NATIONAL INNOVATION SYSTEM OF GHANA, LESSONS DRAWN FROM MALAYSIA

By

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ABSTRACT

The concept of National Innovation Systems (NIS) has been used as framework for understanding differences in innovation intensity across countries and why some have developed and others have failed. In this thesis, it was established that Ghana and Malaysia shared similar socio-cultural, geographic and economic characteristics and were at roughly the same level of economic development at the time of independence from the British. However today, Malaysia is far ahead of Ghana in terms of the intensity of innovations and economically. The study attempts to analyze the available data on the structure and capabilities of the NIS of Ghana and Malaysia to create, diffuse and utilize innovations in order to explain the reasons of superiority that Malaysia has over Ghana and draw lessons that could be used to improve upon the problems in the NIS of Ghana.

A series of linear regressions based on the framework conceptualized from the literature were applied on a set of indicators measuring innovative capability, absorptive capacity, diffusion capability and openness using annual time series covering a 21-year period, from 1990 to 2010. Secondary sources such as World Development Indicators (WDI), World Bank site, World Intellectual Property organization (WIPO) website, the website of Malaysian Science and Technology Information Centre (MASTIC) and the Agricultural Science & Technology Indicators (ASTI) were utilized for data.

The results indicated that the NIS of Ghana has some capabilities to create and utilize innovations but lacks the capability to diffuse innovations. NIS of Malaysia is demonstrating stronger capabilities. By carefully assessing the differences and the reasons behind them, some lessons have been drawn.

Keywords: National Innovation System, Knowledge, Technology, Innovations, Ghana, Malaysia.

CHAPTER 1: INTRODUCTION

The explanatory factors for the differences in the levels of economic development across countries since the 1960's have shifted gradually from single factor explanations such as GDP per capita, levels of education, life expectancy, etc. to mainly technological factors (Schumpeter, 1939; Houghton & Sheehan, 2010; Fagerberg & Srholec, 2008). As a result, technology is increasingly gaining support by nations; and studies into technological performance of nations have also attracted the attention of many researchers. Initial analysis of technological performance traditionally focused on inputs such as Research and Development (R&D) expenditures, number of researchers and output (in the form of patents) as measures used across OECD countries (OECD, 1997). Even though this way of analyzing technological performance was successful (still successful in some areas of science policy) as a reliable basis for policy makers, it was unable to explain the divergence in technological innovations and economic development between countries. According Freeman (1995), the extraordinary technological and economic advancement of Japan and South Korea and the fall of socialist economies of Eastern Europe shows that economic growth does not only depend on countries coming up with radical innovations as asserted by the input-output approach, but also depends on efficient diffusion of innovations. Therefore, in order to understand the reasons behind divergence among countries, one must know how innovation occurs in the modern world and the main processes and actors involved and this is the starting point of understanding national innovation systems (Nelson, 1993).

The National Innovation System (NIS) has been the framework for better understanding the differences in innovation capacity between countries by looking at how globalization and improvements in the methods of science and technology have affected countries and their national systems (OECD, 1996). Besides, innovative ideas can come from many sources and innovation in itself can be in many forms ranging from improvements and adaptations made on products to improvements on processes, thereby making innovation a result of complicated interrelationships between various actors and institutions (OECD, 1997). The capabilities of the NIS's of countries determine their economic growth. These capabilities which also form the foundation of a country's NIS can be grouped into physical investment, human capital and technological effort (Lall, 1992). Furthermore, knowing the performance of a country's national innovation system would require an understanding of the roles played by every part of the system (Carlsson, Jacobsson, Holmen & Rickne, 2002).

The premise to compare the NIS of two economically diverging countries could be derived from the work of Abromovitz (1996), who suggested that for catching-up economies to be successful, they must share some similarities with the developed countries and must also acquire some social capabilities such as education and business infrastructures. Therefore, for developing countries to catch up with the developed countries, they must share some similarities in their national innovative capabilities and moreover must be in the position to acquire these capabilities. Thus, the National Innovation system approach can be applied to this study because Ghana and Malaysia are classic examples of economies virtually starting from similar beginnings in the quest of catching-up to the developed economies, however today; Malaysia is performing better than Ghana in terms of intensity of innovations and economic development. According to Porter and Stern, (2010), assessing the capabilities of the national innovation systems of two diverging countries could answer questions such as: why is the degree of innovations in the countries different and why has a country failed to catch up? Additionally, the answers to such questions could be used to support policy-making on innovations and economic growth in developing countries (Bartels et al., 2012).

Ghana and Malaysia were at roughly the same level of economic development (both were equally poor and dependent on the export of raw materials) at the time independence from the British. But today, Malaysia is far ahead of Ghana economically. For example, Malaysia's GDP per capita (PPP) was $9,977 while that of Ghana was only $1,570 in the year 2011 (World Development Indicators (WDI) World Bank). Moreover, Malaysia is now classified as an upper middle income country and Ghana a lower middle income country by the World Bank in their 2012 list of economies. The manufacturing sector of Malaysia has grown tremendously since its independence whereas Ghana still relies heavily on agricultural exports to support its GDP. According to the World Bank (2007), the impressive performance of Malaysia's economy is a true reflection of good macroeconomic management and political stability, as the country was able to manage very well the inflow of foreign direct investments (FDI's) that played a major role in its industrialization. In addition, the historical path of Malaysia, revealed through institutional and structural changes in the 1960's through to the 2000's, also indicates that Malaysia's current competitiveness can be attributed to the impressive performance of its national system of innovation.

On the other hand, according to the Science, Technology and Innovation Policy Review (STIPR)[1] of Ghana (2011), Ghana has in place the individual components (Education Institutions, Research institutions, Industries, Financial Institutions etc.) necessary for an efficient and effective system of innovation; however, its capacity to create, diffuse and absorb innovation is

[1] The Science, Technology and Innovation Policy Review (STIPR) of Ghana was prepared by the United Nations Conference on Trade and Development (UNCTAD) at the request of the Government of Ghana in 2011.

limited in comparison to upper middle and middle-income countries such as Malaysia and South Africa. Furthermore, the national innovation system of Ghana overall, is not performing to a standard that will enable Ghana to achieve the level of innovation as countries like Malaysia have done. Policies and institutions for science, technology and innovation have not been modernized, nor have they been aligned to economic growth and human development goals. The review further identified features such as weak links and poor positive feedback between and among institutions, including higher education research institutes and the private sector. It also mentioned the fact that the science, technology and innovation system of Ghana has been supply-driven and over relying on public budget and external sources of funding. In a nutshell, lack of funds and the divergence of government policies have left the most important science, technology and innovation institutions in Ghana unable to function effectively.

The government of Ghana is aware of these problems. Policy wise, the "Ghana's Vision 2020" - the country's long-term framework for development prepared by the National Development Planning Commission of Ghana (NDPC) - lays emphasis on the role of local entrepreneurship and technological development in the attainment of sustainable development for the country. Ghana's discovery of oil has also motivated the government of Ghana to renew its commitment to harness science, technology and innovation (STI) by drawing up a new national STI Policy launched in March 2010 under the leadership of the Ministry of Environment, Science and Technology (MEXT). However, the policies implemented and statements made by highly ranked politicians in this regard have often not been backed up by specific actions, thus the problems still remain (STIPR, 2011). Therefore, Ghana urgently needs to acquire the capabilities to innovate if it is to transform its status into an upper middle income country like Malaysia.

Comparative studies between Ghana and Malaysia are just a few but none have looked into the direction of the national systems of innovation of both countries. Issues such as differences in the political history, governance, and political systems of Ghana and Malaysia on the one hand and poor human development, lack of a diversified economy and a domestic entrepreneurial group in Ghana and the negative impact of the West African regional economy on Ghana on the other hand (Asare & Wong, 2004; Khan, 2009; Yusof, 2010) have been raised as the main explanations for the divergence between the two nations, However none of these studies have attempted to use the NIS approach. Therefore, this paper assesses the capabilities of the national innovation systems of both countries, presents evidence of the paths and performance to growth and determines lessons for Ghana based on the national Innovation system of Malaysia.

1.1 Specific Objectives

The main goal of this research is to study the national innovation systems of Ghana and Malaysia by assessing the capabilities of both systems, presenting evidence of the paths and performance to economic growth and determining lessons for Ghana as the country aims to catch up based on the national innovation system of Malaysia. The specific objectives of the study are:

1. To find out the capabilities of the national innovation system of both countries to create, diffuse and absorb technologies.
2. To find out the extent to which difference in these capabilities may help us understand why Malaysia has experienced higher growth while Ghana still lags behind.
3. To identify some lessons from Malaysia's System of Innovation that could be utilized to improve upon the problems in the National Innovation system of Ghana.

1.2 Significance of the Study

Ghana recently introduced a new National Science, Technology and Innovation Policy (NSTIP) in March 2010 with the aim of "integrating Science technology and Innovation (STI) into the national development strategies of Ghana in order to build a science and technology capacity that would achieve national objectives for poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth" (NSTIP, 2010, p. 5). Thereby heightening Ghana to the status of a middle income country which is also the major milestone mentioned in Ghana's Vision 2020 document[2]. Therefore, the goal of this study which is to assess the national innovative capabilities for Ghana and Malaysia and determine lessons for Ghana based on the Innovation system of Malaysia is worthwhile. Besides, Ghana just struck oil in the year 2007 and with the oil revenue flowing into the country, it is important to know which sectors of the economy of Ghana deserve more attention. Studying the NIS's of Ghana and Malaysia, and understanding the success of Malaysia in catching up with advanced economies would provide some perspectives for Ghana.

Moreover, this study would reveal the multiple effects of NIS's of Ghana and Malaysia by pointing out major features and components of the systems, how these components have contributed to the functioning of the entire systems and how these have been translated into the economic development of both countries. By doing this, the study seeks to add to the already existing but scarce literature on NIS's of Ghana and Malaysia. Besides, none of the scanty literature existing have assessed the capabilities of the both systems and out of that drawn

[2] See Ghana-Vision 2020 (The first Step: 1996-2000) was prepared by the National Development Planning Commission (NDPC) of Ghana with the aim to eradicate extreme poverty, achieve universal education, promote gender equality and empower women, reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability and develop global partnerships.

lessons from one for the other. The study would also enlighten major institutions forming part of the NIS of Ghana on their current stake and role in the system. The information from this study may also be a point of reference for policy makers in Ghana in their attempt to formulate science and technology policies, considering the interrelationship between elements of the national innovation system and system differences between the two countries. Finally, this study would also open up new opportunities of research into other areas of the innovation system of both countries, such as regional innovation system, global innovation systems or even innovation system of a particular technology etc.

1.3 Methodology

The methodology utilized for this study first began with an in-depth study of the literature on NIS to gain an understanding of the elements and various approaches already applied in the field. Upon doing this, the study addressed its objectives by utilizing some of the major and recent studies in the catching up literature of national innovation systems. Specifically, the ideas and findings of Furman et. al. (2002), Furman & Hayes (2004), Fagerberg & Srholec (2007) and Castellacci & Natera (2013) were used to form the basis of the conceptual framework and model used in the analysis of the national innovation systems of Ghana and Malaysia.

Secondary data were utilized for all the indicators and were retrieved from reliable sources such as the World Development Indicators (WDI), World Bank site, World Intellectual Property organization (WIPO) website, the website of Malaysian Science and Technology Information Centre (MASTIC) and the Agricultural Science & Technology Indicators (ASTI) facilitated by the International Food Policy Research Institute (IFPRI). The data used were annual time series data covering a 21-year period, from 1990 to 2010. This period was chosen because Malaysia started shifting its focus to the role of technology and building of a knowledge economy around this period (OECD, 2013), while Ghana also transitioned from military rule to democratic rule and further started placing emphasis on the role of science, technology and innovations during the same period. Besides, the industrial development of East Asian economies and some developing economies started attracting the attention of the world from just two decades ago. In addition, some of the economic data used for this study were incomplete until the 1990's (e.g. Data on R&D expenditure, Telephone users etc.). It is also widely recognized that middle income and some developing countries started creating their national innovative capacities just before and within the past two decades (Hu & Mathews, 2005).

