospects such as government serving as, a policy maker and firms (investors) that ultimately benefit from their investments. It will help them to know the exact amount manufacturing firms incur in adjustment costs. In this regard, government can come out with policies that will not overburden the sector. Such policies could be tax rebates or import subsidies. For the manufacturing firms and for that matter investors it will let them know that if indeed there are adjustment costs, then, it pays to spread investment projects over multiple periods so as to incur lower adjustment costs.

The study is also expected to estimate for the first time the marginal internal adjustment costs associated with a cedi of investment in Ghana. Finally, it is going to add to the existing body of knowledge on adjustment costs and the Tobin's *q* theory of investment.

1.6 Scope of the Study

This study is limited in scope in the sense that it considered the investment behaviour of only domestically incorporated manufacturing firms listed on the Ghana Stock Exchange (GSE). Although there were numerous financial and mutual funds firms listed on the GSE, for the sake of this study, those firms were excluded. This is because these institutions do not deal with the direct production of goods.

According to Groth and Khan (2009), anytime firms invest in physical capital; they indirectly end up switching resources to installing the new capital leading to a reduction in marketable output. For this reason, the researcher wanted to establish the relationship existing between investment and the value of capital as well as the marginal internal adjustment costs associated with an additional cedi worth of investment.

This focuses on an internal adjustment cost of capital which is only an aspect of the adjustment cost theory. Again, the entire concept of adjustment cost of labour has also been ignored because according to Lichtenberg (1988) and Hall (2004), these costs are either infinitesimal or unimportant.

1.7 Organisation of the Chapters

This study is organized into five chapters. The first chapter is made up of the general introduction to the study. It discusses issues such as background to the study, statement of the research problem, objectives of the study, research hypothesis, significance of the study, and organization of the chapters.

Chapter two comprises the literature review. It addresses two broad issues namely the theoretical framework which discusses works done by other researchers on the topic and provision of empirical evidence of other researchers' views or comments about the study. Specifically, it addresses concepts such as general overview of investment, theories of investment and investment adjustment costs, a model of investment with adjustment costs, the Tobin's q etc.

The third chapter also touches on the research methodology. Here emphasis is placed on the study design, definition and measurement of variables, data needs, data analysis method, theoretical model, ethical consideration etc. Chapter four is made up of analysis and discussion of results with the fifth chapter consisting of summary, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Investment is important in ensuring the growth of firms' productivity and profit. This section focuses on some theories of private investment decisions. Specifically, the chapter addresses issues relating to the general overview of investment, relationship between public and private investments, ways investment expenditures are financed, the user cost of capital theory, its implications as well as challenges; sources of adjustment costs, the Tobin's *q* theory, investment adjustment costs, and empirical literature.

2.1 Theoretical Literature

2.1.1 Investment and the Manufacturing Sector's Investing Activities

According to Parker (2010), investment encapsulates those transactions that boost the magnitude of real aggregate wealth of an economy. These transactions according to Acheampong (2008) could among other things include the building-up of fixed capital stock such as plant and equipment, machinery, buildings and transport infrastructure by firms from time to time. Investments in any economy are very important because it is the means whereby the capital stock grows; and hence are carried out by both the state and the private sector. Those investments that are embarked on by the state with funding from the central government are referred to as public sector investments. However, those ones that are primarily financed by the private sector are classified under private sector investment or private investment for short (Miles & Scott, 2005).

The overriding goal of both private and public sector investments is to increase the capacity of the economy to grow at a faster rate. Thus in order to grow, new investments be it public or private that represent net additions to capital, is necessary. These investments can be in the form of physical capital, human capital as well as research and development (Romer, 2006 and Acheampong, 2008).

Studies such as Erenburg (1993) and Hatano (2010) have shown that there is a direct relationship between the rate of growth of public investment and private sector capital accumulation. Erenburg (1993) for example, found that each additional percentage point rise in public infrastructure and government investment spending is associated with an approximate three-fifths of a percentage point increase in private sector equipment. This was done using the Stock-Watson method for testing for long-run relationships when variables are integrated of higher order with short run empirical estimates from first-difference model. Although, there is a general view that when public investments increase, crowding out effect occur on private investment. Hatano (2010) argues that the crowding out effect occurs only in the first year; and even so in the subsequent years the rate of growth of private investment begins to rise indicating a crowding in effect instead.

Investment by manufacturing firms takes the dimension of private investment. These manufacturing firms engage in various investing activities which among other things include the purchase of property, plant and equipment, sale of assets, purchase of intangible assets etc. In the context of macroeconomics however, investment usually borders predominantly on physical capital with other specialised fields of economics such as labour economics addressing issues relating to human capital for example (Miles & Scott, 2005 and Acheampong, 2008). It is for this reason that this study focuses on manufacturing sector investments devoted to the acquisition of fixed capital assets.

2.1.1.1 Ways Investment Expenditures are financed

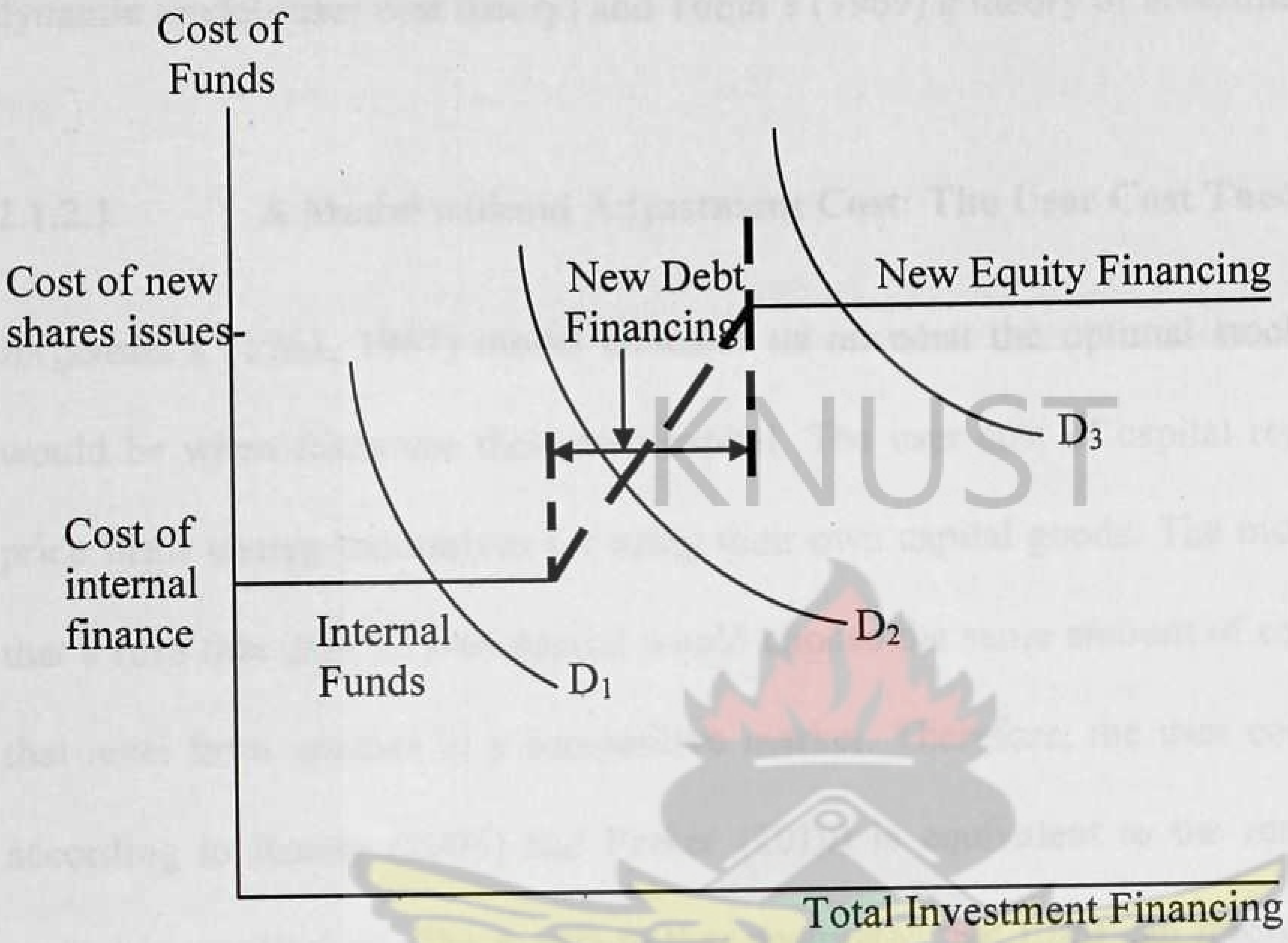
Investments of all types the world over are financed from various sources. Among the lot, the major sources are internal funding, borrowing from banks and issuance of new shares. Of course, each of these financing mechanisms imposes some amount of cost to the firms. The internal funding is whereby firms use their accumulated profit to finance their investments (Fazzari, Hubbard, Petersen, Blinder & Poterba, 1988). The cost associated with this mechanism is the interest they forfeit in case it had lent the money. The second source which is borrowing can be accessed either from banks or through the issue of financial assets such as bonds (long-term) or commercial paper (short-term). It is obvious that when firms choose this trajectory to finance their investments, the interest they inevitably bear become the cost. Issuing new shares of stock creates costs for those who own existing shares because the new shares represent claims on the firms' future profits (Parker, 2010).

The Tobin's q theory indicates that firms should issue new share capital to finance investment expenditure. However, survey work suggests that most investment in the Organisation for Economic Co-operation and Development (OECD) economies of which Ghana is a member is done by means of internal finance. This comes from retained earnings and depreciation. Such funds account for over 90% of capital spending in the UK and US, 80% in Germany and 70% in Japan (Stevens, 2005).

Bank loans comprise the second largest source of funds for investment purposes. The availability of internal funding places a constraint on the speed at which firms will adjust toward a new higher K*. In this view, the level and timing of investment will depend on current corporate profitability. However, profitability is likely to be highly correlated with recent output growth and stock price growth. Nevertheless, according to the Confederation of British Industries (CBI) Industrial Trends Survey, in the mid to late 1990s, 25% of UK firms cited shortages of internal finance as a constraint when asked about the factors that were likely to limit (wholly or partly) their capital expenditure authorisations in the next 12 months. Only 7% cited cost of finance and 2% inability to raise external finance (Stevens, 2005).

The relationship between these financing mechanisms and investment is illustrated in Figure 1 below. According to the Figure 1, any time internal finance exceeds desired investment, the Tobin's q will be less than unity in equilibrium (i.e. $q < 1$). In this case, any value-maximizing firm will issue new shares only after it exhausts internal finance. Once this is achieved the value of the Tobin's q will then be greater than unity (i.e. $q > 1$). The thick lines in the figure represent a simple case of the gap in the costs of internal and external equity finance. When investment demand is low as shown by the D_1 curve, capital spending can be financed from internally generated funds, at the expense of extra dividends. On the contrary, at very high levels of investment demand such as the D_3 curve, firms will issue new shares. The D_2 schedule also represents intermediate levels of investment demand. At this level investment can be financed by a mix of internal funds and debt. Again, to the extent that debt can be secured from lenders such as commercial banks that specialize in monitoring the borrower, information problems in debt markets will be less severe than those in external equity markets (Fazzari *et al*., 1988).

Figure 1: Investment and Financing Decisions



Adopted from Fazzari et al. (1988)

These financing mechanisms have a number of implications for the Tobin's q values and investment decisions at large. First, all other things equal, observed Tobin's q values will differ in firms with different information characteristics. For firms facing asymmetric information, the observed Tobin's q value will be the value assigned by the imperfectly informed market. The model also predicts that the Tobin's q must be substantially higher to induce a new share issue for limited-information firms than for full-information firms (Fazzari *et al*., 1988).

2.1.2 Theories of Investment and Investment Adjustment Costs

Over the last three decades two major theories of investment have been discussed extensively in the investment literature. These models are Jorgenson's (1963, 1967) dynamic model (user cost theory) and Tobin's (1969) *q* theory of investment.