The statistical technique utilized for this research is a series of linear regressions aimed at assessing creative, absorptive and diffusive capabilities of the national innovation system of Ghana and Malaysia. This was done by assessing the interrelationships between innovative capacity, absorptive capacity, openness, diffusion and economic development of both countries, looking at how these variables predict each other. The analysis was done using the Statistical Package for the Social Sciences (SPSS) 21 and the variables showing statistical significance were considered and especially those that showed statistical significance relation with economic development were given priority in the interpretations, i.e. by checking their consistency with the findings in the literature and then their implications on the national innovation systems of both countries.

1.4 Structure of Thesis

Chapter 1: This chapter summarizes the entire thesis. It began with the role of innovations in the economic development of nations and the need to measure innovations using the NIS approach. The chapter also touched on state of the NIS's of Ghana and Malaysia, the purpose and importance of the study and how the study would be done.

Chapter 2: This chapter is the literature review which begins with literature foundations of Innovation systems and national innovation systems. The approaches used in the literature, and concluded with the catching up literature, from which the conceptual framework for this study was derived.

Chapter 3: This chapter is the conceptual framework for this research. It began with the model development which was based on the literature and ended with the actual model for this thesis.

Chapter 4: This chapter covered the background of the study but in much detail. The chapter basically presented evidence of why there is the need for Ghana to draw lessons from Malaysia. The chapter focused on the historical similarities and current differences between Ghana and Malaysia.

Chapter 5: This is the data developments chapter. This chapter addressed issues about the data used for the empirical analysis, including the screening of the data, description of the data and the tests for assumptions for the models.

Chapter 6: This chapter presents the results from the empirical analysis.

Chapter 7: The discussions on the empirical findings and conclusion for this thesis were presented in this chapter.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Recently, knowledge/technology/ innovation is viewed as an immense contributor to economic growth and have been accepted that it should be one most important factor that countries, especially developing countries should consider when planning their paths to economic development, but hitherto economist thought differently when explaining development. Prior 1950's, economic theories that explained development of nations did not regard technology as a factor of growth. In fact the classical economist only focused on capital accumulations to explain the productivity of countries (Fagerberq et al, 2010). The first mention of technology as a function of economic growth was made by the famous Australian economist, Joseph Schumpeter in the year 1939. His ideas provided some of the foundations that led to the development of the famous neoclassical theory in the 1950's, which provides a starting point for the debates in the literature. The neo classical model, also known as the Solow model developed by Robert Solow (1959), described technology as a public good that is available to anybody everywhere. His work challenged the view held by the classical economist that the most important factor explaining economic growth is not increases in factor inputs but lies is the ability of nations to capitalize on science and technology. However the Solow model considered innovation as "exogenous." i.e. something outside the model and is not determined by economic forces. This did not go down well with other economists since they wanted to explain and account for every factor that contributes to economic growth (Feldman, 2004).

The continuous quest by economists to understand the economic importance or contributions of technology brought about the new growth theories. One of the proponents was Abramovitz

(1956) on his study of the US economy. His findings were that; not all of the US productivity growth was explained by factor inputs and that most part of the US productivity could not be explained. The unexplained part he referred to as “residual” and classified it as “Total Factor Productivity.” The new growth theory was of the premise that investing into new technologies and education has positive effects on other sectors of the economy. Therefore innovation is made possible through “external economies” and “technology spillovers”. This model therefore became an alternative to both the classical and neo-classical model, indicating that economic growth can come about from less input, same output or the same input and more output because of Total factor Productivity (TFP) (Dowling & Valenzuela ,2010). Thus innovation or technical change over the years has been widely accepted as the major facilitator of economic growth, competitiveness, comparative advantage and higher standard of living of countries and countries that invest in innovations are better off than those that don’t. Furthermore, innovation or technical change has now taken the center stage in policies to maintain or facilitate strong economic growth (Innovation Framework Report, 2004).

2.1 Invention, Innovation, Knowledge and Technology

According to Schumpeter (1939), Innovation is defined as the “commercialization’s of all new combinations based on the application of: New materials and components; the introduction of new processes; the opening of new markets; and the introduction of new organizational forms.” Freeman (1982) also expressed his view on invention and innovation as follows: “An invention is an idea, a sketch or model for a new or improved device, product, process or system...An innovation in the economic sense is accompanied with the first commercial transaction involving the new product, process, system or device, although the word is used to describe the whole process." In other words the meaning of innovation could be broken down into the creation of a new idea based on a technology, knowledge or capability (invention), the development of this idea into a product (realization) and the diffusion, implementation, and marketing of this new product, technology or knowledge (Commercialization) (Mentz, 1999). Therefore innovation occurs when realized inventions are commercialized.

2.2Traditional Innovation Theories

In the 1950s and 1960s two kinds of theories emerge that explains technical change (Innovation). These were the "technology push theory" and the "demand pull theory" the technology push model saw innovation as a linear process from R&D to the market, thus making innovation supply side driven. On the other hand the demand pull theory is of the view that innovation is more of demand driven, thus market demand is the main determinant of innovation (Peters et al, 2012). Informed by these linear models, Innovation was seen as an activity carried out by highly trained labor and intense R&D in companies linked to first world countries. On the contrary, innovation need not only be high-tech emanating from R&D activities but could also be changes that happen in the local context (Fagerberg et al, 2010). According to the OECD (1997), in real life, innovative ideas may come from several sources and innovation may also take several forms ranging from product adaptation and process improvements. This makes Innovation the outcome of complex interaction among various actors and institutions. Therefore in this context innovation becomes an important factor to growth for both developed and developing countries and covers most aspects of almost all economic activities (Fagerberg et al, 2010).

2.3 Concept of Innovation Systems

Innovation system is the combined effect of every factor ranging from social, economic, political, organizational etc. on the creation, use and distribution of innovation (Edquist, 1997). Just like any system, innovation systems is made up of interrelated components working together to achieve an objective, which is innovation. According to Carlsson, Jacobsson, Holmen and Rickne (2002), these components are the actors or organizations and their relationships are the links between them which shows how behavior of each actor influences the entire system. Moreover every component has attributes or features that they referred to as capabilities. Innovation systems have become widely accepted because it goes beyond the conventional linear approach or beyond R&D to explain the changes in innovation among nations (Radosevic, 1998). However just like any other approach, this approach is not without flaws. Flaws that relate to the dynamics of the structure of the system and it functions (Nilsson & Moodysson, 2011). Naturally these flaws are also the problems encountered when analyzing every system; be it physical or conceptual. Some of these problems are about the boundaries and institutional diversity of the system (Radosevic, 1998). Carlsson, Jacobsson, Holmen and Rickne, (2002) addresses these flaws by tackling the issues associated with the level of analysis, identification of actors/ components and their key relationships and measurement of the performance of innovation systems.

2.3.1 Boundary and Institutional Dynamics

In addressing the problem with boundaries, innovation systems were be categorized into national, regional, sectoral or technological, each addressing a certain level of complexity and analysis (Carlsson, Jacobsson, Holmen & Rickne, 2002). On the other hand the problems of institutional dynamics still remains a challenge and thus creates dilemmas in what institutions and actors are relevant in explaining systems of innovation (Radosevic, 1998). Furthermore, knowing whether the behavior of an actor or institution is impacting positively or negatively to the system becomes difficult, unless its impacts on the process and other sub components have been determined (Bergek et al., (2008).

2.4 The Concept of National Innovation Systems

The concept was first developed by Lundvall in 1985 but publicized by Christopher Freeman in his analysis of the economy of Japan in 1985 and since then, NIS has been another approach of analyzing the ability of countries to profit from innovations (Fagerberg et al., 2010). According to Freeman (2002) the gap between developed countries and underdeveloped countries and the failure of some late-comer countries to catch-up in some situations could be explained by the concept of NIS. The concept has become widely accepted by researchers on the quest of explaining the relationship between innovations or knowledge and economic development. Yet they could not agree on a working definition and a general approach to studying the concept (OECD, 1997). Although some researchers (Liu & White 2001; Johnson & Jacobsson 2003 and Edquist 2004) agree on the need to develop a common definition and methodology, others (Lundval, 2007) still stresses on the advantage of keeping the concept open and flexible (Fagerberg et al., 2010). Hereinafter various authors have come up with various definitions that could be classified into broad and narrow definitions. According to Chung, (2002) the broad definitions includes all interrelated institutional actors that are part of the creation, diffusion and use of innovation while the narrow definitions takes into consideration only institutions and actors directly related to the quest for technological Innovations. Below is a list traditional definitions retrieved from OECD (1997) publication, and these definitions demonstrate attempts made by researchers to show the actors and linkages that make up the national innovation system (Feinson, 2003).

The national system of innovation has been defined as follows:

> "the network of institutions in the public and private sectors whose activities and interaction initiate, import, modify and diffuse new technologies" (Freeman, 1987)

> "the elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge and are either located within or inside the borders of a nation state" (Lundvall, 1992)

> "a set of institutions whose interactions determine the innovative performance of national firms" (Nelson, 1993)

> "the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country." (Patel & Pavitt, 1994)

> "that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies." (Metcalfe, 1995)

The narrow definitions of national innovation systems only takes into consideration institutions and policies directly involved in scientific and technological innovation whiles the broad definitions considers not only the institutions directly involved but the social, cultural and political environment of the country being studied (Feinson, 2003). The narrow view and broad view definitions above show evidence of disagreement among researchers as to how the concept should be defined and studied. However the national innovation systems concept is still very relevant because happenings in home countries still directly impacts on the competitive advantage of nations and firms (Carlsson, 2006). Figure 2.1 shows both the narrow and broad views of national innovation systems and the actors involved.

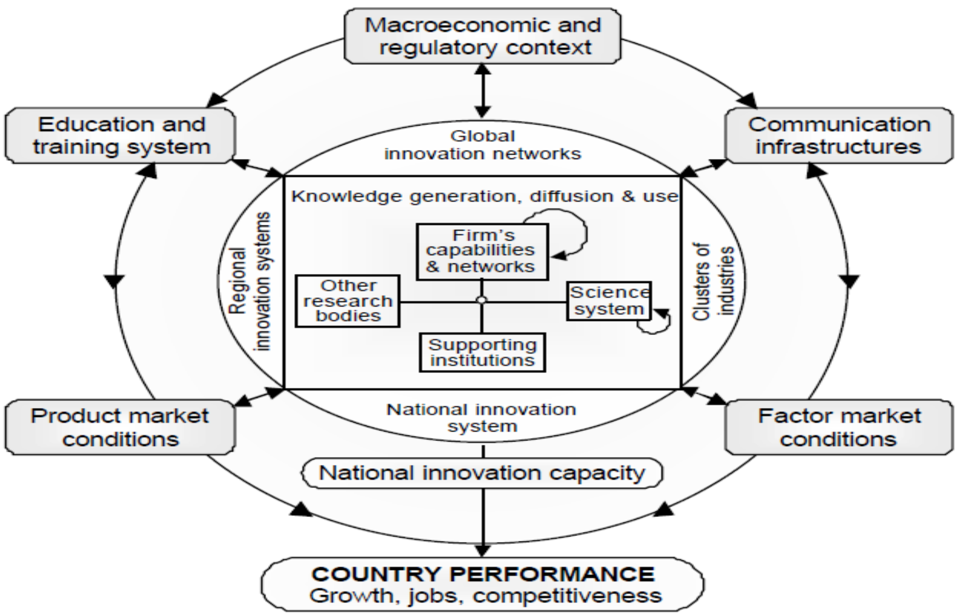


Figure 2.1 Actors and Linkages of National Innovation system
Source: OECD, (1999)

The starting point of understanding the concept of national innovation systems is when all actors in the system and the linkages among actors are understood (OECD, 1997). But the fundamental problem researcher's face is identifying these actors and linkages without falling prey to expanding the concept to cover all aspects of a country's economic system (Feinson, 2003). Therefore according to (Feinson, 2003) identifying the actors and linkages of national innovation systems should not exceed those that are related to creating, diffusing and absorbing innovations.

The national innovation system approach was initially developed to study countries that are already developed with characteristics such as high incomes, well developed knowledge base and market systems, advanced institutional and infrastructure endowments etc.; features that most catching-up nations lacks. Catching-up nations have lower income levels, less knowledge base and market system and weaker institutional and infrastructure endowments compared to developed nations (Varblane, 2007). In view of this, the concept was applied to the study of catching-up nations through benchmarking their national innovation systems to that of the developed nations. This encourages catching-up nations to reflect on approaches to growth after they are being inspired by how it was done by the developed nations (Andersen, Lundvall & Friese, 2002) But care must be taken when benchmarking since its very common for catching up nations to accept a particular approach or national system as best practice even though there are systemic differences between countries and what is considered as best practice may depend on the context (Andersen, Lundvall & Friese, 2002).

2.5 Literature of Cross Country comparisons and Catching up Economies

In literature of cross country comparisons of the national innovation system of catching up economies, One of the first attempts was done by Gerschenkron (1962) who argued that developing countries could easily get and apply modern technologies at much lower cost to their advantage through transfer agreements, foreign direct investment and recruitment of skilled people etc. Therefore they do not have to face the challenges of uncertainties and cost associated with creating new markets since the developed countries have already created them. On the other hand Bell and Pavitt (1993) were of the view that the acquisition of foreign technologies and foreign assistance would not give catching-up countries an advantage. But rather they should implement active learning policies in order to overcome their shortcomings.

The concept "National innovative capacity" was introduced by Furman et al. (2002) and was a big contribution to the literature on cross country comparison of innovative performance among countries. The national innovative capacity according to Furman et al. (2002), "depends on the technical sophistication and labor force of a given economy" and the role played by the private sector and government. Their framework assesses the determinants of innovations through innovation infrastructure, environment for innovations in terms of industry clusters and the quality of linkages between the innovation infrastructure and environment for innovation. Figure 2.2 shows the model used to assess the determinants of innovation by Furman et al, (2002)

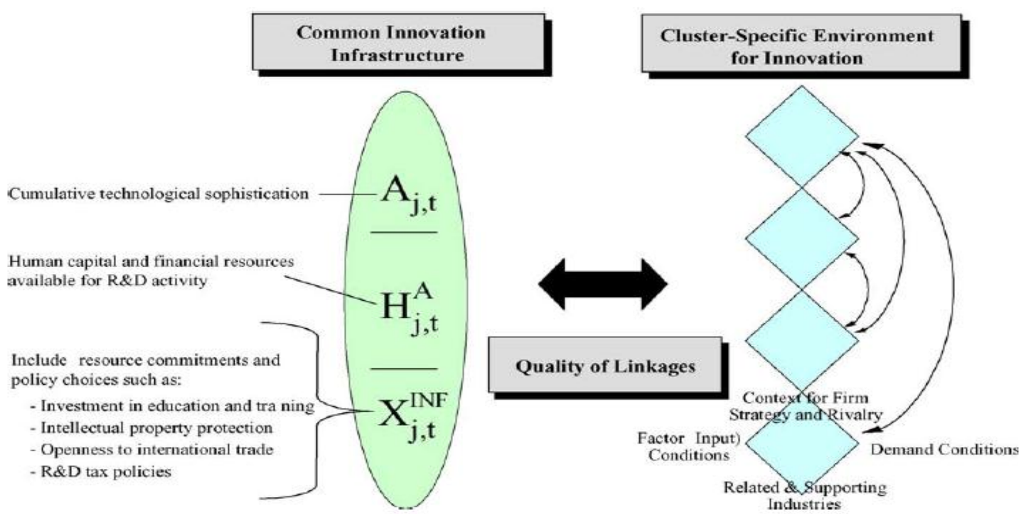


Figure 2.2 National Innovative Capacity by Furman et al. (2002)

However cross country comparisons of the national innovation systems have been in the literature even before the concept was developed by Furman et al. (2002) was applied. For example Nasierowski and Arcleus (1999) also used a cross country approach in their study of the elements of national innovation systems, where they treated the national innovation system as a sector of the economy with inputs, output and moderating elements. Their aim was to determine the contribution of these elements on GDP per capita (productivity) which they termed as the national innovation system overall contribution to the national economy. However treating the national innovation system as a sector of the economy contradicts the widely accepted argument that innovation systems are open systems (Balzat & Hanusch, 2003). Back to Furman et al. (2002), an extension of their model of national innovation capacity was done by Furman & Hayes (2004). Their work was based on the assumption that R&D growth of a country depends on its historical stock of knowledge and its human capital. Furthermore, Innovative productivity of a country also depends on the policies and investments made by a country on factors such as higher education, intellectual property protection and openness to trade. One of the differences between the work of Furman et. al. (2002) and Furman & Hayes (2004) was the sample size used, which was increased from a panel of 17 countries to 75 countries by the latter. To elaborate, their model hypothesized that; "innovation is a function of the factors underlying national innovative productivity":

$$A_{j,t} = \delta\left(X_{jt}^{INF}, Y_{j,t}^{CLUS}, Z_{j,t}^{LINK}\right) H_{j,t}^{A\lambda} A_{j,t}^{\phi}$$

Where $A_{j,t}$ = "Flow of new-to-the-world innovations"

$H_{j,t}^{A\lambda}$ =Total level of capital and human capital devoted to innovations

$A_{j,t}^{\phi}$ =Stock of useful Knowledge available to drive future innovations

X_{jt}^{INF} = Policies and resource commitments

} Common Innovation Infrastructure

$Y_{j,t}^{CLUS}$ =The environment for innovation in a country's industrial clusters

$Z_{j,t}^{LINK}$ = Strength of linkages between common infrastructure and industry clusters

Using a multiple regression analysis with data measuring innovation output (dependent variable), quality of common innovation infrastructure, Cluster-specific innovation environment and other related outcome factors, their findings indicated that GDP per capita and full time equivalent R&D Personnel across all sectors had a significant impact on patents. Also, education expenditure (%) GDP and Trade (%) GDP significantly impacted on Patents. However after adding country fixed effects to their model, R&D expenditure and Human capital remain significant elements of innovative infrastructure but Trade (%) GDP even though still significant, ended up being negatively related to Patents. Furthermore, the coefficients for GDP per Capita also changed, suggesting that different income levels of countries have different effects on their Innovative capabilities. Their findings were only applicable to developed and middle income countries but were not applicable to developing countries since they did not include developing countries in their analysis. Moreover the use of patents as a sole measure of innovative capacity places a strong limitation on the application of the findings to developing countries since most innovative activities of developing countries are unrecognized by this approach (Fagerberg & Srholec, 2007).

According to Porter & Stern (2002) the national innovative capacity is the political and economic potential of a country to generate innovations and in identifying elements of the national innovative capacity that are statistically significant to innovation, Porter and stern drew on a sample of 75 countries. This sample according to Balzat & Hanusch (2003) was bigger than the initial sample used by Furman et. al. (2002). However their sample only comprised on developed countries and did not take into account catching up economies. Based on the framework and data sources provided by Furman et al. (2002); Hu & Mathews, (2005) also studied the national innovation capability of latecomer countries, specifically East Asian economies in order to differentiate their results from the results of Furman et al. (2002).

One thing all these studies (Nasierowski and Arcleus, 1999; Furman et. al., 2002 and Hu and Mathews, 2005) have in common is that they contribute to the catching up theory by studying the national innovation capabilities of catching up economies, In terms of providing answers to a question such as; why is there a big gap between developed nations and catching-up nations. However these papers did not tackle the question of how catching up economies can change their status or how catching up economies could close up the technology gap between them and the developed world. The answer to this question was provided by Abromovitz (1996) after he coined the term "absorptive capacity". According to him, for catching up economies to be successful, they must share some similarities with the developed countries and must also acquire some social capacity such as education and business infrastructure. Therefore developing a good national innovative capacity alone is not enough, but also requires the existence of properly working innovation systems comparable to developed economies in order to be successful.

Works that addresses both national innovative capacity and absorptive capacity of catching-up countries was initiated by Fagerberg & Srholec (2007), who revealed that innovation capacity development, quality of governance; political system and degree of openness are the reasons for divergence in economic performance across countries. They included developing countries in their analysis of 115 countries for the period 1992 to 2004. Their aim was to identify the capabilities of the NIS's, governance, political systems and the degree of openness for these countries. Given the high number of indicators (over 20 indicators) being identified in their study, they used factor analysis to select relevant indicators for their analysis. Their first factor loaded highly on Patents, scientific publications, ICT infrastructure, ISO 9000 certifications and access to finance which were all correlated to education. They named this factor innovation system, which they interpreted as the measure of the capabilities influencing the development, diffusion and use of innovation. The other factors were governance, political system and openness. Imports of goods and services and foreign direct investments loaded high on openness, however according to Fagerberg & Srholec (2007), these indicators do not correlate to economic development (GDP per capita). After putting all these factors in a linear regression model, Innovation system and governance significantly impacted on economic development. Meaning that all the following indicators; patents, scientific publications, ICT infrastructure, ISO 9000 certifications and access to finance, were all highly significant and positive predictors of GDP per capita for both catching up economies and developed economies, whiles openness and political system seems to be only significant for developed economies. However they did not distinguish between the results for middle income countries and developing countries. They also ignored the internal dynamics of the national innovation systems, which would have produced differences in the findings for developed, middle-income and developing countries. Furthermore, they also did not consider the reverse impact of the level on economic development on their factors.

Finally the work Castellacci & Natera (2013) seemed to have tackled the weaknesses in the work of Furman and Hayes (2004) and Fagerberg and Srholec (2007) by including developing countries in their analysis of panel of countries and by presenting their results in accordance with the income groups of countries. Therefore their findings could be applied to all countries at different stages of development. They also dealt with the internal dynamics of national innovation systems via the coevolution between innovative capability and absorptive capacity and their interrelationships with income level (GDP per capita) using the vector autoregressive model. The results from their study were categorized into three country groups or income groups. These groups were advanced (OECD) countries, middle income (East Asia, Latin America and Eurasia) countries and less developed (Africa and south Asia) countries. For the purpose of this study, only the findings on middle income (East Asia) and less developed (Africa) would be considered since the focus of this research is on Malaysia and Ghana which are countries from East Asia and Africa respectively and even though Ghana is now a lower middle income country, that is still very debatable since Ghana may still have some characteristics of a developing country.

The results in their analysis of the internal dynamics of innovative capability of middle income economies by Castellacci & Natera (2013) indicated that technological output (patents) and scientific output (scientific and technical journal articles) are negatively correlated but are both positive and significantly related to income level (GDP per capita) and vice versa. This confirms the findings of Furman & Hayes (2004) and Fagerberg & Srholec (2007) to some extent with the former suggesting that GDP per capita impacts on patents while the latter suggested that patents and scientific outputs were positive predictors of GDP per capita. Moreover the findings of Castellacci & Natera (2013) on less developed economies indicated no significant relationship between R&D expenditure, Science and technical articles and Patents. But rather patents were found to be significant predictor of GDP per capita and R&D expenditures.

On the issue of dynamics of absorptive capacity of middle income countries, the results of Castellacci & Natera (2013) indicated bidirectional causality between infrastructure and international trade and between infrastructure and human capital. Neither Furman & Hayes (2004) nor Fagerberg & Srholec (2007) tested for bi-causal relationships amongst their variables but their findings confirmed Infrastructure, trade and human capital as significant elements of national innovation systems. Furthermore, Castellacci & Natera (2013) indicated bidirectional causality existing between infrastructure and income level and according to them; income level further causes the growth of international trade. On the other hand the results for less developed economies indicated only a unidirectional causality between human capital and Infrastructure, and bidirectional causality between income level and international trade and income level further causing the growth of human capital. In contrast Fagerberg & Srholec (2007) discovered no significant relationship between trade and income level for developing countries.