2.1.2.1 A Model without Adjustment Cost: The User Cost Theory

Jorgenson's (1963, 1967) model educates us on what the optimal stock of capital would be when firms use their own capital. The user cost of capital represents the price firms charge themselves for using their own capital goods. The model predicts that a firm that uses its own capital would choose the same amount of capital as one that rents from another in a competitive market. Therefore, the user cost of capital according to Romer (2006) and Parker (2010) is equivalent to the rental price of capital in equilibrium. The model further postulated that firms can freely adjust their capital stock instantaneously without any hitches in order to stay on their optimal path.

Such a framework poses no problems as long as the desired capital path is smooth, so that the level of investment does not become too large or too small. In case interest rate falls, since the cost of capital would have fallen as well, firms would want to increase their capital stock by some finite amount according to this analysis (Sala-i-Martin, 2005). This discrete increase in capital stock likewise suggests an infinite rate of investment. It also implies that because firms can discretely get the desired capital level at every moment in time, it does not pay them to plan for the future since future changes in business conditions will be absorbed by future discrete changes in capital stocks (Romer, 2006 and Parker, 2010).

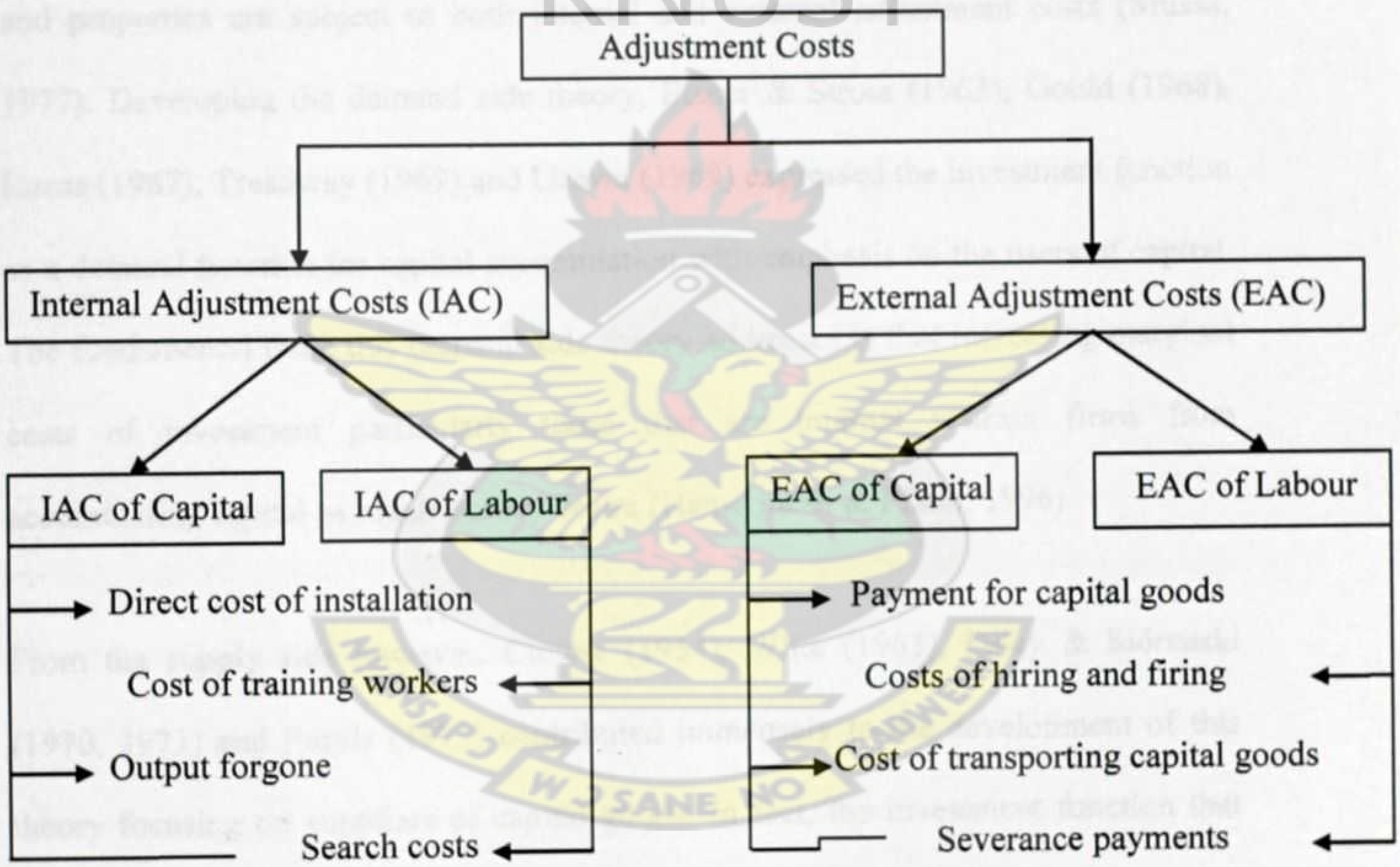
Although this model is attractive because it clearly defines the user cost of capital, it has been criticized because of its reliance on an ad hoc adjustment mechanism imposed to determine the rate of investment (Chirinko, 1993). Firstly, the proposition that a discrete change in any of the exogenous variables (such as interest rate) would lead to a discrete change in investment is not entirely consistent with what happens in reality. This stems from the fact that there exist constraints in the system that bar firms from increasing their investments endlessly as the model is proposing. Thus, investment can simply not be infinite (Romer, 2006). Another objection to the user cost model is the ad hoc nature of the lag structure between investment and the revenue/user cost variable. This lag apparently reflects costs of adjusting the capital stock, K, immediately to its optimal level, K^*. This is explained by the fact that if no such costs existed there would be no reason why capital stock would not exactly equal its optimal level (Parker, 2010).

The model also fails to define the functional form of the investment function as far as interest rate changes are concerned. Under constant returns to scale, the model proposes that discrete changes in any of the exogenous variables lead to a discrete change in labour and capital. But it does not tell what happens in the case of heterogeneous firms with different production functions (Sala-i-Martin, 2005). Apart from these, it also does not acknowledge the critical role expectation plays when it comes to firms' investment behaviours. As indicated above because future changes in business conditions are considered to be taken care of by future discrete changes in capital stocks, it is therefore of no use to plan for the future. Contrary to this assertion, in reality expectations in the area of demand and costs tend to have either positive or negative effects on investment decisions in the interim (Romer, 2006).

2.1.2.2 Conceptual Framework of the Sources of Adjustment Costs

In terms of the sources or components of adjustment costs, the literature makes a distinction between two sources of adjustment costs namely internal and external costs also referred to as technological and market sources respectively (Galeotti, 1990). The technological and market sources of adjustment costs together with their determinants are illustrated in the framework in Figure 2 below.

Figure 2: Sources or Components of Adjustment Costs



Source: Author's construct, 2013

According to Hamermesh and Pfann (1996), whereas internal adjustment costs usually occur as part of production, external costs arise outside of the firm. Adding to the discussion, Sala-i-Martin (2005) explained that external costs reflect those costs external to firms and which show up in the increasing price firms face in the amount of investment they demand. These adjustment costs exist for both labour inputs and capital goods as shown in Figure 2 above. In the case of labour according to Figure 2, the internal costs take the form of recruitment and training costs while that of the external constitute costs of moving and costs of acquiring non-firm specific skills needed for new jobs. In relation to capital, whilst the internal costs comprise of planning and installation costs (i.e. direct cost of installation and opportunity cost of output forgone); costs of movement and acquisition that are borne by capital goods suppliers explain the external costs of capital (Hall, 2004). The investment function can be viewed from both the supply and demand sides and for that matter its form and properties are subject to both internal and external adjustment costs (Mussa, 1977). Developing the demand side theory, Eisner & Strotz (1963), Gould (1968), Lucas (1967), Treadway (1969) and Uzawa (1969) expressed the investment function as a demand function for capital accumulation with emphasis on the users of capital. The fundamental issue this demand side theory addresses is that increasing marginal costs of investment particularly those that are internal restrain firms from accumulating capital as much as they desire (Hamermesh & Pfann, 1996).

From the supply side however, Clower (1954), Witte (1963), Foley & Sidrauski (1970, 1971) and Purvis (1973) contributed immensely to the development of this theory focusing on suppliers of capital goods. In fact, the investment function that emerges from this theory represents the supply function of the capital goods suppliers. Here the stock of capital demanded by asset holders plus the size of existing capital stock determines the unit price of capital. According to Mussa (1977), this price and the supply function of capital goods producers work to determine the rate of capital accumulation. Both the demand and supply theories offer important contributions. The supply price that suppliers of capital goods charge reflects adjustment costs that are external to any particular capital using firm. On the other hand, the price of existing units of capital reflects the demand price for an increment of capital (Mussa, 1977).

Due to the presence of internal marginal adjustment cost, this demand price is not the same as the supply price. This gives rise to the internal and the external adjustment costs of the adjustment cost theory (Mussa, 1977). This study focuses on the internal adjustment costs. The reasons being that, while for external the negative impact of investment on current output has to be postulated a priori, in the internal case it can be empirically assessed. Also while in case of the internal it is possible to study the interaction between adjustment costs and the levels of the variable and other production inputs it is not so with the external.

Finally, the relationship between adjustment costs and other technological features (namely, the degree of returns to scale) and their consequences for investment modelling can be analysed on the basis of the internal (Galeotti, 1990). Even in considering the internal adjustment costs, the study is concerned with only internal adjustment cost of capital because Lichtenberg (1988) and Hall (2004) have shown that internal adjustment cost of labour are either low or unimportant from year to year. Hereafter, the usage of the term adjustment costs implies internal adjustment costs.

2.1.2.3 A Model of Investment with Adjustment Costs

Due to the inherent flaws in the Jorgenson's (1963, 1967) dynamic model of investment, there arose the need for a modification so as to have a better understanding of actual investment decisions. The model that actually does this take into accounts the presence of adjustment cost to changing the capital stock. Thus, Jorgenson's (1963) model of investment is revised by introducing costs firms incur in the adjustment of their capital stock. The more quickly firms adjust their capital stock (i.e., the higher the rate of investment) the higher the cost they are assumed to incur (Parker, 2010).

Modelling this structure of investment, Romer (2006, 2012) assumes an industry with N identical firms. Each firm has a real operating profit function given by $\pi[K(t)]$ $\kappa(t)$, where $\kappa(t)$ represents each firm's capital stock with $K(t) = N\,\kappa(t)$ being the aggregate industry-wide capital stock. The π function represents the profit the firm earns per unit of its capital. It is downward sloping because the industry faces the same demand curve. This means that as the industry's capital stock and output increase, profit per unit of output decreases. The function $\pi[K(t)]\kappa(t)$ also gives the firm's real operating costs as a function of its own capital stock and the aggregate industry capital stock. The production function of each firm is assumed to exhibit constant returns to scale which implies that each firm's real profit can be represented in multiplicative manner (Parker, 2010).

The adjustment costs is represented mathematically as $C\,[I(t)]$, with $C\,[0] = 0$ meaning that adjustment cost is zero when there is no investment, $C'\,[0] = 0$ implying that marginal adjustment is zero when there is no investment with $C''\,[I] > 0$ also indicating that the marginal adjustment cost increases with investment. Again, the purchase price of capital goods is assumed to be fixed and equal to 1 (Romer, 2006, 2012). The adjustment cost function most often used is a parabola opening upward from its vertex at the origin (Hammermesh and Pfann, 1996). This form of the adjustment cost function has strong implications for the behaviour of investment that are not fully consistent with observed behaviour. The strict convexity of the adjustment cost function implies that firms always incur lower adjustment costs if they spread an investment project over more years.

In other words, convex adjustment costs imply that firms will spread the investment associated with a change in desired capital over multiple periods. Firms incur positive adjustment costs when they change their capital stock either upward or downward, and those costs rise at an increasing rate as the amount of net investment rises. The above postulations together imply that each firm aims at maximizing its profits over an infinite horizon. The present value of its profits at time zero (0) therefore is; $\Pi = \int_{t=0}^{\infty} e^{-rt} [\pi[K(t)]\kappa(t) - I(t) - C(I(t))]dt$ .... **(1).**

The $\pi[K(t)]\kappa(t)$ in the equation (1) above according to Parker (2010) represents revenue less labour costs. The inclusion of $C(I(t))$ as an argument of the equation captures adjustment costs in terms of forgone output of a change in capital stock. This posits that the cost firms incur on the acquisition of capital exceed the purchase price suppliers receive for the capital (Lichtenberg, 1988).