Finally, Castellacci & Natera (2013) also addressed the mutual relationships between the indicators of innovative capacity and absorptive capacity. Their results indicated that Innovative input (R&D expenditure) has a causal effect on Infrastructure (Electricity consumption per capita). Also, a bidirectional causal relationship exists between infrastructure and scientific output and between infrastructure and technological output for East Asian Economies. On the other hand, their results for developing economies rather showed bidirectional causal relationship between infrastructure and scientific output, and a unidirectional causal relationship between Innovative input and international trade, with innovation input causing the growth of International trade. In conclusion, even though Castellacci & Natera (2013) included indicators that measure the diffusion of innovation in a country in terms of infrastructure, they did not address the dynamics of diffusion capacity in their analyses.

2.6 Towards a framework for this research

The framework is based on and extending the works in the literature of cross country comparisons of the national innovation system of catching up economies. The framework is especially drawn from the studies made by Furman et. al. (2002), Furman & Hayes (2004), Fagerberg & Srholec (2007) and Castellacci & Natera (2013). The idea is to demonstrate similarities in the approaches and the findings in the literature that would lead to the development of a suitable approach (model) that would be applied in this study. It is therefore important to note that this research intends to use multiple regression analysis to answer the research questions in chapter 1. Besides, almost all the papers discussed above utilized this technique. "Multiple regression analysis is a statistical technique that can be used to analyze the relationship between a single dependent variable and several independent variables" (Fair et al. 2010). The research question for this thesis of accessing the capabilities of the national innovation system of Ghana and Malaysia to create, absorb and utilize innovation makes this technique worthwhile.

CHAPTER 3: CONCEPTUAL FRAMEWORK

3.0 Introduction

The conceptual framework showing the researcher's intents and model for the empirical analysis is shown in this chapter. The framework is mostly drawn from the ideas and findings of Furman et al. (2002), Furman and Hayes (2004), Fagerberg and Srholec (2007) and Castellacci and Natera (2013) and that provided the guidelines for designing the model for this thesis.

3.1 Model Development

The concept of assessing "national innovative capability" was borrowed from Furman et al. (2002) and Furman and Hayes (2004); and this was used to determine the capabilities of the national innovation systems of Ghana and Malaysia. Hopefully by identifying the factors that drive innovations in both countries, questions such as why there is a huge gap between the two countries and why Ghana has failed to catch up would be addressed. Therefore, their work was used as guide in the modeling and choosing of indicators for the analysis. However, this paper did not include all the elements identified by them due time constraints and lack of data on these elements. E.g. elements such as environment for innovations in terms of industry clusters and the quality of linkages between innovation infrastructure and environment for innovation as explained by Furman et al. (2002) were not included in the model. This study however, introduced a different dimension from Hertog et al., (1995), which was mentioned but not specifically addressed or discussed in detail by any of the researchers mentioned in the literature search. This is the "distribution power", or in other words, diffusion capacity of the national innovation systems of Ghana and Malaysia. According to Hertog et al. (1995), "distribution power" of innovation systems is the capability of the system to transfer, transform and make accessible stocks of innovations.

The work of Fagerberg and Srholec (2007) and Castellacci and Natera (2013) were also used as guide in the selection of the appropriate indicators for openness, absorptive capacity and diffusion that were used in the empirical analysis. The model designed for this research aimed at assessing, individually, the dynamics of innovation capacity/ creative capacity, absorptive capacity, openness and diffusion capacity of the national innovation systems of Ghana and Malaysia. This was done by finding out the extent to which these capabilities interrelate to the economic development of both countries. Furthermore, the study also addressed the interrelationship between the innovative capacity, absorptive capacity, openness and diffusion capacity in order to grasp detailed understanding of the links and interactions within both systems and their differences.

3.2 Indicators

Table 3.1 shows the list of indicators and their titles selected from the literature. The sources of data for these indicators/ variables and their symbols are provided.

Table 3.1 Selected Indicators for the Analysis

Measure	Symbol	Indicator Title	Variable	Data Source
Innovative Capacity	X1	Innovative Inputs	Total agricultural R&D expenditure (% of GDP) [a]	ASTI of IFPRI (for Ghana)
			Total R&D expenditure (% of GDP)[b]	MASTIC
	X2	Technology Output	Number of patent applications [c]	WIPO
	X3	Scientific Output output	Number of scientific and technical journals [d]	WDI, World Bank
Openness	X4	Openness	Trade (% of GDP) [e]	WDI, World Bank
	R1	Openness	Foreign direct investments (Net inflows (% of GDP)[f]	WDI, World Bank
Absorptive Capacity	X5	Human Capital	Tertiary enrollment ratio of total [g]	WDI, World Bank
	R2	Human Capital	Secondary enrollment ratio of total [h]	WDI, World Bank
Diffusion	X6	Infrastructure	Number of kilowatt of electricity consumed per capita [i]	WDI, World Bank
	R3	Infrastructure	Number of Telephone uses per 100 people [j]	WDI, World Bank
	Y	Economic Development	GDP per capita (constant US$)[k]	WDI, World Bank

Notes:

a) Indicator used as a proxy for Total R&D expenditure due to the non-availability of data for Ghana
b) Nasierowski and Arcleus (2009), Furman and Hayes (2004) Fagerberg and Srholec (2007) and Castellacci and Natera (2013)
c) Nasierowski and Arcleus (2009), Furman and Hayes (2004) and Castellacci and Natera (2013)
d) Nasierowski and Arcleus (2009), Furman and Hayes (2004), Fagerberg and Srholec (2007) and Castellacci and Natera (2013)
e) Nasierowski and Arcleus (2009), Furman and Hayes (2004) Fagerberg and Srholec (2007) and Castellacci and Natera (2013)
f) Nasierowski and Arcleus (2009), Furman and Hayes (2004) Fagerberg and Srholec (2007)
g) Nasierowski and Arcleus (2009), Furman and Hayes (2004) Fagerberg and Srholec (2007) and Castellacci and Natera (2013)
h) Nasierowski and Arcleus (2009), Fagerberg and Srholec (2007) and Castellacci and Natera (2013)
i) Castellacci and Natera (2013)
j) Nasierowski and Arcleus (2009), Furman and Hayes (2004) Fagerberg and Srholec (2007) and Castellacci and Natera (2013)

k) Nasierowski and Arcleus (2009), Furman and Hayes (2004) Fagerberg and Srholec (2007) and Castellacci and Natera (2013)

3.2.1 Economic development (GDP Per Capita Constant US$)

The variable GDP per capita has often been used in the literature as the overall output of national innovation systems. It has been given titles such as "Productivity" by Nasierowski and Arcleus (1999), "Level of economic development" by Fagerberg and Srholec (2007), "Output" by Kutlaca (2008) and "Income level" by Castellacci and Natera (2013). It has been used in the same way by all of these researchers to represent the overall contribution of innovative activities on the economy of a nation. Moreover, "it defines the overall level of economic and social development of a country" (Castellacci & Natera, 2013, p. 4). In the past, patent count has been the sole measure of contributions of innovative activities (OECD, 1999; Furman et al. 2002). However, according to Fagerberg and Srholec (2007), this leads to a measurement bias in the situation where developing countries are involved in the analysis, since most innovations in developing countries are not recognized by the international patent system. Therefore, for the purpose of this research, GDP per capita is used instead of patents.

3.2.2 Innovation Inputs (Gross R&D expenditure as % of GDP)

According to Castellacci and Natera (2013, p.5), innovation input "represents the total efforts and investments carried out by each country for R&D and innovative activities". There are several indicators used to represent innovation inputs in the literature. These include Gross R&D expenditure as a percentage of GDP and Personnel employed in R&D (Furman et al., 2002). This study only utilizes gross R&D expenditure as a percentage of GDP as a measure for Innovative Inputs. However, due to lack of data on this indicator at the national level for Ghana, Gross agricultural R&D expenditure as a percentage of GDP which was retrieved from the Agricultural Science & Technology Indicators (ASTI) was be used as proxy. The ASTI is facilitated by the International Food Policy Research Institute (IFPRI) (http://www.asti.cgiar.org/home). The researcher is aware of the shortfalls this indicator would bring to the findings since it represents only a fraction of R&D expenditures made by Ghana. Therefore, the interpretation of this variable was as much as possible limited to the agricultural sector of Ghana. The researcher acknowledges Agricultural R&D as an imperfect proxy; however, Ghana's economy is still agriculture-based, meaning that huge chunks of Ghana's R&D expenditures still goes to the Agriculture sector, therefore it would be worthwhile to study the impact of such expenditures.

3.2.3 Technology Output (Patent count)

Technological output in this research was used to represent number of Patent applications. According to Nasierowski and Arcelus (1999), patents are categorized as solution innovations and they are the results of short term investments into innovative activities by a country. Furthermore, they are innovation outputs produced by private and public firms in a country (Castellacci & Natera, 2013). In the context of developing countries, this variable gives a partial view of their technological outputs, since "patents are awarded to inventions, not innovations" and the willingness to patent varies across countries (Fagerberg & Srholec, 2007, p. 1420). Therefore the researcher included number of patent applications in the model as grounds for universality of the model. However this variable is likely to be omitted from the model for Ghana due to the inadequate data on the variable as anticipated by the researcher.

3.2.4 Scientific Outputs (Scientific and Technical articles counts)

According to Castellacci and Natera (2013, p. 581) scientific outputs are “the result of research and innovation activities carried out by the public Science and Technology system”. Moreover Nasierowski and Arcelus (1999) categorized them as knowledge solutions and are the results of long term investment to innovative activities.

3.2.5 Human Capital (Tertiary enrollment & Secondary enrollment ratios)

National innovation systems require inputs for the present and future development of innovations and these inputs can be categorized into human resource and capital. The Education sector of a country is responsible for the training and supply of the former. Innovation being the process of change that either improves performance or adds value is not something that institutions do, but rather are done by the people within those institutions (Group of Eight, 2011). Human capital has been recognized as the main indicator responsible for the absorption of innovation in a country (Castellacci & Natera, 2013). Moreover, Feinson (2003, p.19) wrote that: “development of human capital via education and training is essential for fostering absorptive capacity.” Finally, according to Fagerberg and Srholec (2007), the education variables have been identified with the term “social capability”, a term coined by Abramovitz (1986).

3.2.6 Openness Trade % of GDP & FDI (net inflows % of GDP)

Openness simply means the openness of a national innovation system to its international environment. In other words, openness is the rate of interaction between a system and other systems across borders. According to Fagerberg and Srholec (2007), interaction across borders may encourage technology transfers across countries, transfers not just limited to movement of goods and money but also movement of ideas. Movement of goods and money can be measured and data on them exist in the form of trade as a percentage of GDP and FDI. However, finding suitable data to measure movement of ideas is a very difficult, according to Fagerberg and Srholec (2007).

3.2.7 Infrastructure (Number of kilowatt of electricity consumed & Number of Telephone uses per 100 people)

The variables considered in this research for the measurement of infrastructure are related to the energy and technology infrastructures of both countries. According to Smith (2002), infrastructure needs to be considered as an element of national innovation system because of its economic effect and the network externalities that it provides. One of the main roles of national innovation system is to diffuse innovations and infrastructure is "an essential precondition for the diffusion of major technologies" (Smith, 2002, p.14). For example, according to Smith (2002, p. 14), "the internal combustion engine and the automobile required road and highway construction; the electricity power generation and supply network was a precondition for diffusion of industrial and consumer electrical products; the fax machine requires a telephone system; diffusion of advanced information technology requires internationally-compatible telecommunication networks etc."

3.3 Data

Data for all the indicators were retrieved from the World Development Indicators (WDI); World Bank website, except for the Patent counts, Gross R&D expenditure as a percentage of GDP for Malaysia and Gross agricultural R&D expenditure as a percentage of GDP for Ghana. Patent counts were retrieved from the World Intellectual Property organization (WIPO) website, Gross R&D expenditure of Malaysia (% GDP) was also retrieved from the website of the Malaysian

Science and Technology Information Centre (MASTIC). However, due to the lack of data on Gross R&D expenditure (% of GDP) for Ghana at the national level, Gross agricultural R&D expenditure as a percentage of GDP which was retrieved from the Agricultural Science & Technology Indicators (ASTI) was used as proxy; therefore, any conclusions about R&D related measures for Ghana was treated with caution. The ASTI is being facilitated by the International Food Policy Research Institute (IFPRI). It was the intent of this paper to collect data available from the year of independence of both countries. Nevertheless, the difficulty in doing so is that most data for lower middle income and some middle income countries such as Ghana and Malaysia are necessarily incomplete for the 50-year period intended for this study. Besides, the industrial development of East Asian countries and some developing countries only started gaining the world's attention just two decades ago. Therefore, some of the economic data to be used for this study were incomplete until the 1990's (e.g. Data on Patents and R&D expenditure).

Data used for this study are time series data covering a period of 21 years, from 1990 to 2010. This period is of much concern because Malaysia started shifting its focus on the role of technology and building of a knowledge economy around the start of this period, specifically in 1992 (OECD, 2013). Ghana also transitioned from military rule to democratic rule and furthermore started placing emphasis on technology and innovations starting from the beginning of the same period. Moreover, it is no secret that developing countries started creating their national innovative capacities just before and within the past two decades (Hu & Mathews, 2005).

3.4 Model and Hypothesis

Based on the conceptual analysis of findings from the literature, Figure 3.1 shows the dynamics of Innovative Capacity, Absorptive Capacity, Openness and Diffusion and their interrelationship with Economic Development. The models utilized in this study not only assesses the extent to which the innovative capacity, absorptive capacity, openness and diffusion capacity impact on economic development; but also assesse the reverse impact of the level of economic development on these factors as well. Moreover, the models also test the dynamics or the interrelationships among the factors in terms of measuring the extent to which they all predict each other. The same model was applied to Ghana and Malaysia. Variables that demonstrated a strong relationship with economic growth were considered and their implications on the national innovation system in question were determined. Their interrelationships with the other elements in the system were also considered as well.

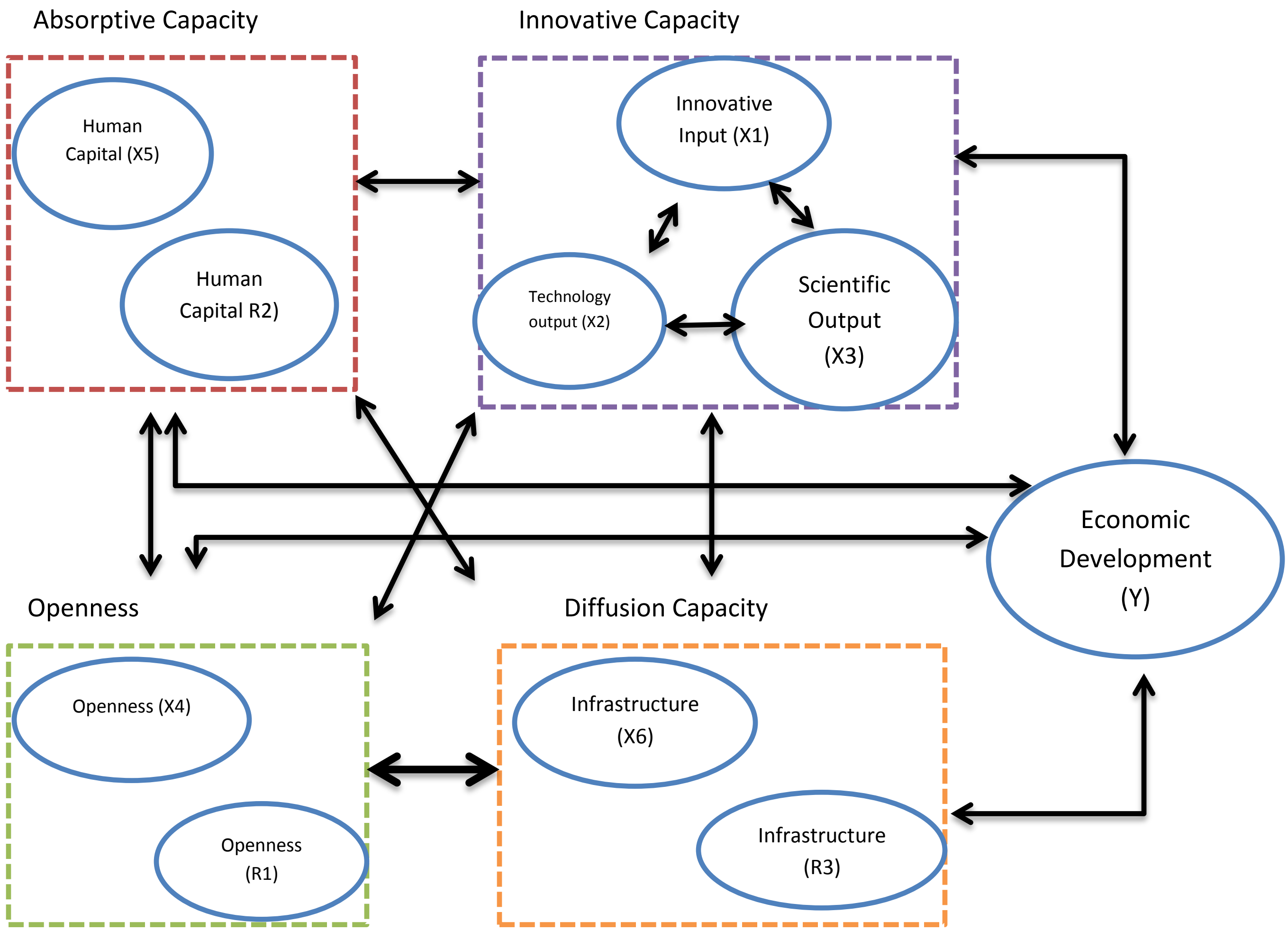


Figure 3.1: Model of Dynamics and the Interrelationships between Innovative Capacity, Absorptive Capacity, Openness and Diffusion

Note: Variables X_{1}, X_{2}, X_{3}, X_{4}, X_5 and X_6 are the variables used in the initial analysis for all models. However the variables R_1=Openness, R_2=Human Capital and R_3=Infrastructure were used to check the sensibility of Models B1 to C6, i.e. looking at the extent to which the results for the models would change if variables X_4, X_5, and X_6 were replaced with R_1, R_2, and R_3. The following are explanations of the models used in the empirical analysis.

The statistical technique utilized for this research is a series of multiple regression models. The main question of this research which is to assess the capabilities of the national innovation system of Ghana to create, diffuse and absorb innovation was addressed by assessing the impact of the variables for Innovative Capacity, Absorptive Capacity and Openness on economic development.

Therefore the main or overall model for this research is as follows;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2\ \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon_1$$

Understanding how the indicators in Figure 3.1 interact with each other was also tested separately. This was achieved by breaking down the main model above into several categories looking at the impacts of a smaller number of variables on economic development when assessed separately. The interrelationships among the variables in terms of the extent to which they predict each other were also analyzed. The initial model was therefore broken down into the following categories:

Models A: *Dynamics of Innovative Capacity*: Models A1 to A4 would be assessing the interrelationship between of the variables for innovative capacity and economic development of both countries. The intent of these models is to gain a deeper understanding of the similarities and differences in creative capacities of the national innovation system of Ghana and Malaysia. Therefore, the variables involved in these models are X_1= Innovative Inputs, X_2= Technology Outputs, X_3= Scientific Output and Y= Economic Development.

Models B: *Dynamics of Absorptive Capacity, Openness and Diffusion*: Models B1 to B4 are assessing the interrelationships between the variables describing the concepts of Absorptive Capacity, Openness and Diffusion and Economic Development. This is in order to gain deeper knowledge about the concepts. Therefore, the variables in these models are X_5=Human Capital, X_4=Openness, X_6=Infrastructure and Y= Economic Development

Model C: Model C1 to C6 assesses the interrelationship between Absorptive Capacity, Openness and Diffusion and Innovative capacity. Still, the intent is to gain further understandings on how these concepts are related to each other. The intent is to gain understanding into the internal workings or interactions within the NIS of both countries. All variables were used in these models except for Y=Economic Development. Table 3.2 shows the regression models from A1 to C6.

Table 3.2 Models

Model	Regression Model
A1	$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_1$
A2	$X1 = \beta_0 + \beta_1 Y + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_1$
A3	$X2 = \beta_0 + \beta_1 Y + \beta_2 X_1 + \beta_3 X_3 + \varepsilon_1$
A4	$X3 = \beta_0 + \beta_1 Y + \beta_2 X_1 + \beta_3 X_2 + \varepsilon_1$
B1	$Y = \beta_0 + \beta_1 X_4 + \beta_2 X_5 + \beta_3 X_6 + \varepsilon_1$
B2	$X4 = \beta_0 + \beta_1 Y + \beta_2 X_5 + \beta_3 X_6 + \varepsilon_1$
B3	$X5 = \beta_0 + \beta_1 Y + \beta_2 X_4 + \beta_3 X_6 + \varepsilon_1$
B4	$X6 = \beta_0 + \beta_1 Y + \beta_2 X_4 + \beta_3 X_5 + \varepsilon_1$
C1	$X1 = \beta_0 + \beta_1 X_4 + \beta_2 X_5 + \beta_3 X_6 + \varepsilon_1$
C2	$X2 = \beta_0 + \beta_1 X_4 + \beta_2 X_5 + \beta_3 X_6 + \varepsilon_1$
C3	$X3 = \beta_0 + \beta_1 X_4 + \beta_2 X_5 + \beta_3 X_6 + \varepsilon_1$
C4	$X4 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_1$
C5	$X5 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_1$
C6	$X6 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_1$

On each model the variable on the left of the equation is the dependent variable and those on the right side are considered the independent variables. Two types of test were conducted on each model. First to establish that the sample suggests a linear relation exist between the dependent and the independent variables of the model. This equals to the value of R^2 which would show how suitable it is to generalize the results to other samples. Having done that, it is required to test if indeed each independent variable plays a role in the model. This equates to test for each$i$, $H_0: \beta_i = 0 \; and \; H_1: \beta_i \neq 0$ .The results are only valid under some assumptions, so tests will be used to ensure that all assumptions hold.

CHAPTER 4: BACKGROUND OF THE STUDY: Similarities and Differences between Ghana and Malaysia

On Monday 4th April 2005, the British Broadcasting Corporation (BBC) world affairs correspondent Mark Doyle traveled to Ghana and Malaysia to make comparative analysis of these two Nations based on their development experience, which he documented in an article titled; “Two countries’ contrasting tales” (http://news.bbc.co.uk/2/hi/africa/4398537.stm). The story was on the premise that; despite the sharp differences in their economic status today, 50 years ago, Ghana and Malaysia were at roughly the same level of economic development (both were equally poor and dependent on the export of raw materials). This revelation encouraged the author, with vested interest in Ghana, to investigate the reasons behind this discrepancy and what could be done to redirect Ghana to more growth.

Figure 4.0 shows the GDP growth rate for both countries for the 50 years prior to 2012. With relatively high GDP growth rate in the 1950s and early 1960s, Ghana’s economy started experiencing a decline in GDP growth in 1964. It further recorded some negative growth in the 70s especially from 1975 to 1976. However, began to stabilize after 1984. Some analysts attributed these negative growths to the frequent coup d’états and frequent changes in government coupled with policy changes and reversals (Danquah, 2006). Specifically, the first negative growth of Ghana’s economy was recorded during the first coup d’etat in 1966 which led to the overthrow of Ghana’s first elected president, Dr. Nkrumah and his regime to a military regime which lasted for about seven years until another coup d’etat followed. The -14% recorded in 1975 was the lowest growth in Ghana’s history and was mainly as a result of the oil-supply shock, “as well as the policy reversal from a market-oriented to an inward-looking protectionist regime" (Aryeetey, Fosu & Bawumia, 2001). On the other hand, the year 1997 was a very drastic year for Malaysia due to the fall in foreign direct investment as capital flew out of the country. This was largely due to the Asian financial crisis as Malaysia's GDP growth declined by 7.5 % in the year 1998 However Malaysia managed to recover and grew by 5.6% in 1999 (OECD, 2013).