Further, the expression is in real rather than nominal terms, suggesting that no price of capital is required in front of the investment variable $I(t)$ and that the $\pi[K(t)]\kappa(t)$ function implicitly expresses revenue less labour costs in real rather than nominal terms. The investment decision process can be modelled in both discrete and in continuous times subject to the constraint that capital growth is accomplished only through (costly) investment (Romer, 2006, 2012). In the discrete time, the maximization is done by the method of Lagrange multipliers. But in the continuous time it is done as a continuous-time Hamiltonian. The key variable emerging from this maximization problem is the Lagrange multiplier $q(t) = 1 + C'(I(t))$ .... **(2),** in the case of the discrete time which also is called the *costate variable* under the continuous time. The expression in equation (2) explains that any value-maximizing firm will choose a rate of investment such that the shadow value of a unit of installed capital *q*(*t*) equals the marginal cost of investment which is the sum of the purchase price of the capital good and the marginal adjustment cost *C'(I(t))* (Kim & Nelson, 2003 and Romer, 2006, 2012). Due to the fact that empirical data are available usually in discrete time intervals, the implementation of empirical models tend to be in discrete time instead. For this reason, the discrete time model presented here follows Romer's (2006, 2012) exposition. The model asserts that *q*(*t*) is the single most important variable that firms observe in forming their investment decisions. Thus, whenever *q*(*t*) assumes a higher value, firms invest more. In the same way, firms disinvest whenever it is low. Since *C'* [0] = 0, it follows that the value of one more unit of investment is precisely its purchased price. This is the conclusion arrived at in the model without adjustment cost discussed in section **2.1.2.1** above (Sala-i-Martin, 2005).

Apart from equation (2), from the discrete-time case, *q* which represents the shadow value of a unit of installed capital can also be defined at time *t* as:

$q_t = \pi(K_t) + \frac{1}{1+r} q_{t+1}$ .... (3), where, q_t, as defined above is the value the firm attaches to a unit of capital in period *t* measured in period *t* Ghana cedi, and q_{t+1} is the value the firm will attach to a unit of capital in period *t+1* also measured in period *t + 1* Ghana cedi. This means that the value the firm attaches to a unit of capital q_t must be equal to the amount the capital contributes to the firm's objective function this period $\pi(K_t)$ plus the value the firm will attach to the capital next period but measured in current cedi, $q_{t+1}/(1+r)$. This condition also implies that the *q's* ought to be consistent over time (Romer, 2006, 2012).

On the basis of this, suppose a firm buys an additional unit of capital today (t = 0) and intends to hold it forever, this additional unit of capital will surely contribute to the firm's objective function and in line with equation (3),

$$q_0 = \pi(K_0) + \frac{1}{1+r}q_1 \Rightarrow q_0 = \pi(K_0) + \frac{1}{1+r}\left[\pi(K_1) + \frac{1}{1+r}q_2\right] \ldots\ldots\ldots\ldots (4).$$

Continuing further equation (4) can be generalized as:

$q_0 = \left\{\lim_{t\to\infty}\left[\sum_{t=0}^{T-1}\frac{1}{(1+r)^t}\,\pi(K_t)\right] + \frac{1}{(1+r)^T}\,q_T\right\}$...... (5), to represent the value the firm would attach to this additional unit of capital over its life time (Romer, 2012).

2.1.2.4 Tobin's *q*

This model of investment adjustment costs also asserts that the level of investment by firms depends on the ratio of the present value of installed capital to the replacement cost of capital. This ratio is ***Tobin's q***. According to Tobin's (1969) *q* theory of investment, firms would want to increase their capital when $q > 1$ and decrease their capital stock when $q < 1$. The intuition here is that if $q > 1$, a firm can buy one Ghana cedi (GH¢1.00) worth of capital (at replacement cost) and earn profits that have present value in excess of one Ghana cedi (GH¢1.00). In such a situation, firms increase profits by investing in more capital, and so investment is expected to be high. Conversely, should $q < 1$, then the present value of the profits earned by installing new capital are less than the cost of the capital, so more investment lowers profit. In such times one would expect investment to be near zero (Sala-i-Martin, 2005 and Parker, 2010).

This implies that whenever $q < 1$, it will be in the interest of any prospective investor wanting to enter a particular industry to acquire the necessary capital assets more cheaply by buying an existing firm rather than building a new one with new capital. This is true because the value of installed capital (i.e., the cost of buying an existing firm) is less than the replacement cost (the cost of building a new firm). Following Romer's (2012) analysis, it can be deduced that the Tobin's q being referred to in this section is precisely the Lagrange multiplier $q(t)$ mentioned in equation **(2)** of section **2.1.2.3** above. It was as a result of the Tobin's q that the term $q(t)$ was used to represent the value of capital in equation **(2)**. The connection between this Lagrange multiplier $q(t)$ and Tobin's (1969) market interpretation of q is explained by the equation: $q(t) = \int_{\tau=t}^{\infty} e^{-r(\tau-t)}\,\pi[K(\tau))d\tau$........................ (6). This equation shows that $q(t)$ is equal to the present value of the stream of real profits per unit of capital that will be earned from time t into the infinite future.

This Tobin's q actually summarizes all the information about the future that is relevant to a firm's investment decisions. Thus, the firm does not need to know anything about the future apart from the information that is summarized in the Tobin's q in order to decide whether or not to increase its capital stock (Tobin, 1969). Giving this model, the optimal rate of investment which happens to be an increasing function of Tobin's q, is $\dot{K} = f(q, K)$, with $f' > 1$ and $f(1) = 0$. More generally, since $\dot{K} = I =$ gross investment, the Tobin's q model of investment can be summarized as $I = I(q, K)$. If investment demand is linear homogenous in K, then

$\frac{I}{K} = \frac{I}{K}(q)$ .... (7)

If the adjustment cost function is quadratic, as indicated in section **2.1.2.3** above, then the f function is linear and investment is a linear function of Tobin's q. Hence, one of the key predictions of this model of investment is that investment increases in Tobin's q (Hammermesh & Pfann, 1996; Kim & Nelson, 2003; Parker, 2010 and Romer, 2012).

From the above discussion, it has been established that the Tobin's q measures the ratio of the market value of installed capital to its replacement cost (Romer, 2012), but what is more important to this study and the analysis of firms' investment decisions is the marginal q which measures the ratio of the market value of a marginal unit of installed capital to its replacement cost. However, in real life, it is highly improbable to get data on this marginal q. Meanwhile its counterpart also called the average q is rather easier to estimate (Sala-i-Martin, 2005). Since the average q can be approximated by comparing the market value of the firm's outstanding stock and debt with the estimated replacement cost of its capital stock, it makes it easier then to measure. Once marginal q is measured this way, the outcome is the average q which is based on average revenue and cost rather than the more useful marginal q. As a result of these computational challenges, most empirical work using the Tobin's q has been based on the average rather than the marginal q (Parker, 2010 and Romer, 2012).

2.1.2.5 Analysis of the Tobin's *q* Model of Investment

This section analyses the Tobin's q model of investment based on the joint evolution of capital stock K and q over time. The capital stock K is treated as a true state variable. This means that it cannot adjust freely. On the contrary, the market value of of capital according to this model can and so is called a "control" variable (Parker, 2010).

Given their initial quantities, the equilibrium is a saddle point which is characterized by $q = 1$. The saddle path describes the convergence of the system when the future values of exogenous variables are stable. The control variable q jumps at any instant to the value given by the saddle path at the current value of K. The industry then converges down or up along the saddle path to a steady state in which neither q nor K is changing. This is to say that for a given level of K there is a unique level of q ($q = 1$) that produces a stable path. At this unique level of q, K and q converge to the point where they are stable (Romer, 2012).

Now assume that all else in the industry remains constant, but that capital stock for some reason is below its optimal level. This means that in the initial equilibrium $q > 1$. This also implies that q is starting from a higher level. The capital stock will then expand along the saddle path. As the capital stock expands, q retreats toward one, eventually converging to a steady-state equilibrium with the capital stock at its optimal level and $q = 1$. The implication is that $\dot{K} = 0$ and $\dot{q} = 0$ (Romer, 2012). The fact that $q = 1$ demonstrates that the market and replacement values of capital are equal; hence firms will have no incentive to increase or decrease their capital stocks.

2.1.2.6 Effects of the Tobin's *q* Model on Changes in Output, Interest Rates and Tax Policies

The model so developed is able to address a number of issues. This section examines the implications of the model in the face of changes in certain variables particularly output, interest rate and tax policies. Romer (2006, 2012) analyses the model in the face of both permanent and temporary changes in these three (3) variables as the effects will be different depending on whether the exogenous change is permanent or temporary.

According to Parker (2010), a permanent change in any of the variables results in an immediate jump to the new saddle path followed by convergence along the path. But a temporary change will not put the industry on the saddle path because the exogenous variables are known to be changing in the future. Instead, the industry jumps to an unstable saddle path that leads back to the original path at the moment that the policy reverts to its original state. Once the temporary change is reversed, the industry must be on the saddle path associated with the original (and ultimate) equilibrium and converges, since no future changes in exogenous variables are expected. With this, Romer (2006, 2012) shows that an increase in output demand will cause the q curve to shift to the right. The value of q initially jumps upward to the saddle path, stimulating positive investment and an increase in the capital stock as the economy converges down the saddle path. In the second instance, an increase in the interest rate lowers q and reduces the equilibrium capital stock in the long run. The final example shows that an investment tax credit increases the profitability of capital and raises the long-run capital stock (in Parker, 2010).

2.1.2.7 Empirical Applications of Adjustment Costs and Tobin's q Model

The adjustment cost function can be specified in a variety of ways. If adjustment costs are to explain why firms do not adjust the actual capital stock rapidly in response to changes in the desired stock, then these costs must impose a disproportionate cost on large changes in the capital stock. Put differently, adjustment costs must increase more than proportionally with investment. In mathematical terms, the adjustment cost function must be convex in investment. A common specification in empirical applications is: $C(I(t),k(t) = \frac{1}{2}\alpha \left[\frac{I(t)}{K(t)}\right]^2 k(t)$... (8);

where α represents the marginal adjustment cost parameter and that it is positive (Summers, 1981b in Romer, 2006, 2012 and Parker, 2010).

This specification assumes that adjustment costs exhibits constant returns to scale. This by implication and in accordance with Hayashi (1982) the marginal and average *q's* are equal. It also assumes that adjustment costs are quadratic. Substituting for *C'(I(t),* in equation (2), the condition that relates investment to the value of capital is $q(t) = 1 + \alpha\frac{I(t)}{K(t)}$. Re-arranging the terms gives: $\frac{I(t)}{K(t)} = \frac{1}{\alpha}[q(t) - 1]$ ……….. (9). The equation (9) further assumes that (marginal) *q* is very instrumental for describing investment behaviour and that once the effects of the current value of *q* are accounted for, no other variables should have independent effects on investment (Parker, 2010). In effect, according to this model, all other variables that seem to determine the amount of investment at any given point does so through their effects on the *q*. However, variables such as capacity utilization (von Furstenberg, 1977), output (Blanchard and Wyplosz, 1981), profits, cash flow as well as government investment policies (Parker, 2010) that keep appearing in most empirical literature almost always seem to have independent effects on investment apart from any effects they may have on the Tobin's *q*.