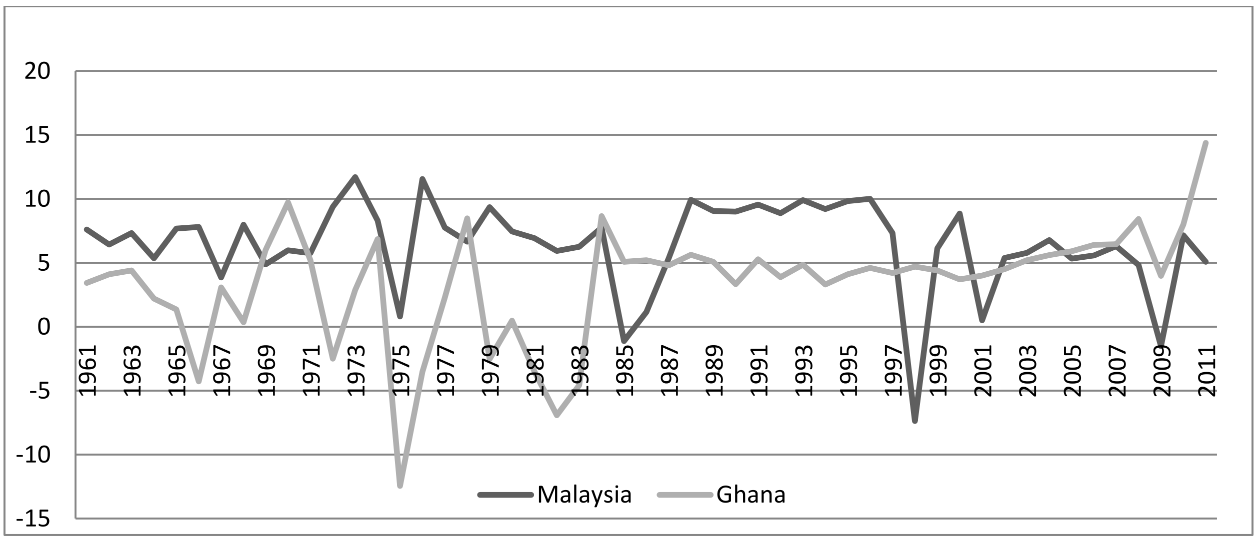


Fig 4.0 GDP Growth Rate (%) Ghana vs Malaysia (1961-2011)
Source: World Development Indicators (WDI)

Malaysia is now far ahead of Ghana economically with GDP per capita (constant 2000 US$) of $5345 in 2011 whiles that of Ghana was only $403 in the same year (world development indicators (WDI), World Bank). Ghana is still a major exporter of raw materials like cocoa and gold whiles Malaysia have advanced to being an exporter of heavy industrial products like cars and could boast of Infrastructural developments that compares to those in developed cities such as New York and London. The fact is that this year (2012), Malaysia entered the top 10 most competitive countries in the Asian Pacific region ranking 21st in the world according to the 2011-2012 World Competitiveness Yearbook (WCY). Table 4.1 and 4.2 show the rank and competitiveness of Malaysia in the Asia Pacific region and in the world respectively.

Table 4.1 The Global Competiveness Index 2011-2012 (Top 10 out of 22 Asia-Pacific Countries)

Country	Rank (2011-2012)	Score
Singapore	1	5.63
Japan	2	5.40
Hong Kong SAR	3	5.36
Taiwan, China	4	5.26
Australia	5	5.11
Malaysia	**6**	**5.08**
Korea, Rep	7	5.02
New Zealand	8	4.93
China	9	4.90
Brunei Darussalam	10	4.78

Source: World competitiveness year book (2011-2012)

Table 4.2 Global competitiveness 2011-2012 rankings (Top 25 out of 142 Countries)

Country	Rank	Score
Switzerland	1	5.74
Singapore	2	5.63
Sweden	3	5.61
Finland	4	4.47
United States	5	5.43
Germany	6	5.41
Netherlands	7	5.41
Denmark	8	5.40
Japan	9	5.40
United Kingdom	10	5.39
Hong Kong SAR	11	5.36
Canada	12	5.33
Taiwan, China	13	5.26
Qatar	14	5.24
Belgium	15	5.20
Norway	16	5.18
Saudi Arabia	17	5.17
France	18	5.14
Austria	19	5.14
Australia	20	5.11
Malaysia	**21**	**5.08**
Israel	22	5.07
Luxembourg	23	5.03
Korea, Rep.	24	5.02
New Zealand	25	4.93

Source: World competitiveness year book (2011-2012)

Ghana and Malaysia shared many similarities at the time of independence especially in terms of their geographic settings, Socio- cultural and above all, both started from very humble beginnings. According to Dadzie (2005), although these similarities may not be clear-cut, they present a strong debate for the comparativeness of these nations that have demonstrated diverging growth in terms of Innovations and technological developments. Both Ghana and Malaysia were colonized by the British in the 19th and 18th centuries respectively and they both gained independence in the year 1957, precisely 6th March and 31st August respectively. At the time of independence, the economies of both countries were based on agricultural goods and other mineral resources. Ghana was and still is into the exportation of Cocoa and gold as major supporter of its economy, whiles Malaysia exported mainly rubber and Tin with almost all the exports of both countries heading to Britain. Therefore at the time of Independence, the economies of Ghana and Malaysia were dominantly agricultural based (Asare & Wong, 1999).

Figure 4.1 shows the agricultural share of GDP of both Ghana and Malaysia Since their independence from the British and as clearly demonstrated, both Ghana and Malaysia were highly dependent on the agricultural sector to stimulate growth of their economies four years after independence. But as years have gone by, Malaysia’s economy has shifted largely from its Agricultural base by the decreasing share of agriculture in its GDP. On the other hand Ghana’s economy is still largely dependent on the agricultural sector showing a rather lager share of agriculture in its GDP.

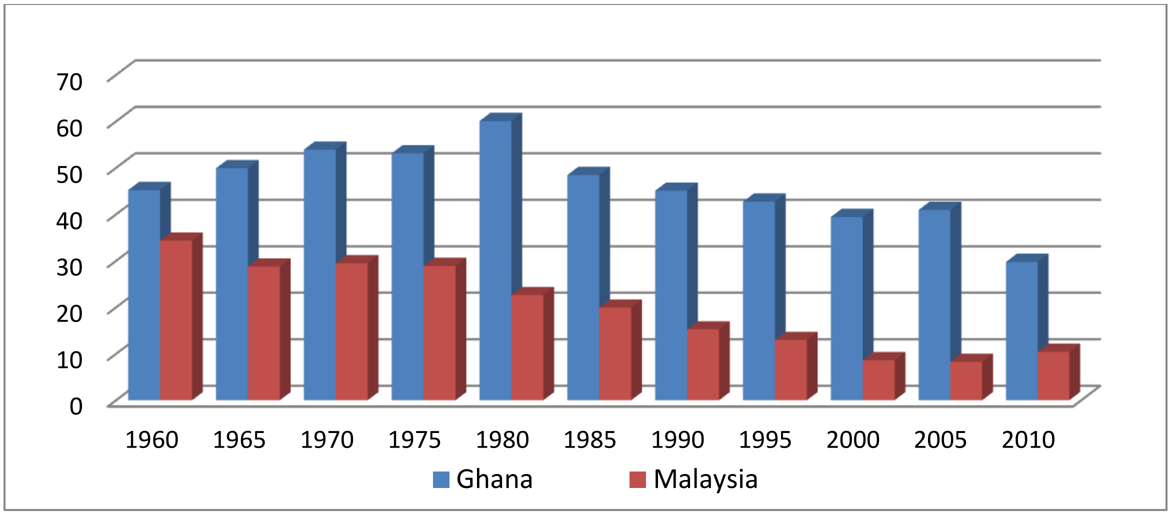


Figure 4.1 Agricultural Sector Share of GDP, Ghana vs. Malaysia, 1961-2009
Source: World Development Indicators (WDI)

In terms of socio-cultural similarities, Ghana and Malaysia have roughly similar characteristics of ethnic, linguistic and religious diversity. Specifically there are over 20 ethnic groups in both countries. The Akan (45.3%), Mole-Dagbon (15.2%), Ewe (11.7%) and Ga Adangme (7.3%) form the majority ethnic groups in Ghana whiles the Melayu or Malay (50.4%), Chinese(23.7%), Indians (mostly Tamil; 7.1%), Indigenous (11%) are the majority in Malaysia (CIA world Fact book 2012). Figure 4.2 and 4.3 summarizes the ethnic distribution of Malaysia and Ghana respectively.

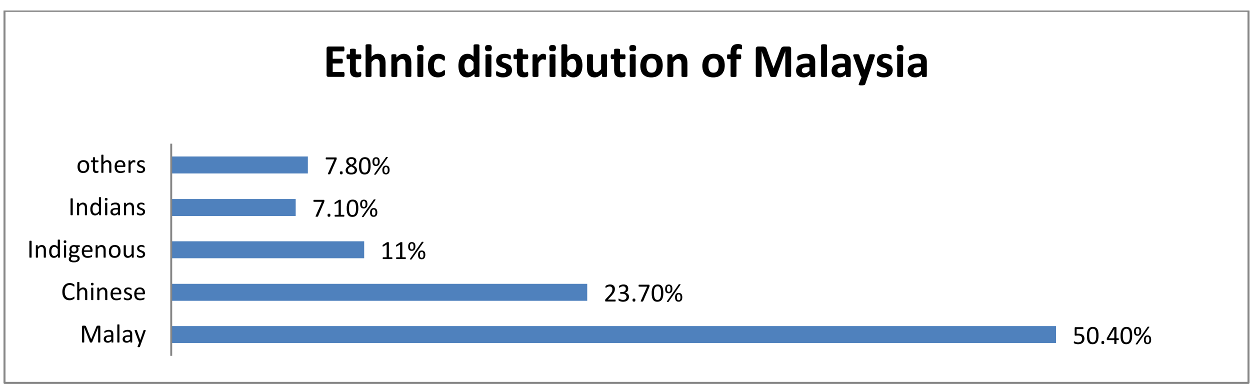


Figure 4.2 Ethnic distribution of Malaysia

Data source: CIA world Fact book 2012

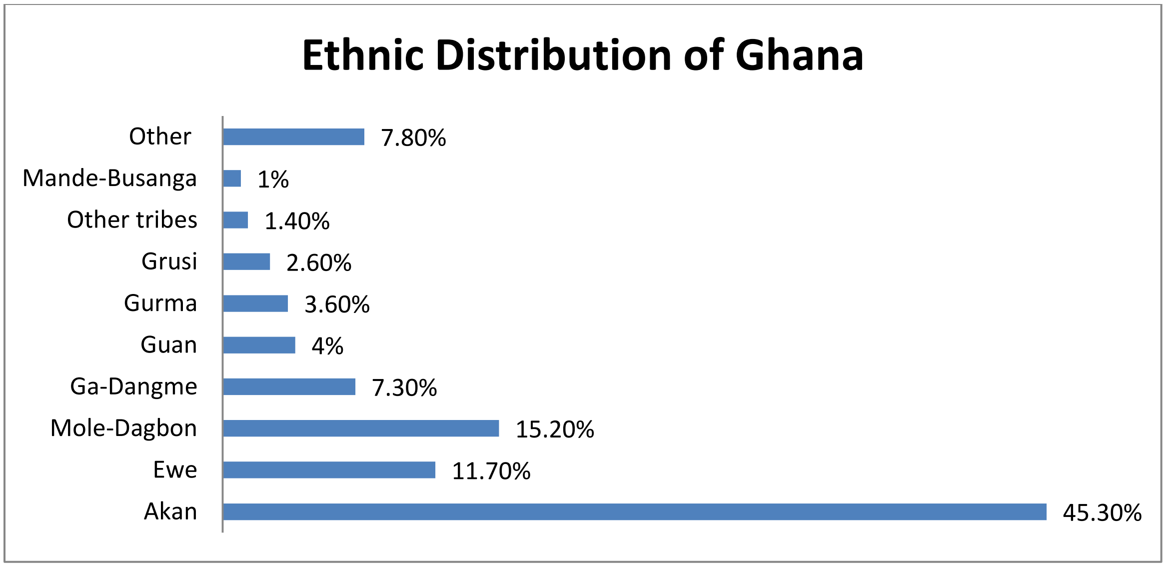


Fig 4.3 Ethnic Distribution of Ghana (Based on 2000 population Census)

Source: CIA world fact book.

Each citizen in both countries can speak more than one language; with English being the official language in both countries. Ghana and Malaysia are both located near the equator in terms of geographic positioning and also share tropical climate in terms of whether (Asare & Wang, 1999).

The estimation of the populations for Ghana and Malaysia for the year 2011 according to the World Bank was 24,965,816 and 28,859,538 respectively and the population growth rate according to the United Nations Population Division for the years 2005-2010 were 2.394% and 1.690 % for Ghana and Malaysia respectively. Figure 4.4 shows the total population level and growth rate for Ghana and Malaysia from 1995 to 2010.

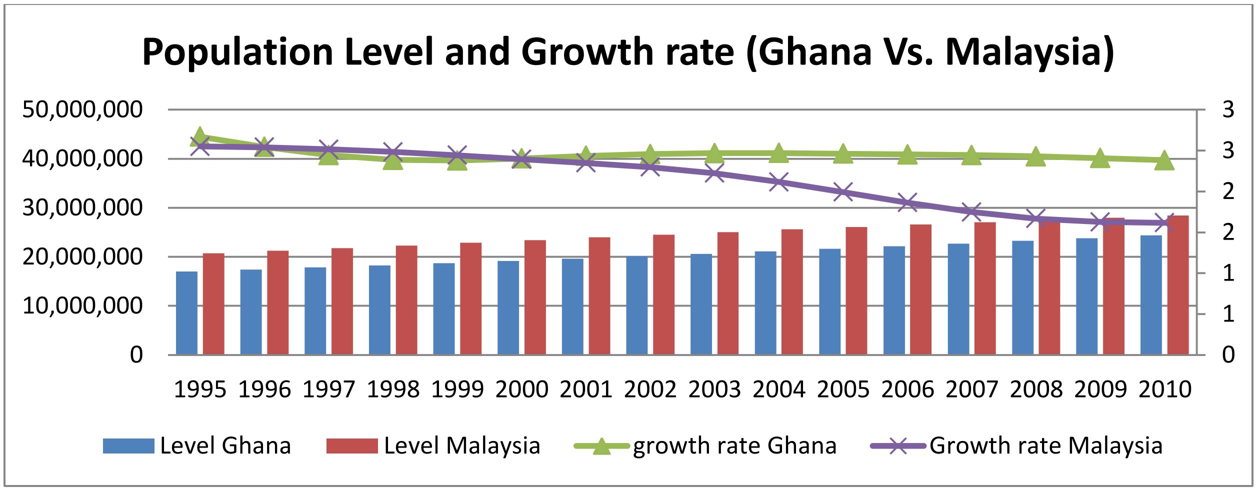


Figure 4.4 Total Population level and Growth Rate for Ghana and Malaysia (1995-2010)

Source: World Development Indicators (WDI)

Figure 4.4 indicates no much difference in the population growth rate and total population levels before the year 2000. A complete picture of the population growth rate of both countries is showed by figure 4.5 in the form average population growth rate taken within 5 years period interval stating from 1960 to 2010.

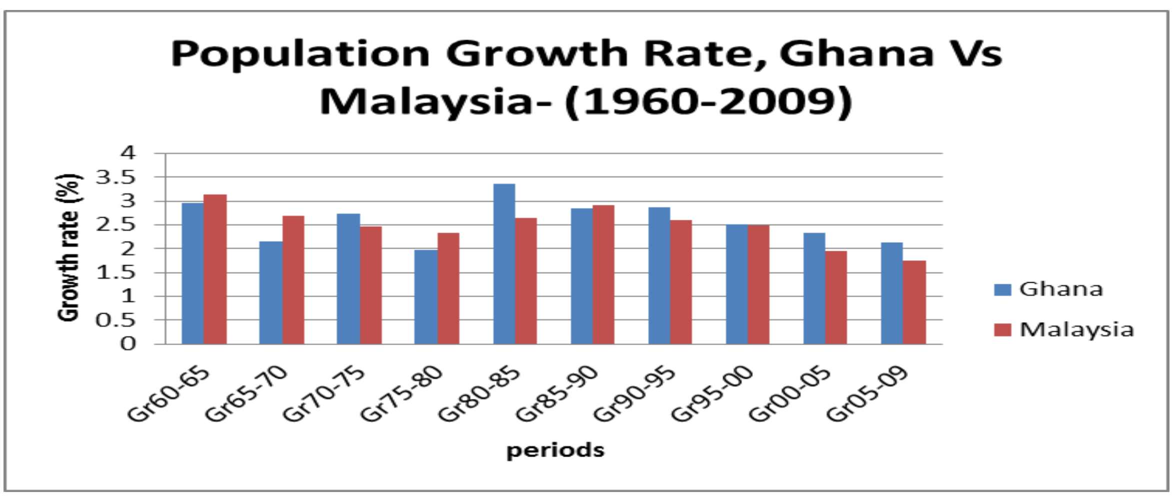


Figure 4.5: Average Population Growth Rate, Ghana vs. Malaysia, 1960-2010

Source: World Development Indicators (WDI)

About 30% of the population of Ghana and Malaysia were living in the urban areas at the time of independence and this figure has increased to over 50% for both countries by the year 2007, but Malaysia is in the lead in terms of real numbers. Figures 4.6 and 4.7 illustrate the similarities in the trends of rural and urban populations for Ghana and Malaysia.

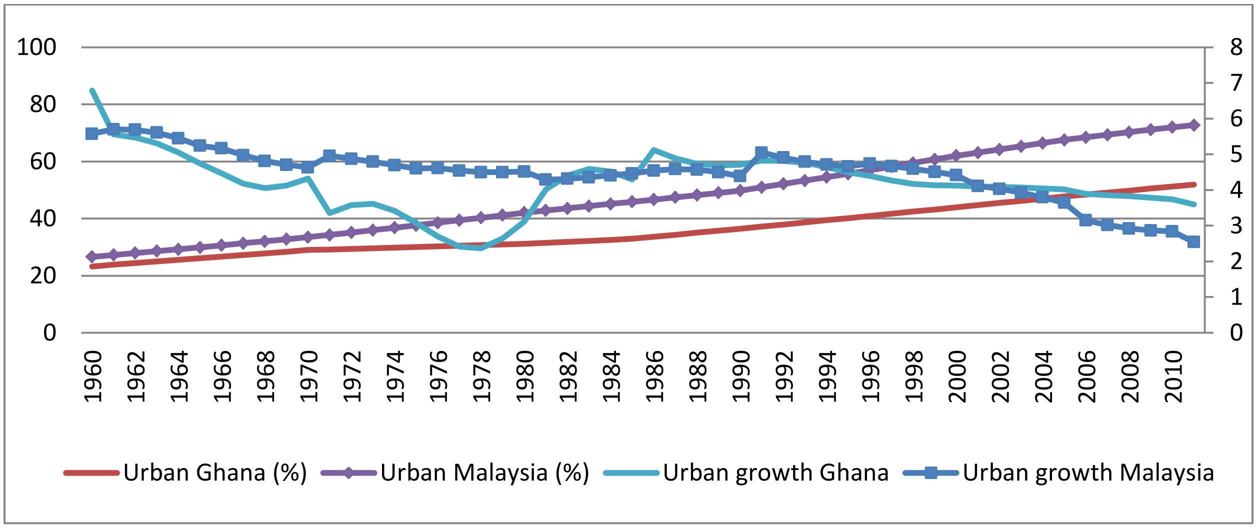


Fig 4.6: Trends In Urban Populations levels and growth rate, Ghana vs. Malaysia (1960-2010)

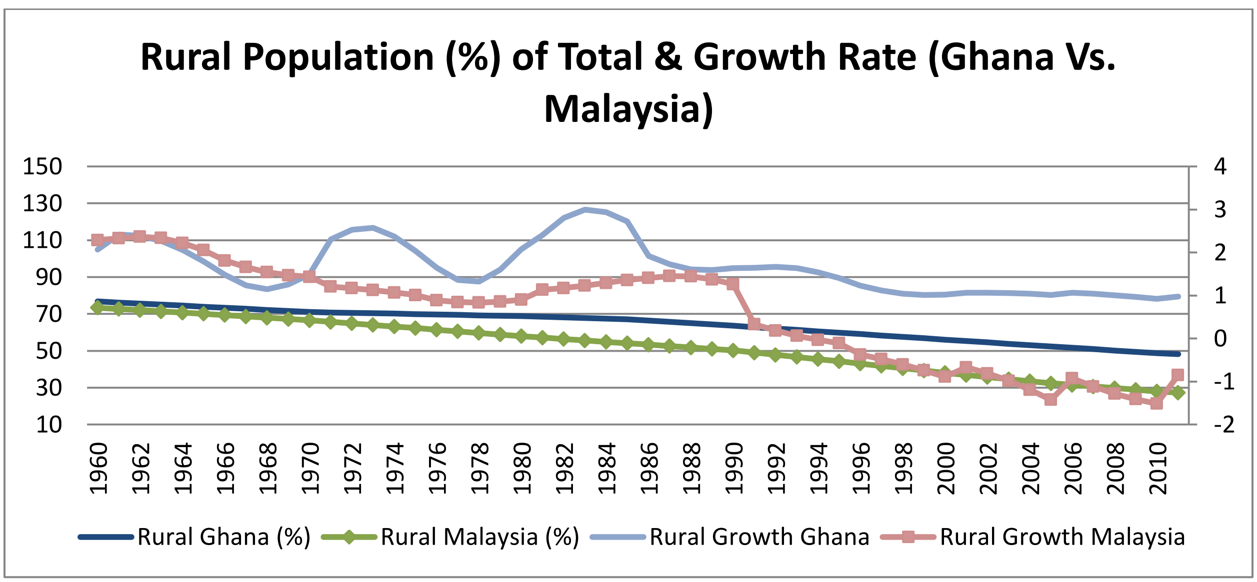


Figure 4.7 Trends in Rural Population Levels and Growth rate Ghana vs Malaysia (1960-2010)

Source: world Development Indicators (WDI)

Many more similarities in terms of socio-cultural similarities could be cited but are beyond the purpose of this paper. However the reality is that, there is a huge gap between Ghana and Malaysia in terms technological developments and economic growth even though both countries were roughly at the same level. The Manufacturing sector of Malaysia has grown tremendously since its independence whiles that of Ghana kept declining. Manufacturing share of GDP for Ghana was about 12% in the mid-1980 but somehow started declining after this period. This was as a result of the failed state industrialization pursued in the 1960's and 1970's via the so called "Kwame Nkrumah seven year plan" (Diao, 2010). Figure 4.8 shows side by side the manufacturing share of GDP (%) for both Ghana and Malaysia from 1960 to 2010.