Many empirical works have been done based on this specification and various values obtained for the Tobin's *q*. Following the above specification Von Furstenburg (1977) decided to test whether or not *q* effectively summarizes all the information relevant to firms' investment decisions. However, he added a measure of capacity utilization (CU) and estimated the following regression:

$$\frac{I_t}{K_t} = c + \sum_{i=1}^{7} \alpha_i q_{t-i} + \sum_{i=1}^{4} \beta_i CU_{t-i} + e_t \quad \text{.......................................} (10)$$

Summers (1981b) also estimated various regressions from the above analysis as:

$$\frac{I_t}{K_t} = c + b[q_t - 1] + e_t \quad \text{...} (11)$$

The coefficient of the Tobin's q, $b = \frac{1}{\alpha}$, with α being the internal adjustment cost parameter or the coefficient that helps in measuring the marginal internal adjustment cost associated with a given value of the investment-capital ratio (I/K). Hence, the marginal cost of adjustment associated with a given value of I/K is given by α *(I/K)*. This specification is based on the assumption that Tobin's q is the only statistic firms look up to when taking their investment decisions (von Furstenberg, 1977 and Romer, 2012). This particular model is estimated in the chapter four of this study. From these specifications, various estimates have been obtained for the value of capital q and its corresponding marginal adjustment cost. Empirically, the q theory of investment seems to be more appealing because Tobin's q can be measured on a firm-by-firm level or aggregate basis. To sum up, a firm's Tobin's q is the ratio of the stock-market value of the firm (share price times number of shares outstanding) to the replacement value of its installed capital stock (Kim & Nelson, 2003).

2.2 Empirical Literature

Based on the above specification, von Furstenberg (1977) estimated a regression of I/K for nonfinancial firms on lagged values of q (Tobin's q) in addition to other variables using quarterly aggregate data for the United States from 1952 to 1976. In order to actually test whether q (Tobin's q) effectively summarizes all the information relevant to firms' investment decisions, he added a measure of capacity utilization (CU). The result showed that the coefficient on the measured q was positive and statistically significant. The capacity utilization also had a significant positive effect. This implied that utilization must be proxying for some aspect of prospective profitability that is not being adequately captured by measured q.

Additionally, the sum of the coefficient on the q variables was 0.047, implying that the adjustment cost parameter α is $1/0.047 \approx 21$. Since, the marginal adjustment cost of an additional dollar's worth of investment is α (I/K), for a typical value of I/K of 0.15, the last dollar of firms' investment was estimated to cost $21 \times 0.15 = 3.15$ dollars (von Furstenberg, 1977).

Blanchard and Wyplosz (1981) also estimated a similar regression using a quarterly U.S. sample from 1953 to 1978. The significance of the estimated coefficient on the current output suggested that q is not capturing all of the incentives for firms to invest. Here too, adding up the four coefficients on current and lagged q gives 0.035, which corresponds to $\alpha = 1/0.035 \approx 29$ which is even larger than von Furstenberg's (1977) estimates shown above.

Summers (1981b) also developed a tax-adjusted q that has been used in many investment studies, incorporating the effects of investment tax credits, taxes on corporate profits, capital gains, and dividends, and the tax treatment of depreciation expenses. The tax-adjusted version of $q - 1$ was denoted by Q. Thus, $Q = q - 1$. Because one is subtracted in the calculation of Q, a value of $Q = 0$ corresponds to $q = 1$ and zero desired net investment. Summers' (1981b) test compares regressions of I/K on an uncorrected $q - 1$ with those on Q for a 1931–78 annual sample. He finds that Q explains fluctuations in investment slightly better than $q - 1$ and that when both are included together in a regression, the estimated coefficient on $q - 1$ becomes slightly negative and insignificantly different from zero while the coefficient on Q remains significantly positive and essentially unchanged by the addition of $q - 1$ to the regression. However, the magnitude of the estimated coefficients on Q were even smaller than those for $q - 1$. When he included a lagged value of Q as well as its current value, the sum of the coefficients was 0.025, which corresponds to $\alpha = 40$.

Furthermore, Pindyck and Rotemberg (1983) also estimated dynamic factor demand equations for blue-collar and white-collar labour, equipment, and structures using annual U.S. manufacturing data for 1949 to 1976. The technology was represented by a translog input requirement function specifying the amount of blue-collar labour needed to produce an output level given quantities of three quasi-fixed factors namely non-production workers, equipment, and structures. A complete description of the production structure was obtained by simultaneously estimating the input requirement function and three stochastic Euler equations. The estimation was done using three-stage least squares approach. They found marginal adjustment costs for equipment and structures to be 23 cents and 34 cents per dollar of investment, respectively (Pindyck and Rotemberg, 1983).

Again, the corresponding total adjustment cost being 0.7 cents; and 0.5 cents respectively per dollar of investment respectively. The long-run elasticity of equipment demand with respect to its cost was also estimated to be − 0.52; the long run cost elasticity of structures is − 0.16. Elasticities of equipment and structures demand with respect to output were 1.1 and 0.5, respectively. These elasticities suggest a fairly strong effect of both output and capital cost on the demand for capital. This suggests on the basis of the sampled data adjustment costs are small in total but large for the marginal, and differ considerably across factors (Pindyck and Rotemberg, 1983).

Another model developed by Kokkelenberg and Charles (1986) on expectations and factor demand estimated an inter-related factor demand with rational expectations, in the presence of internal adjustment costs. Three variables were considered namely capital, labour and energy warranting the formulation of three equations. The capital demand equation was obtained by solving the Euler equations derived from the minimization of the present value of costs. Future exogenous variables were supplied from solutions of Autoregressive Integrated Moving Average (ARIMA) equations. All three equations were estimated by a nonlinear multivariate technique using quarterly, aggregate data for U.S. manufacturing for the period 1959 through 1977. The findings revealed that capital responds very slowly and that only 1.3% of its total response is seen in the third quarter after an output shock. This response included the time it takes for the optimum capital, K*, to adjust to the output shock, plus the time for the actual capital to adjust to the perceived optimum level. Finally, the paper concluded that the adjustment costs expressed as a percentage of the total costs associated with a change in capital stock was substantial, totalling 44.7% over the span of the data, with a possible upward trend (Kokkelenberg and Charles, 1986).

In a pair of papers, Shapiro (1986a, 1986b) used Generalized Method of Moments (GMM) and similar methods to estimate the Euler equations of an aggregate production model with adjustment costs using quarterly U.S. manufacturing data from 1955 to 1980. The Shapiro (1986a) study included adjustment costs for capital, labour employment, and hours worked while the Shapiro (1986b) added in variable rates of capital utilization. The marginal adjustment cost which was estimated to be 8 cents or 9 cents for capital at quarterly frequency were even smaller than that of Pindyck and Rotemberg (1983) but higher than that of Hall (2004). The marginal cost of a dollar of investment in Shapiro's (1986a, 1986b) was less than 10 cents. He reported a long-run elasticity of the capital stock with respect to the cost of capital as − 0.31 which was within the range of Pindyck and Rotemberg's (1983) estimates for equipment and structures (cited in Parker, 2010).

In a paper estimating the adjustment costs model using Longitudinal Establishment Data, Lichtenberg (1988) sought to develop econometric evidence concerning the extent and nature of internal costs of adjustment to new plant and equipment. In doing so, a simple production frontier was formulated incorporating the rate of an investment as an output from which both a production function and a labour demand function were estimated. Both models were estimated using annual panel data for 1092 manufacturing establishments for the years 1973 to 1981. These estimates gave strong support for the adjustment costs hypothesis, and suggested that the magnitude of these costs was substantial. The production function based estimate indicated further that a dollar of expansion investment causes a 35 cent reduction in current output. The marginal cost of adjusting to replacement investment also was about 60% as much as expansion investment. The cost of adjusting to equipment investment was also higher than the cost of adjusting to plant investment (Lichtenberg, 1988).

Galeotti (1990) also provided an empirical investigation into the nature of adjustment costs and their implications for modelling the investment process. Although the method of estimation was not explicitly shown in this paper, two models i.e., quadratic technologies under the linear homogeneity and the non-homogeneity hypotheses representing two non-nested regression systems of equations, were estimated using data for the U.S. total manufacturing sector over the 1950 to 1971 period (Galeotti, 1990). The estimation results were presented for an aggregate short-run production model integrating a rich structure of adjustment costs in the capital input, under the assumption of competitive profit maximizing behaviour. The study found that the magnitude of overall internal adjustment cost in capital on average was equal to 4 billion dollars using 1958 prices. The impact on variable profits of a unit adjustment cost was quantified to be 1.5 billion on average. The incidence of adjustment cost expenditures on total investment expenditures per dollar of investment represents a 60% of the unit cost of investment (Galeotti, 1990). The study concluded noting that: in the aggregate adjustment costs negatively affect current production and rise rapidly as the rate of investment increases; the installation of new capital goods is not a separate activity relative to current production within the firm i.e. adjustment costs are non-separable and that the levels of both variable and quasi-fixed inputs affect marginal adjustment costs internal to the firm; and finally, the adjustment cost technology is best described by long-run constant returns to scale (Galeotti, 1990).

Another study aimed at estimating UK capital adjustment costs, used a data set for 34 industries spanning the whole UK economy for the period 1970-2000. The results showed that it is costly to install new capital, and that it has been more costly to adjust the level of non-ICT capital (plant, machinery, buildings and vehicles) compared to the level of ICT capital (computers, software and telecommunications). The results were then applied to an analysis of Total Factor Productivity (TFP) growth. The estimates suggested further that capital adjustment costs accounted for around two thirds of the observed slowdown in UK TFP growth. However, the adjustment is not large enough to reverse the finding that UK TFP growth declines in the second half of the 1990s, unlike the US experience of rising TFP growth (Groth, 2005).

Conducting an empirical assessment of investment adjustment costs Groth and Khan (2009) estimated a model with investment adjustment costs for the US, using annual two-digit industry data for 18 US manufacturing industries over the period 1949 to 2000. The Euler equation approach was employed from which the log-linearized first-order condition for capital was estimated using Generalized Method of Moments (GMM). The estimates of the investment adjustment cost parameter in sixteen of the eighteen industries were positive but small. In five industries the estimates were statistically significant. The implied elasticities were all greater than one and ranged from 1.6 to 37.7, suggesting that the costs associated with changing the flow of investment appear to be quite small. The benchmark weighted average of the elasticity was 13.7. This estimate is over seven times larger than the largest estimate based on US aggregate data reported in Levin, Onatski, Williams and Williams (2005).

The differences in the estimates may be explained by the differences in econometric approaches as well as types and amount of data used. For instance, Hall (2004) explained that the differences in his estimates and that of Shapiro (1986a, 198b) are attributable to the specification variances among other things; while the former employed annual data the latter used quarter data. Again from the above studies, it is clear that the value of capital (*q*) is usually found to have a significant positive effect on investment but the coefficients are so small that the implied lag lengths and adjustment costs are unrealistic. On the basis of this, Shapiro (1986) explained to the effect that large estimates of adjustment costs are unavoidable due to the extent of variation in stock prices relative to investment. This is because the stock market is much more volatile than investment. The *q* theory would have investment respond to all of these changes except for adjustment costs. As a result, estimated adjustment costs must be very high to rationalize the relatively small response of investment to changes in the stock market (Shapiro, 1986a).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter deals precisely with the specific procedures used to gather the data for the study in order to achieve the research objectives. The chapter presents how the research has been designed, a brief definition and measurement of the variables used in the study and the sources from which they were obtained. The chapter also considers the method for analysing the data, theoretical model, estimation techniques, as well as ethical consideration. The study employed entirely quantitative methods as the means of data analysis. The chapter also describes both fixed and random effects estimation techniques as well as how the Hausman's specification test is used to choose between these two estimation techniques.

3.1 Research Design

This study takes a quantitative dimension as the stated hypotheses were subject to statistical testing in order to examine the relationship between investment-capital ratio and the *q*. Additionally, the study follows the explanatory type for the reason articulated in Saunders, Lewis and Thornhill (2009). According to Saunders *et al.* (2009), explanatory study enables a researcher to study a situation in order to explain the relationships between variables. Thus, the study type enables the researcher to explain the relationship between a cedi of investment and the adjustment cost associated with it. This falls within the class of correlational research design; as it examines the relationship between two or more non manipulated variables. With correlational research designs, causality cannot be inferred (Emlen, 2006). The major purpose is purely to "establish whether such relationship exists and if it is significant, and the nature of such relationship, whether positive or negative" (Nwadinigwe, 2002, p. 13-14).

3.2 Selection of Manufacturing Companies

The study used a total of eleven (11) manufacturing firms. These firms comprised all the manufacturing firms listed on the Ghana Stock Exchange (GSE) during the study period. These domestically incorporated manufacturing firms were African Champions Industries (ACI), Aluworks Ltd (ALU), Ayrton drugs (ARYT), Camelot Ltd (CAM), PZ Cussons (PZ), Starwin Products Ltd (STAR), Unilever Ghana Ltd (UNI), Pioneer Kitchenware Ltd (KIT), Sam Woode Ltd (SAM), Golden Web Ltd (WEB) and Benso Oil Palm Plantation (BEN) (See Appendix One, for their details).

3.3 Definition and Measurement of Variables

The variables under consideration are gross investment (I), capital stock (K) and the value of capital (q). How each variable is measured and the data needs are explained below.

3.3.1 The Value of Capital (Tobin's q)

The Value of Capital according to Tobins (1969), Sala-i-Martin (2005) and Romer (2012) contains all the information firms need to know when taking their investment decisions. Firms need not to worry about anything about the future apart from the information in this variable. For this reason, it constitutes the only independent or explanatory variable in the model. Hence:

The value of capital is the ratio of the market value (also known as market capitalization) to the replacement or estimated value of installed capital stock of domestically incorporated firms listed on the Ghana Stock Exchanges (GSE) (Kim & Nelson, 2003). Thus, Value of Capital (Tobin's q) = market value ÷ replacement or estimated value of installed capital stock.

Market value (market capitalization) is the price of common and preferred shares multiplied by the number of number of common and preferred shares outstanding (Grunfeld, 1958 in Gujarati, 2004 and Kim & Nelson, 2003). In computing this statistic, the researcher obtained the number of shares issued by each company per year (from 2000 to 2012) as well as the average share price for the year from the Facts Books at the library of the GSE. These two statistics were multiplied to obtain the market value or capitalization per firm per year. Thus, Market Value = share price × shares issued.

Value of installed capital stock refers to the accumulated sum of net additions to plant and equipment (Grunfeld, 1958 in Gujarati, 2004). It is the current value of an asset measured by how much it would cost to be replaced. It is the same in value as the existing stock of capital. In this study, the value of the existing stock of capital or fixed assets (value of property, plant and equipment in current GH¢) was extracted directly from the Balance Sheet section of the annual financial statements of the manufacturing firms used in this study.

3.3.1.1 Expected Sign of the Value of Capital (Tobin's q)

One of the key predictions of the q (Tobin's q) model of investment is that investment increases in q (Hammermesh & Pfann, 1996; Kim & Nelson, 2003; Parker, 2010 and Romer, 2012). Thus, if adjustment costs explain why firms do not adjust the actual capital stock rapidly in response to changes in the desired stock, then these costs must impose a disproportionate cost on large changes in the capital stock. Put differently, adjustment costs must increase more than proportionally with investment. Studies such as von. Furstenberg (1977), Summers (1981), Lichtenberg (1988), Galeotti (1990), Groth and Khan (2009) have all shown that adjustment costs rise rapidly as the rate of investment increases and that the coefficient on q is usually found to have a significant positive effect on investment. Likewise, this study expects a positive significant relationship between investment and the value of capital (q).

3.3.2 Investment Variable (I)

Investment here involves the accumulation of fixed capital stock such as plant and equipment, machinery, buildings and transport infrastructure by firms over a given period of time that increase the magnitude of real aggregate wealth in the firm (Acheampong, 2008 and Parker, 2010). It is measured in terms of expenditures on new buildings and new machinery (additions to plant and equipment) plus maintenance and repairs during the course of the period being considered. Since these expenditures involve the sum of net investment and replacement investment, it constitutes gross investment. In this study, the amount devoted to investment in property, plant and equipment in current GH¢ was extracted directly from the Cash

Flow Statement section of the annual financial statements of the manufacturing firms used in this study under investing activities. The ratio of investment to capital (I/K) represents the dependent variable of the model.

3.3.3 Existing Stock of Capital (K)

The stock of plant and equipment represents the total value of physical capital owned by firms. Thus, it involves the accumulated sum of net additions to plant and equipment minus depreciation allowance over a given period of time. This constitutes the value of installed or existing property, plant and equipment in current GH¢. This value was as well taken out directly from the Balance Sheet section of the annual financial statements of the manufacturing companies used in this study under fixed or non-current assets.

3.4 Data Needs and Sources

Following the variables defined in section 3.3, the study required data on three key variables namely: the value of capital *(q)*, investment as well as the value capital stock all in current Ghana cedi (GH¢).

In the quest to obtain data on these variables, the study dwelt extensively on secondary data. Once information has existed, it is secondary data when it is used. These data came from different sources namely internet sites and web pages, lecture notes, text books, journals as well as other published data. Apart from these, the researcher obtained a panel dataset of annual manufacturing sector data on the stock-market value (market capitalization), investment and capital stock on a cross-section of all the eleven (11) domestically incorporated firms over a period of 13 years (i.e.

from 2000 to 2012). The choice of the sample period was influenced by the availability of data on all the variables used in the study as well as cost. Information relating to the investing activities and existing capital stock were readily available from the annual audited financial statements of these firms published at the http://annualreportsghana.com/Services/Reports.aspx, by Annual Reports Ghana and also at the GSE's library. The market value or capitalization which could not be extracted from the financial statements was computed by the researcher. This was done with the help of data obtained on the issued shares and average share price of each firm for each year from the Facts Book at the library of the Ghana Stock Exchange. Again, all the data/values were expressed in thousands of Ghana cedis.

The Annual Report Ghana (ARG) operates a site (a data bank) where information relating annual reports, circulars, GSE filings, Market data and financial statements of firms listed on the GSE can be accessed freely or at a cost depending on the nature of the information needed. The data were presented in a time series format and spanned from the year 2000 to 2012. The manufacturing firms listed on the Ghana Stock Exchange whose financial data were used for the study are listed in the Table 4 in Appendix One.

3.5 Theoretical Model

The study examines the relationship between investment and the values of capital in order to explain how adjustment costs impact on firms' decision to invest. In doing so, the researched regressed investment on the value of capital following Summers'

(1981b) formulation stated earlier in equation (11) in the literature review. The regression model is thus: $\frac{I_{it}}{K_{it}} = c + b[q_{it} - 1] + e_{it}$

Where,

I_{it} = Investment expenditures for firm *i* at time *t* (*i = 1, 2, 3...11*; *t = 1, 2, 3...13*)

K_{it} = Capital Stock per firm at time *t*

q_{it} = Value of Capital per firm at time *t*

c = Constant Parameter

b = Slope Parameter

e_{it} = Stochastic disturbance term

The assumption that adjustment costs are quadratic in the level of investment is usually specified as I/K which represents the ratio of investment to capital. This specification has become much popular in recent times.

3.6 Econometric/Estimation Approach

The model was estimated using the Stata 12 Statistical Software Package. Studies such as von Furstenberg (1977), Blanchard and Wyplosz (1981), Summers (1981) as well as Cummins, Hassett, and Hubbart (1994) have all estimated models of this kind using the Ordinary Least Square (OLS) econometric methodology. This is because it is simple and according to the Gaus-Makov theorem, among all linear estimators, it is BLUE (Best Linear Unbiased Estimator) because of the minimum variance it has. However, as this study makes use of longitudinal or panel data to analyse the first objective of the study, from a theoretical standpoint, Lichtenberg (1988) and Mili and Rayhan (2012) have said that applying OLS to longitudinal or panel data often creates endogeneity problem that contaminates the OLS estimates.

To correct this situation, a choice is usually made between fixed and random effects estimation. Meanwhile, Lichtenberg (1988) employed fixed effects to estimate various regressions for his longitudinal study. In the same way, the facilities of these two estimation techniques were employed in this study. With the help of the Hausman's specification test, a choice was made in favour of the random effects model. Thus, the random effects estimation technique was used to estimate the model in section 3.3 above. The next three sections elaborates on the both the fixed effects and random effects estimation techniques as well as the Hausman's specification test.

3.6.1 Fixed Effects Estimator

Since every firm is unique in itself, this individuality (in terms of managerial style or philosophy) might influence the predictor variables. One of the methods to allow for the individuality of each cross-sectional unit is to let the intercept vary (Gujarati, 2004).

Fixed-effects models principally assume that there is a correlation between unobserved effects (the cross-sectional specific error component) and the predictor. Thus, in doing fixed effects estimation, an assumption is made that each unit (for instance firm) has a different y intercept so each firm is somehow different. The error term in the regression model is thus broken into two components. The equation (a) below illustrates these two components of the error term:

$$\frac{I_{it}}{K_{it}} = c + b(q_{it} - 1) + v_i + \lambda_{it} \quad (i = 1, 2 \ldots 11; t = 1 \ldots 13) \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(12)}$$

The first part of the error term (v_i) is assumed to take care of the differences or the heterogeneity between the individual firms. The second component of the error term (λ_{it}) represents the error term modelled in normal OLS regressions, which is assumed to be spherical in nature. The fixed-effects estimator is also known as the within estimator (Wooldridge, 2006).

To model (v_i) error term, fixed-effects models assign a dummy variable to all but one entity and included in the model. This means that if four (4) firms are being considered, then three (3) dummy variables would be included in the model. The reason for the inclusion of dummy variables for each firm is the researcher believes the firms are different but the difference in the firms is probably related to the other explanatory variables. In this case, the dummy variable controls for each unit being different (Wooldridge, 2006; Gujarati, 2004 and Mili & Rayhan, 2012).

Not only this, there is also the tendency that this difference (in say managerial style or philosophy) might be correlated with the behaviour of the independent variable(s). What actually is the problem does not really matter but the reason for doing the fixed effects model is that the researcher thinks there might be a correlation between something individual about the firms and the other explanatory variables. Therefore, to take care of this effect, dummy variables are included in the model for each company. Consequently, fixed-effects models are also referred to as the Least Squares Dummy Variable (LSDV) model (Beck, 2001 in Certo and Semadeni, 2006).

If indeed such a relationship exists and the fixed effect dummy variables are not included, it will cause bias in the slope coefficients and as a result there will be what is called omitted variable bias. Therefore, the inclusion of dummy variables is to make up for the lack of knowledge. Using for instance four cross section units and going by the LSDV approach, the model in equation (13) can be written as:

$$\frac{I_{it}}{K_{it}} = c_1 + c_2 D_{2i} + c_3 D_{3i} + c_4 D_{4i} + b(q_{it} - 1) + \lambda_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(13)}$$

(Wooldridge, 2006 and Kmenta, 1986 in Gujarati, 2004).

3.6.2 Random Effects Estimator

The number of dummy variables fixed effects estimation require results in a notable loss in degrees of freedom which cause the standard errors to increase and that can be a problem sometimes (Wooldridge, 2006). So the alternative is the use of random effects estimation. The proponents of this model argue that if dummy variables do in fact represent a lack of knowledge about the true model, then it is appropriate to express this ignorance through the disturbance term (Gujarati, 2004). The random effects estimation assumes that the individual specific effect is uncorrelated with the explanatory variable(s). Suppose this assumption is true then the dummy variable that controls for fixed effects can be left out and it will not bias the slope coefficients. Therefore, what random effects basically do is to leave out the variables that control for the individual effects or differences in the companies at times. Thus, random effects omit the dummies.

As a result, instead of letting v_i be fixed as in equation (12), it can be treated as a random variable with a mean value of zero and constant variance. Hence, the random effects model becomes: $\frac{I_{it}}{K_{it}} = c + b(q_{it} - 1) + \varepsilon_{it}$ .... (14).

Where $\varepsilon_{it} = (v_i + \lambda_{it})$ is called composite error (Wooldridge, 2006). This composite error consists of the between-entity error or a time invariant component(v_i) and the within-entity error (λ_{it}) representing a combined time series and cross section error. The entity's disturbance term is assumed to be statistically independent of the predictors which allows for time-invariant variables to play a role as explanatory variables. As a result, unlike the fixed effects models, the random-effects models use both between and within-unit information to calculate estimates (Stock & Watson, 2007).

On the contrary, if the assumption does not hold but the researcher runs random effects estimation without controlling for individual effects, by doing so, a kind of heteroscedasticity or serial correlation is created. This is because as represented by equation (14) when the fixed effects are omitted, the variable $(\mathbf{v_i})$ becomes part of the error term. Now suppose the fixed effects are not controlled and random effects estimation is run and the variable $(\mathbf{v_i})$ becomes part of the error term, this situation causes what is called non-spherical error variance. Thus, the mean of the error term is no longer independent and identically distributed with a mean of zero (Beck, 2001 in Certo and Semadeni, 2006). This implies that one cannot just run a model and drop those fixed effects.

3.6.3 Hausman's Specification Test

The choice between fixed and random-effects models is something that still remains difficult task. This is because each technique has its own merits and demerits. Under the fixed-effects models, for instance, it is unrealistic to expect that the panel-level disturbance term exerts a constant influence over time. As pointed out by Kennedy (1998), this entails claiming ignorance about the panel-level error term. Alternatively, it is perhaps more likely that this error term changes over time, which is consistent with the resource-based view that firm resources and capabilities change over time as competitors adapt (Peteraf & Barney, 2003). This changing panel-level error term is more consistent with random-effects models. In addition, researchers such as Wooldridge (2006) suggest that fixed-effects models should be employed when all members of a group are included in a sample, whereas random-effects models should be used when a random sample of all members of a group are included in a sample. The issue of covariates that do not vary over time may also inform the choice between fixed and random effects models.

Whereas fixed-effects models do not allow for the inclusion of such variables, random-effects models do allow researchers to model them. It is important to note, however, that fixed-effects models implicitly allow researchers to control for all variables that do not vary over time. The key difference between the two techniques is that random-effects models are able to report coefficients for these variables, whereas fixed-effects models are not able to report these coefficients (Allison, 2005).

Other considerations are that if the number of time periods is larger than the cross-sectional units, the variation in the values of the parameters estimated by two methods is likely going to be small. Consequently the choice at this point is based on computational convenience and as far as this is concerned; the fixed-effects models may be preferred to the random-effects models. The contrary also holds in favour of the random-effects models provided the cross-sectional units in the sample are treated as random. Again, in case the number of cross-sectional units is large but the number of the time series data is small, and provided the assumptions underlying random-effects models hold, then the random-effects models estimators would be more efficient than that of the fixed-effects models (Judge *et al.,* 1982 in Gujarati, 2004).

Finally, the choice between fixed and random-effect models also depends on statistical assumptions underlying the models. As described above, random-effects models assume that the estimated panel error term is uncorrelated with the independent variables. The Hausman's specification test helps in evaluating this conjecture. It tests H_0: the preferred model is random effects as against the H_1: fixed effects. The test statistic H is given by;

H = (b-B)'[(Var (b) – Var $(B)^{-1}$] (b-B) ………………… **(16),** which is an asymptotic χ^2 distribution; where, 'b' represents fixed effect parameter estimate which is consistent under H_0 and H_1 but the 'B', also representing random effect parameter estimate which is inconsistent under H_1. It is however efficient under H_0 (Taylor, 1980 in Gujarati, 2004).

The Hausman test will reject random effects model if this assumption is false. When the Hausman test is rejected, researchers should rely on fixed-effects models, which are not restricted by this assumption (Certo and Semadeni, 2006). Thus, the Hausman's test compares the results a researcher gets for running fixed effects model to random effects model and determines which one is best. Wooldridge (2006, p. 252) described this issue of correlation as the "key issue" in deciding between fixed and random effects models.

In the chapter four (4) of this study, the Hausman's specification test has been used to compare the results of both the fixed effects and the random effect estimations to determine the one that is best for the study.

3.7 Ethical Consideration

In a study of this nature, the issue of ethics emerges the moment the research was planned. Seeking access to organizations, collecting, analyzing and reporting data all involve some kind of consideration. In the context of research, ethics refers to the appropriateness of one's behaviour in relation to the rights of those who become the subject of one's work, or are affected by it. Wells (1994) defines ethics in terms of a code of behaviour appropriate to academics and the conduct of research. The appropriateness or acceptability of the researcher's behaviour is affected by broader social norms of behaviour (Wells, 1994 and Zikmund, 1994). A social norm demonstrates the type of behaviour which a researcher ought to adopt in a particular situation (Robson, 1993 and Zikmund, 1994). The researcher therefore needed to consider ethical issues throughout the period of the research and remain sensitive to the impact of work on those who were affected. In doing so, the researcher had to send an introductory letter from the Head of the Department of Economics, the Kwame Nkrumah University of Science and Technology (KNUST), to inform and ask for permission from the Ghana Stock Exchange from whom the information concerning the firms' financial statements and data on market capitalization were obtained. Again, the researcher ensured that the information obtained was used solely for the purpose for which it was obtained and finally confidential information was treated as such.

CHAPTER FOUR

EMPIRICAL RESULTS, ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter presents the results obtained after the model in equation (11) was estimated within the panel data framework followed by textual elaborations. The results obtained from the fixed effects estimation is first presented and discussed followed by the discussion of the results from the random effects estimation. To enable the researcher make a choice between these two estimation approaches, thus, the approach that suitably fits the data, the Hausman's specification test was carried and the results also presented and discussed. The study covered a total of eleven (11) manufacturing firms listed on the Ghana Stock Exchange (GSE). The data were also collected for the period of 2000 to 2012 (13 years).

4.1 Presentation and Analysis of Data

4.1.1 Finding the Best Estimation Method

As indicated in latter part of section 3.6.3 of the methodology, this section presents and explains the results of both the fixed effects and random effects estimations which were used to analyse the both objectives of the study. These are followed immediately by the results of the Hausman's specification test which compares the results of both the fixed effects and random effects estimations and helps to determine which one is the best. These estimations were done using the data displayed in Table 5 of Appendix Two.

4.1.1.1 Results from Fixed Effects Estimation

The results of the fixed effects estimation are presented in the Table 1 below.

Summary Statistics

Fixed-Effects (within) regression		Number of observations	= 143
		Number of Companies	= 11
R-square:	Within = 0.4579	Observations per company: min	= 13
	Between = 0.5459	Average	= 13
	Overall = 0.4722	Maximum	= 13
F(1,131) = 110.64	corr(u_i, Xb) = 0.1274	Prob > F	= 0.0000

Source: Author's Estimation: July, 2013

Table 1: Results of Fixed Effects Estimation

I/K	Coefficient	Std. Err.	t	P>|t|	[95% Conf. Interval]	
q	0.0467338	0.0044429	10.52	0.000	0.0379447	0.0555228
Constant	0.1299792	0.0239733	5.42	0.000	0.0825543	0.177404

F test that all u_i = 0: F(10, 131) = 4.41 Prob > F = 0.0000

Source: Author's Estimation: July, 2013

The results of the fixed effects estimation, in Table 1, show that the coefficient on *q* is positive. This suggests that there is a positive relationship between investment represented by *I/K* and *q*. Apart from this, it gives an indication of a statistically significant relationship between the two variables. This is because it has a probability value of 0.000 which is highly significant at the 0.05 significance level.

From this findings it is also seen that, the test of group effect reject the null hypothesis that all the unobserved effects are zero. As a result, the fixed effect model is significant. Since fixed-effects models use only within-unit information to calculate estimates, the within R-square effect explains about 46% of the total variation.

4.1.1.2 Results from the Random Effects Estimation

The results of the random effects estimation are presented in the Table 2 below.

Summary Statistics

Random-Effects GLS regression			Number of observations	= 143
			Number of Companies	= 11
R-square:	Within	= 0.4579	Observations per company: min.	= 13
	Between	= 0.5459	Average	= 13
	Overall	= 0.4722	Maximum	= 13

Source: Author's Estimation: July, 2013

Table 2: Results of Random Effects Estimation

I/K	Coefficient	Std. Err.	z	P>|z|	[95% Conf. Interval]	
q	0.047614	0.004332	10.99	0.000	0.0391233	0.0561046
Constant	0.1278312	0.0467579	2.73	0.006	0.0361874	0.219475

Wald $chi^2(1)$ = 120.80; corr (u_i, X) = 0 (assumed) Prob > chi^2 = 0.0000

Source: Author's Estimation: July, 2013

From the Table 2, the results of the random effects estimation shows that time invariant variables are significant. This stems from the fact that unlike fixed effects model which does not allow for estimating time invariant variables, random effects treatment allow the models to contain observed time invariant characteristics. The estimated random effects result shows that the coefficient on *q* is positive with a probability value of 0.000; also suggesting a positive highly significant relationship between investment represented by *I/K* and *q*. Also since random-effects models use both between-and within-unit information to calculate estimates, both the within and between R-square effects explains about 46% and 55% of the total variation respectively with the overall R-square being 47%. Once again, the test of group effect reject the assumption that the unobserved variables are assumed to be uncorrelated with (or statistically independent of) all the observed variables.

4.1.1.3 Hausman's Specification Test

From Table 3, the results of the Hausman's specification test are presented. It tests the H_0 that the difference in coefficients is not systematic or substantial. Put differently, it tests H_0: the preferred model is random effects as against the H_1: fixed effects model is preferred. Also, b = consistent under H_0 and H_1; and that B = inconsistent under H_1, efficient under H_0.

Table 3: Results of Hausman's Specification Test

	---- Coefficients ----			
	(b)	(B)	(b - B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
q	0.0467338	0.047614	-0.0008802	0.0009862

Source: Author's Estimation: July, 2013

Summary Statistics

$chi^2(1) = (b-B)'[(V\_b-V\_B)^{(-1)}](b-B) = 0.80$

$Prob>chi^2 = 0.3721$

Source: Author's Estimation: July, 2013

From Table 3, *b* represents the fixed effects estimates and *B* the random effects estimates. As indicated above, the Hausman's specification test tests whether or not the difference between the fixed effects and the random effects estimates is significant. Also the fixed effects estimate (represented by *b*) is consistent under both the null and alternative hypotheses. Conversely, the random effects estimate (also represented by *B*) is inconsistent under the alternative hypothesis but very efficient under the null hypothesis. The result of the Hausman's specification test indicated by the probability value of 0.3721 suggests that the difference in the two coefficients is not statistically significant. The acceptance of the null hypothesis suggests that the random effect model is appropriate and should be preferred to the fixed effects model. It also suggests that there is no correlation between unobserved effects (the cross-sectional specific error component) and the predictor.

4.2 The Marginal Internal Adjustment Cost

Based on the results of the Hausman's specification test, the results of the random effects estimation shown in Table 2 should be preferred and the estimates used to answer the objectives. Table 2 depicts that the estimated coefficient shows a highly significant relationship between investment and the value of capital *q* at the 5% significance level with the expected sign. The positive significant effect of *q* on investment suggests that adjustment costs rise rapidly as the rate of investment increases (von. Furstenberg, 1977; Summers, 1981; Lichtenberg, 1988; Galeotti, 1990 as well as Groth and Khan, 2009). Again, this result supports the assertion by Hammermesh & Pfann (1996), Kim & Nelson (2003), Parker (2010) and Romer (2012) that one of the central predictions of the *q* model of investment is that investment increases in *q*.

Again, the coefficient on the *q* was 0.0467338. On the basis of this value, the internal adjustment cost parameter $\alpha = 1/b$, is estimated as: $1 \div 0.0467338 \approx 21$. Since the marginal internal adjustment cost of an additional cedi worth of investment is given by $\alpha\ (I/K)$, it suggests that, for a given value of investment-capital ratio, I/K, of say 0.04, the marginal internal adjustment cost associated with $I/K = 0.04$ is: $21 \times 0.04 = 0.84$ cedis. Similarly, for a value of I/K of say 0.12, it will cost $21 \times 0.12 = 2.52$ Ghana Cedis in marginal internal adjustment costs. Although the magnitude of the internal adjustment cost is substantial, it is expected. This is because Shapiro (1986) has said that large estimates of adjustment costs are unavoidable due to the extent of variation in stock prices relative to investment. From these results, it can be said that if the value of capital, Tobin's *q*, changes by 1%, the level of investment activities the companies will undertake will as well change by 21%. Consequently, the marginal internal adjustment cost associated with a cedi worth of investment that brings the investment-capital ratio (*I/K*) to say 0.04 and 0.12 is GH¢0.84 and GH¢2.52 respectively.

Similar estimates have been obtained for the value of capital q and its corresponding marginal adjustment cost by earlier researchers. For example, the coefficients on all the q variables added up to 0.047 in von. Furstenberg (1977), 0.035 in Blanchard and Wyplosz (1981), 0.031 in Summers (1981) and 0.5 for Cummins, Hassett, and Hubbart (1994). With these coefficients, the implied value for the adjustment cost parameter was respectively 21, 29, 32 and 2. The values obtained in this study for both q and the adjustment cost parameter α suggest that the Ghanaian manufacturing sector incurs adjustment costs by changing their level of capital stock. This result is consistent with the adjustment cost hypothesis which states that the cost to a company for acquiring fixed capital assets exceeds the purchase price paid to the suppliers of these assets (Lichtenberg, 1988); therefore based on this information, the null hypothesis that the adjustment costs of Ghanaian manufacturing firms do not obey the adjustment cost theory cannot be accepted.

4.3 The effectiveness of the Tobin's q in summarizing all the information relevant to firms' investment decisions

Although Tobin's q had a significant positive impact on investment, it could explain only about 47% of the variations in investment. This means that the remaining 53% of the variations in investment are due to factors other than Tobin's q. This also suggests that the Tobin's q obviously is not the only statistic that Ghanaian manufacturing firms look up or does not summarize or contain all the information required by the companies in taking their investment decisions. This result seems to support the view espoused by von. Furstenberg (1977) that after including a measure of capacity utilization to proxy for some aspect of prospective profitability which is not adequately captured by measured Tobin's q, capacity utilization also had a significant positive effect. Also estimating similar regression, Blanchard and Wyplosz (1981) found that current output also had significant effect on investment. All these findings suggest that the Tobin's q does not capture all incentives for firms to invest. Therefore, the null hypothesis that the Tobin's q does not summarize all information Ghanaian manufacturing firms' require in making their investment decisions cannot be rejected.

As indicated in the literature, in addition to output and capacity utilization, other variables such as profits, cash flow as well as government investment policies (Parker, 2010) that seem to determine the amount of investment at any given point are believed to work through their effects on the Tobin's q. However, these early studies as well as the findings from this study give credence to the fact that these variables actually have independent effects on investment apart from any effects they may have on the Tobin's q. this finding in effect is suggestive of the fact that the prediction by the Tobin's q theory of investment cannot be entirely true.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes what the researcher has so far done in the quest to achieve the stated research objectives. Again, the results or findings are revealed by the study are also summarized in this chapter. It also presents the conclusion that the study draws from the findings, gives suggestions for future research and ends the chapter with some policy recommendations.

5.1 Summary of Findings

The following are the summary of the major findings as relating to the objectives of the study:

The study revealed that two main sources of investment adjustment costs exist in the literature. These are internal and external adjustment costs which are also referred to as technological and market sources respectively. Again, whereas the internal adjustment costs explains the additional costs firms incur from the demand side, the external adjustment costs explain this phenomenon from the supply side of the investment function.

The study estimated the magnitude of the adjustment cost parameter to be 21. The study again has shown that once the value of the adjustment cost parameter has been estimated, the marginal adjustment cost associated with any value of the ratio of investment to capital *(I/K)* can be estimated as well. As a result, the study estimated that the marginal adjustment cost associated with a value of *I/K* of say 0.04 is

GH¢ 0.84. This result is therefore consistent with the adjustment cost hypothesis which states that the cost to a company for acquiring fixed capital assets exceeds the purchase price paid to the suppliers of these assets.

Another finding from the study indicates that the value of capital, Tobin's *q*, does not contain all the information firms need in taking their investment decisions. This indicates that obviously factors such as profits, cash flow, output, capacity utilization and government investment policies which the *q* theory fails to recognise have some independent effects on investment apart from any effects they may have on the Tobin's *q*. This suggests that the prediction by the Tobin's *q* theory of investment might not be wholly true.

5.2 Conclusion

The main objective of this study was to estimate and analyse the adjustment costs of Ghanaian manufacturing companies and their decision to invest using the Tobin's *q* theory approach. Summers (1981) model of adjustment cost was adopted and estimated using annual panel data for 11 manufacturing firms listed on the GSE for the years 2000 to 2012. The choice of random effect over the fixed effects estimation procedure by the Hausman's specification test shows that even if there were any unobserved factors common to plants and equipment within the industry in any given year such as technical change and output and input prices, they could not have any relationship with the explanatory variable.

The estimated coefficient also showed a highly significant relationship between investment and the value of unit of capital (marginal *q*) at the 5% significance level with the expected positive sign; hence, supporting one of the central predictions of the q model of investment - investment increases in q. The magnitude of the marginal adjustment cost parameter was 21 although substantial, it was expected. This is because large estimates of adjustment costs are obvious according to Shapiro (1986). This marginal adjustment cost parameter makes it possible to estimate the marginal adjustment cost of an additional Ghana cedi of investment associated with a given value of I/K. Finally, the results of the study also suggests that q obviously is not the only statistic that companies look up or the q does not summarize all the information relevant to the companies in taking their investment decisions. Based on this result and that of earlier studies other variables have independent effects on investment apart from any effects they may have on the q.

From this study the researcher noticed that the results were consistent with the adjustment cost hypothesis. Therefore, the null hypothesis that the adjustment costs of Ghanaian manufacturing firms do not obey the adjustment cost theory of the study could not be accepted.

5.3 Policy Implications and Recommendations

The existence of adjustment costs as shown by the Ghanaian manufacturing data used in this study implies that it will be costly for a Ghanaian manufacturing firm to lower or increase its levels of today's investments if they turn out to be wrong for tomorrow's prices of its outputs and demand conditions. It is therefore recommended companies facing adjustment costs should take expected future demand and prices into consideration in making today's investment decisions.

Again, the existence of adjustment costs imposes additional costs on the manufacturing sector, therefore, in order not to overburden the sector unduly but make it flourish, government ought to as a matter of urgency support the sector by given them tax rebates, import subsidies etc. since investment tax credit increases profitability of capital and raises the long run capital stock.

Additionally, it is recommended that since an increase in output demand shifts the q curve rightwards stimulating positive investment and an increase in capital stocks, efforts must be made by government to keep aggregate demand high.

Finally, it is recommended that monetary authorities should work more closely with financial institutions to keep the lending rate as low as possible. This is because an increase in interest rate lowers the q and reduces the equilibrium capital stock in the long run. The Ghanaian manufacturing sector faces a 'double agony' in the sense that the average lending rate in Ghana hovers around 27% which is quite high.

5.4 Limitations and Further Studies

5.4.1 Limitations of the Study

Challenges can never escape a person or a researcher in any field of human endeavour and this study is no exception. Among the challenges that the researcher encountered were:

The researcher found it very difficult getting data on the variables used in this study. This is because most firms in Ghana do not keep proper records of their activities. Even the few that keep proper records are usually adamant releasing such information which most firms classify as 'confidential'.

As a result, the study was limited to only domestically incorporated manufacturing firms listed on the Ghana Stock Exchange (GSE) due to the fact that those firms readily publish the report of their activities in their annual financial statements for public consumption. Even at the GSE, not all the information needed was readily available at their library. Most firms did not have their annual financial statement there. As at August 2013, the 2012 annual financial statements of most listed manufacturing firms could not be located at the GSE's library.

Another challenge was time and money. Due to the difficulty in getting data on all variables, the researcher could not work within the stipulated time frame. This also was partly due to the fact that the organisation – Annual Report Ghana – that indicated they could provide the data in the form the researcher needed on the three variables quoted a fee of GH¢50.00 per item per year. This amount the researcher could not raise.

Apart from the above, this study assumed that q is the only statistic firms look up to or possesses all information firms need to in taking their investment decision which was imposed in this study and for which reason only q was used as explanatory variable. As the study has revealed, with q explaining only about 47% of the variations investment lend support to the fact that this assumption might not be entirely true.

5.4.2 Further Studies

From this study as well as earlier studies it has become obvious many other factors influence investment decisions apart from the information contained in the q. But since none of these variables was captured in this study and none such study exist in

Ghana apart from this, this study explored the explanatory power of the q because of the theoretical predictions. Having realized that the q does not wield so much power, there is the need for the subject to be explored.

Therefore, the researcher recommends that further studies this subject can be focused on incorporating such variables like output, profits, government investment policies – tax, capacity utilization into the adjustment cost model as was done by von. Furstenberg (1977) and Blanchard and Wyplosz (1981) so as to assess their explanatory power as far as the Ghanaian manufacturing industry is concerned.

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APPENDIX ONE

Table 4: Manufacturing companies listed on the Ghana Stock Exchange

SN	COMPANY CODE	NAME OF COMPANY	NATURE OF BUSINESS
1	ACI	African Champion Industries	Manufacture toilet rolls
2	ALU	Aluworks	produce and sell semi-finished flat-rolled sheet products
3	ARYT	Ayrton Drug Manufacturing	Manufacture, importation, exportation and sale of pharmaceuticals
4	BEN	Benso Oil Palm Plantation	Processing of Palm fruits into Crude Palm Oil
5	CAM	Camelot Ghana Ltd	Manufacturing (Printing of Security Documents & Computer Forms)
6	WEB	Golden Web Ltd	Processing of Vegetable Oil
7	KIT	Pioneer Kitchenware Ltd	Production of aluminium household wares such as Heavy Casseroles etc.
8	PZ	PZ Cussons Ghana	Manufacturing and distribution Of Soaps and Electricals
9	SAM	Sam-Woode Ltd	Publishing. printing and related businesses
10	STAR	Starwin Products Ltd	Pharmaceutical Manufacturing
11	UNI	Unilever Ghana Ltd	Manufacturing (soaps, detergents, foods and personal care products), distribution and service enterprises.

Source: Annual Report Ghana and Ghana Stock Exchange

APPENDIX TWO

Table 5: Data on key variables of the study

COMP. CODE	ID	T	I	K	MKT. VALUE	I/K	Q	Q-1
ACI	1	2000	67197	1821089	756600	0.036899	0.415466	-0.58453
ACI	1	2001	67197	1821089	436500	0.036899	0.239692	-0.76031
ACI	1	2002	67197	1821089	640200	0.036899	0.351548	-0.64845
ACI	1	2003	57667	1821089	3244000	0.031666	1.781352	0.781352
ACI	1	2004	76727	618126	3244000	0.124128	5.248121	4.248121
ACI	1	2005	6270	3024053	756600	0.002073	0.250194	-0.74981
ACI	1	2006	33939	2951561	436500	0.011499	0.147888	-0.85211
ACI	1	2007	89324	2931094	640200	0.030475	0.218417	-0.78158
ACI	1	2008	72132	7104180	3244000	0.010153	0.456633	-0.54337
ACI	1	2009	46004	6974408	3244000	0.006596	0.465129	-0.53487
ACI	1	2010	148627	6923192	3244000	0.021468	0.46857	-0.53143
ACI	1	2011	73604	7489887	3244000	0.009827	0.433117	-0.56688
ACI	1	2012	73604	8056582	3244000	0.009136	0.402652	-0.59735
ALU	2	2000	480784	4524700	3472500	0.106258	0.767454	-0.23255
ALU	2	2001	2234947	6044700	17922400	0.369737	2.964978	1.964978
ALU	2	2002	2929800	8014100	15421600	0.365581	1.924308	0.924308
ALU	2	2003	175900	7245800	16672000	0.024276	2.300919	1.300919
ALU	2	2004	648400	6951800	41680000	0.093271	5.995569	4.995569
ALU	2	2005	101500	6339300	20852504	0.016011	3.289402	2.289402
ALU	2	2006	2272200	8005300	30222168	0.283837	3.77527	2.77527
ALU	2	2007	11498000	18957000	29592800	0.606531	1.561049	0.561049
ALU	2	2008	6729000	44978000	25424800	0.149606	0.565272	-0.43473
ALU	2	2009	2418000	44552000	18339200	0.054274	0.411636	-0.58836
ALU	2	2010	304000	41859000	18339200	0.007262	0.438118	-0.56188
ALU	2	2011	1008000	39854000	18339200	0.025292	0.46016	-0.53984
ALU	2	2012	8210000	44820000	18339200	0.183177	0.409174	-0.59083
ARYT	3	2000	536605	1630777	0	0.329049	0	-1
ARYT	3	2001	536605	1630777	0	0.329049	0	-1
ARYT	3	2002	536605	1630777	0	0.329049	0	-1
ARYT	3	2003	536605	1630777	0	0.329049	0	-1
ARYT	3	2004	536605	1630777	0	0.329049	0	-1
ARYT	3	2005	387208	1447382	17568000	0.267523	12.13778	11.13778
ARYT	3	2006	686003	1814173	20984000	0.378135	11.5667	10.5667
ARYT	3	2007	1098227	2584097	21027000	0.424994	8.137078	7.137078
ARYT	3	2008	615797	2763660	34400000	0.222819	12.44726	11.44726
ARYT	3	2009	547414	2830850	27950000	0.193374	9.87336	8.87336
ARYT	3	2010	714005	4394941	27950000	0.162461	6.359585	5.359585
ARYT	3	2011	1066128	4808040	27950000	0.221739	5.81318	4.81318
ARYT	3	2012	1147454	5239672	27950000	0.218993	5.334303	4.334303
BEN	4	2000	356404	2620400	1496400	0.136011	0.571058	-0.42894

BEN	4	2001	567200	2646800	1496400	0.214297	0.565362	-0.43464
BEN	4	2002	337600	2673200	1600800	0.126291	0.598833	-0.40117
BEN	4	2003	831634	9885859	1600800	0.084124	0.161928	-0.83807
BEN	4	2004	574495	9514650	3375600	0.06038	0.354779	-0.64522
BEN	4	2005	838914	9560897	19140000	0.087744	2.001904	1.001904
BEN	4	2006	810264	14351000	19140000	0.05646	1.333705	0.333705
BEN	4	2007	592000	14476000	17052000	0.040895	1.17795	0.17795
BEN	4	2008	500000	14525000	34800000	0.034423	2.395869	1.395869
BEN	4	2009	881000	15695000	16704000	0.056133	1.064288	0.064288
BEN	4	2010	833000	16351000	16704000	0.050945	1.021589	0.021589
BEN	4	2011	2066000	18302000	16704000	0.112884	0.912687	-0.08731
BEN	4	2012	3641000	22312000	16704000	0.163186	0.748655	-0.25134
CAM	5	2000	27236	187978	277950	0.144889	1.47863	0.47863
CAM	5	2001	27236	49441	281220	0.550879	5.687992	4.687992
CAM	5	2002	260530	88132	3008400	2.956134	34.13516	33.13516
CAM	5	2003	374433	159642	3008400	2.345454	18.84466	17.84466
CAM	5	2004	549324	228539	6343800	2.403634	27.75806	26.75806
CAM	5	2005	254986	768897	1111800	0.331626	1.445967	0.445967
CAM	5	2006	1680428	2310917	1111800	0.727169	0.481108	-0.51889
CAM	5	2007	136844	2142217	1111800	0.06388	0.518995	-0.481
CAM	5	2008	253729	2158242	1046400	0.117563	0.484839	-0.51516
CAM	5	2009	81373	1979386	1046400	0.04111	0.528649	-0.47135
CAM	5	2010	154749	1896179	1046400	0.081611	0.551847	-0.44815
CAM	5	2011	663484	2328795	1046400	0.284904	0.449331	-0.55067
CAM	5	2012	309410	2303906	1046400	0.134298	0.454185	-0.54581
WEB	6	2000	166254	521362	0	0.318884	0	-1
WEB	6	2001	166254	521362	0	0.318884	0	-1
WEB	6	2002	166254	521362	0	0.318884	0	-1
WEB	6	2003	166254	521362	0	0.318884	0	-1
WEB	6	2004	101146	423657	1648350	0.238745	3.890765	2.890765
WEB	6	2005	231362	619067	1648350	0.373727	2.662636	1.662636
WEB	6	2006	541470	1124877	1648350	0.481359	1.46536	0.46536
WEB	6	2007	69558	1166103	1648350	0.05965	1.413554	0.413554
WEB	6	2008	18825	1157384	1648350	0.016265	1.424203	0.424203
WEB	6	2009	711119	1560095	1648350	0.455818	1.05657	0.05657
WEB	6	2010	88053	1438079	1648350	0.06123	1.146217	0.146217
WEB	6	2011	711119	1560095	1648350	0.455818	1.05657	0.05657
WEB	6	2012	88053	1438079	1648350	0.06123	1.146217	0.146217
KIT	7	2000	78300	356100	440550	0.219882	1.237152	0.237152
KIT	7	2001	6500	323300	1320000	0.020105	4.082895	3.082895
KIT	7	2002	6700	290800	1237500	0.02304	4.255502	3.255502
KIT	7	2003	20947	271481	1221000	0.077158	4.497552	3.497552
KIT	7	2004	18784	1994510	1320000	0.009418	0.661817	-0.33818
KIT	7	2005	11816	1895512	1320000	0.006234	0.696382	-0.30362
KIT	7	2006	39704	1817078	1320000	0.02185	0.726441	-0.27356

KIT	7	2007	9059	1708419	1320000	0.005303	0.772644	-0.22736
KIT	7	2008	0	1591432	2667200	0	1.675975	0.675975
KIT	7	2009	1552	1483315	2333800	0.001046	1.573368	0.573368
KIT	7	2010	3227	1375797	2333800	0.002346	1.696326	0.696326
KIT	7	2011	3240	1269263	2333800	0.002553	1.838705	0.838705
KIT	7	2012	3240	1162729	2333800	0.002787	2.007175	1.007175
PZ	8	2000	92626	3068010	2240000	0.030191	0.730115	-0.26989
PZ	8	2001	157877	2949328	2828000	0.05353	0.958862	-0.04114
PZ	8	2002	324934	2983741	5614000	0.108902	1.881531	0.881531
PZ	8	2003	482084	3147937	5712000	0.153143	1.814522	0.814522
PZ	8	2004	344915	6898434	9240000	0.049999	1.339434	0.339434
PZ	8	2005	1156880	7416220	16800000	0.155993	2.265305	1.265305
PZ	8	2006	1110535	7573126	18228000	0.146642	2.406932	1.406932
PZ	8	2007	2643511	9128238	20160000	0.289597	2.208531	1.208531
PZ	8	2008	1881871	9909824	24640000	0.1899	2.486422	1.486422
PZ	8	2009	1869702	10353125	30800000	0.180593	2.974947	1.974947
PZ	8	2010	1000430	9909619	30800000	0.100955	3.108091	2.108091
PZ	8	2011	1778433	10012320	30800000	0.177624	3.07621	2.07621
PZ	8	2012	2152609	9825119	30800000	0.219092	3.134822	2.134822
SAM	9	2000	1517	32395	0	0.046828	0	-1
SAM	9	2001	7731	45655	0	0.169335	0	-1
SAM	9	2002	6937	58915	633070	0.117746	10.74548	9.745481
SAM	9	2003	6937	52095	633070	0.133161	12.15222	11.15222
SAM	9	2004	31127	50280	578495	0.619073	11.50547	10.50547
SAM	9	2005	60999	92665	633070	0.658274	6.831814	5.831814
SAM	9	2006	19155	85058	578495	0.225199	6.801183	5.801183
SAM	9	2007	57625	104077	578495	0.553677	5.558337	4.558337
SAM	9	2008	39527	104480	654900	0.378321	6.268185	5.268185
SAM	9	2009	29349	84285	654900	0.348211	7.770066	6.770066
SAM	9	2010	20487	60228	654900	0.340157	10.87368	9.87368
SAM	9	2011	24918	84285	654900	0.29564	7.770066	6.770066
SAM	9	2012	24918	86394	654900	0.288423	7.580388	6.580388
STAR	10	2000	46136	65223	0	0.707358	0	-1
STAR	10	2001	46136	70551	0	0.653938	0	-1
STAR	10	2002	46136	73831	0	0.624887	0	-1
STAR	10	2003	15999	76732	0	0.208505	0	-1
STAR	10	2004	76274	120643	3926240	0.632229	32.54428	31.54428
STAR	10	2005	774186	842821	4296640	0.918565	5.097927	4.097927
STAR	10	2006	845759	1559979	4074400	0.542161	2.61183	1.61183
STAR	10	2007	355199	1815536	4074400	0.195644	2.244186	1.244186
STAR	10	2008	183468	1785251	3704000	0.102769	2.074778	1.074778
STAR	10	2009	52905	1640828	3704000	0.032243	2.257397	1.257397
STAR	10	2010	106909	1546034	3704000	0.06915	2.395808	1.395808
STAR	10	2011	314812	1598814	3704000	0.196903	2.316717	1.316717
STAR	10	2012	111343	1507667	3704000	0.073851	2.456776	1.456776

UNI	11	2000	1907100	25762800	10000000	0.074025	0.388157	-0.61184
UNI	11	2001	2900200	29830700	14375000	0.097222	0.481886	-0.51811
UNI	11	2002	3687900	29321900	30031250	0.125773	1.024192	0.024192
UNI	11	2003	2777800	35314900	87756250	0.078658	2.484964	1.484964
UNI	11	2004	4051800	33234400	137500000	0.121916	4.137279	3.137279
UNI	11	2005	4677100	30630500	96250000	0.152694	3.142293	2.142293
UNI	11	2006	6729300	33788900	93750000	0.199157	2.77458	1.77458
UNI	11	2007	1859000	23290000	131875000	0.07982	5.662301	4.662301
UNI	11	2008	2550000	22789000	250000000	0.111896	10.9702	9.970205
UNI	11	2009	3142000	23458000	212500000	0.133942	9.058743	8.058743
UNI	11	2010	6294000	21139000	212500000	0.297744	10.05251	9.05251
UNI	11	2011	15194000	34074000	212500000	0.445912	6.236427	5.236427
UNI	11	2012	13201000	40973000	212500000	0.322188	5.186342	4.186342

APPENDIX THREE

RESULTS FROM THE FIXED EFFECTS ESTIMATION

Fixed-effects (within) regression		Number of obs=	143
Group variable: ID		Number of groups =	11
R-sq: Within = 0.4579		Obs per group: min =	13
Between = 0.5459		avg =	13.0
Overall = 0.4722		max =	13
F(1,167)	= 110.64		
corr(u_i, Xb)	= 0.1274	Prob> F =	0.0000

I/K	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
q	0.0467338	0.0044429	10.52	0.000	0.0379447	0.0555228
_cons	0.1299792	0.0239733	5.42	0.000	0.0825543	0.177404
sigma_u	0.15008593					
sigma_e	0.25568542					
rho	0.25626367	(fraction of variance due to u_i)				

F test that all u_i=0: F(13, 131) = 4.41 Prob> F = 0.0000

RESULTS FROM THE FIXED EFFECTS ESTIMATION

Random-effects GLS regression		Number of obs=	143
Group variable: ID		Number of groups =	11
R-sq: Within = 0.4579		Obs per group: min =	13
Between = 0.5459		avg =	13.0
Overall = 0.4722		max =	13
Wald $chi^2(1)$	= 120.80		
corr(u_i, X)	= 0 (assumed)	Prob> chi^2 =	0.0000

I/K	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval	
q	0.047614	0.004332	10.99	0.000	0.0391233	0.0561046
_cons	0.1278312	0.0467579	2.73	0.000	0.0361874	0.219475
sigma_u	0.13349449					
sigma_e	0.25568542					
rho	0.21420282	(fraction of variance due to u_i)				

HAUSMAN'S SPECIFICATION TEST

	Coefficients			
	(b)	*(B)*	(b – B)	Sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
q	0.0467338	0.047614	-0.0008802	0.0009862

b = consistent under Ho and H_1; obtained from xtreg

B = inconsistent under H_1, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

$chi^2(1)$ = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 0.80

Prob>chi^2 =0.3721