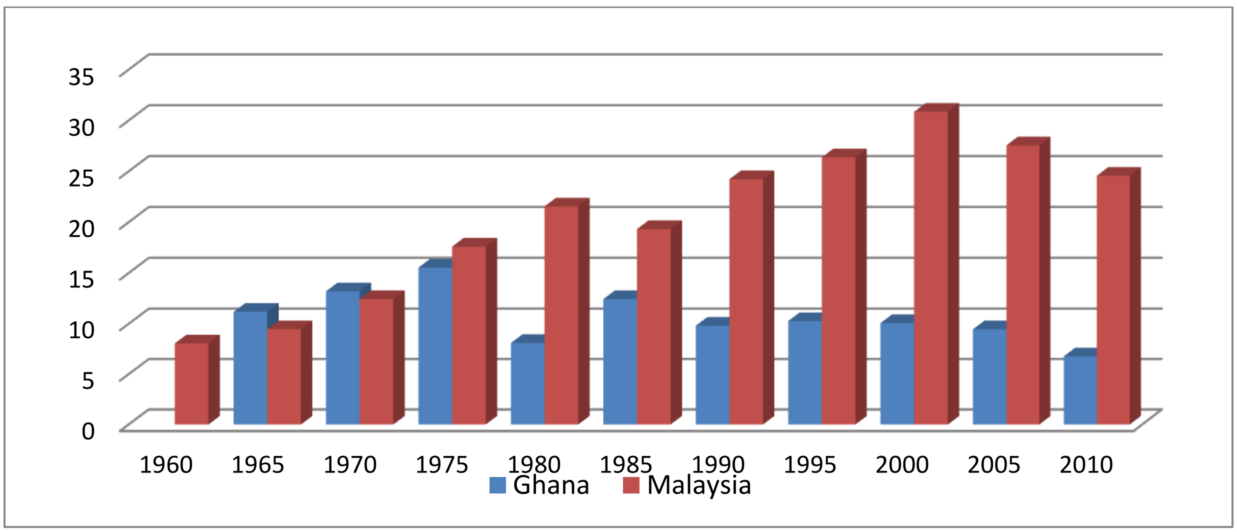


Fig 4.8: Manufacturing Sector Share of GDP (%) Ghana vs. Malaysia (1961-2009)

Source: World Development Indicators, (WDI)

In terms of exports, Ghana still relies heavily on Agricultural exports, mainly cocoa to support its GDP over the past years whiles Malaysia's exports have shifted from Agricultural products to manufactured and high-tech goods. This are shown in figure 4.9 and 4.10 in terms of agricultural exports share of GDP and manufacturing exports share of GDP for Ghana and Malaysia respectively.

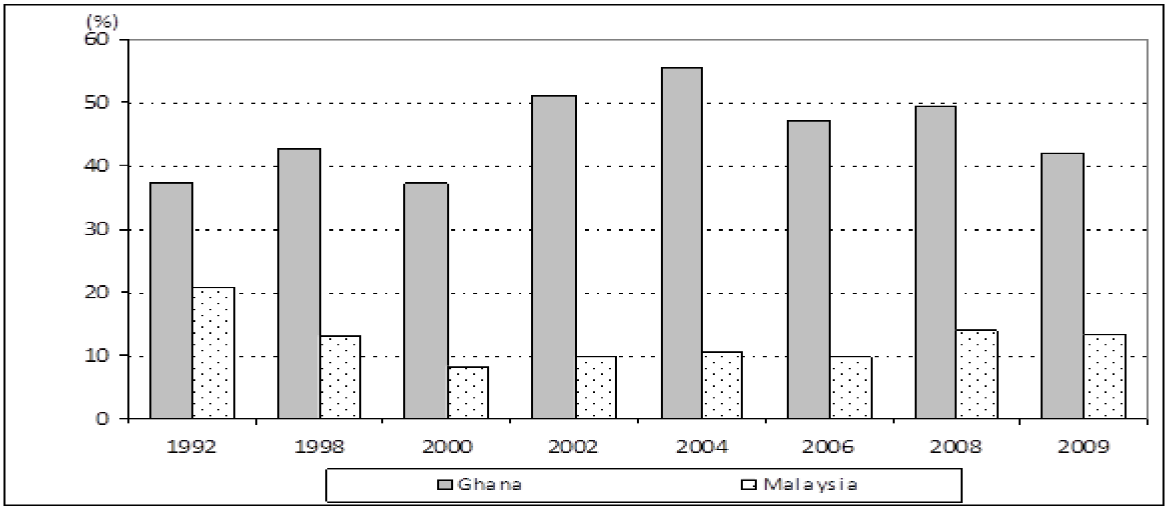


Fig 4.9: Agricultural Exports Share of GPD, Ghana vs. Malaysia, (1990-2009)

Source: World Development Indicators, WDI, Retrieved from Yusof (2010)

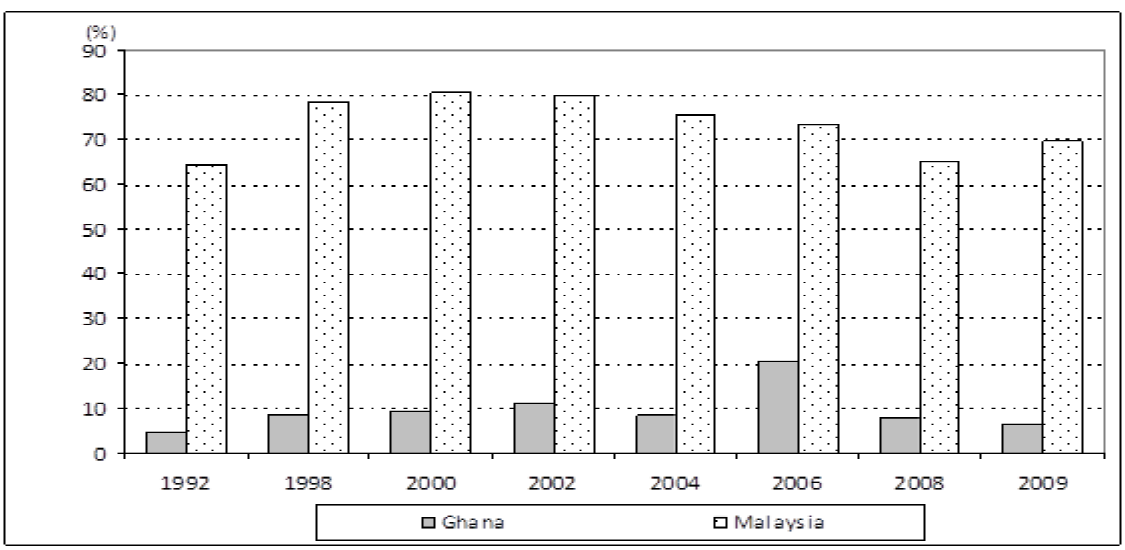


Fig 4.10: Manufacturing Exports Share of GDP, Ghana vs. Malaysia (1990-2009)

Source: World Development Indicators, WDI, Retrieved from Yusof, (2010) All these evidence show that even though Ghana and Malaysia started off at the same level, Malaysia has been able to attain higher economic heights and technological developments. There have been several independent and somehow unrelated economic, political and social explanations for these developmental discrepancies between Ghana and Malaysia in the literature. However none of them have put the issues into a quantitative framework that could guide some conclusive points to be utilized for the benefit of both countries. Based on the findings from the literature search in this study, we adopt the perspective of National Innovation Systems by assessing its impact on innovation and therefore economic growth. Hopefully out of that analysis would enable the researcher to drawing conclusive points that could be utilized by Ghana in improving its national innovation system.

CHAPTER 5: DATA DEVELOPMENTS

5.0 Introduction

This section discusses the data on the variables for Innovative Capacity, Absorptive Capacities, Openness, Diffusion Capacity and Economic Development of Ghana and Malaysia that was used in the analysis. Issues related screening of data and tests for some assumptions for the models are presented in this section. Also, graphs of the raw data for the two countries are shown in this chapter in order to show the true state of divergence between the two countries.

5.1 Data Screening and Test for Assumptions

After screening the annual time series data for the empirical analysis, it was discovered that some of the data for the variables, specifically (tertiary enrollment ratio, secondary enrollment ratio, scientific and technical articles counts and number of telephone users) had very few missing values for both Ghana and Malaysia. Therefore they were replaced using interpolations via this equation; $X_{t=0} = (X_{t-1} + X_{t+1})/2$ where X is a data point. The variable Agricultural R&D expenditure for Ghana was missing only two data points for the years 2009 and 2010. On the Other hand, R&D expenditure for Malaysia was also missing three data points for the years 1990 and 1991 and 2010. The study therefore used linear regression as the imputation method for these variables. Finally the Variable Patent application count has too much missing data for Ghana. Approximately 81% of the data for this variable for Ghana was not available. The researcher therefore has no other choice than to delete this variable from the analysis. Therefore Models A3 and C2 in Chapter 3 were not considered for Ghana and the variable X2 (Patent Applications) was also not considered for Ghana. The remaining variables had no issues of missing data.

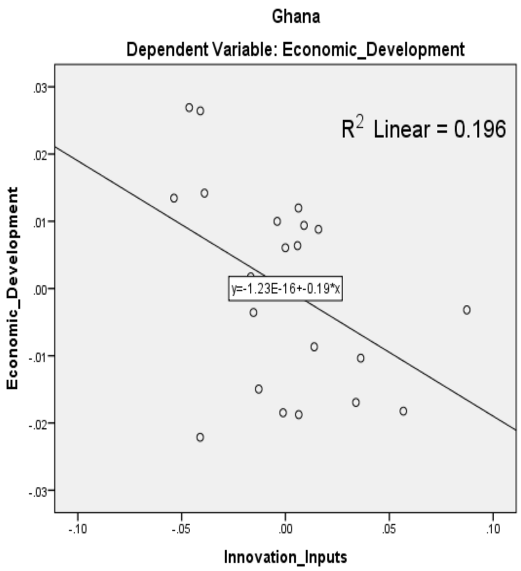
In order to draw conclusions from the models utilized in this research, the necessary assumptions underlying multiple linear regressions needs to be addressed. The simplest of these assumptions relates to the variable types used in the analysis. According to Field, (2005) the “all predictor variables must be quantitative or categorical, and the outcome variables must be quantitative, continuous and unbounded”. Furthermore all these variables must not have a negative variance. Fortunately the data for the variables used in this study already meets the above assumptions. i.e. they are all quantitative with positive variations. Please see the descriptive statistics in Tables 5.5.3 and 5.5.4 for Ghana and Malaysia.

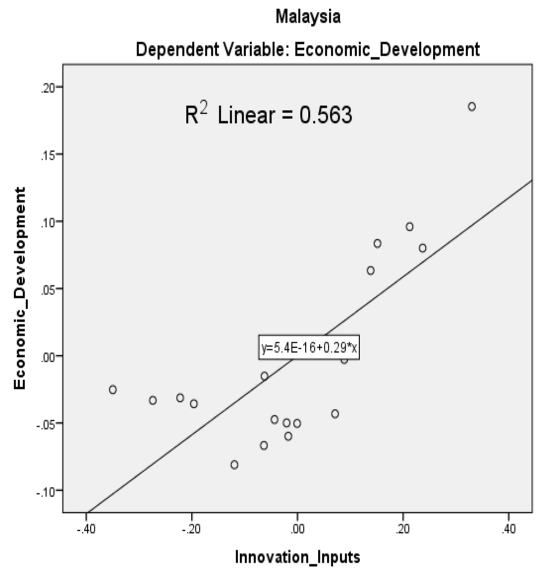
The distribution of the data for each variable is also another fundamental assumption, referred to as normality of data. According to Field, (2005) the reason for testing for hypotheses is often based on having data which is normally distributed. This study attempts to address this assumption by investigating for any possible distributional problems in the data through a normality test examining the Skewness and Kurtosis of the data for both Ghana and Malaysia. The skewness and kurtosis can be used to diagnose to some extent the deviation of the data from normality (Field, 2005). Table 5.1.1 shows the skewness and the kurtosis of the data for each variable for Ghana and Malaysia respectively. According to Hair et al., (2010), Skewness and Kurtoses are given values of zero and values that are far from this figure shows features of departure from normality. Almost all the values for skewness and kurtoses in Table 5.1.1 are far from zero, thus indicating that the data for the variables are not normally distributed. Therefore to correct these distribution discrepancies, all the variables were log transformed before they were used in the analysis.

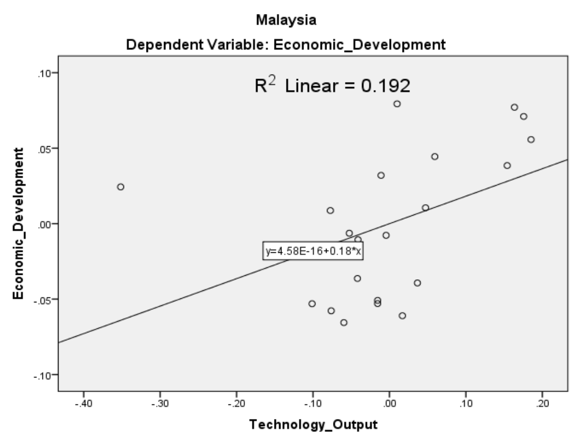
Table 5.1.1 Skewness and Kurtosis of Data for Variables

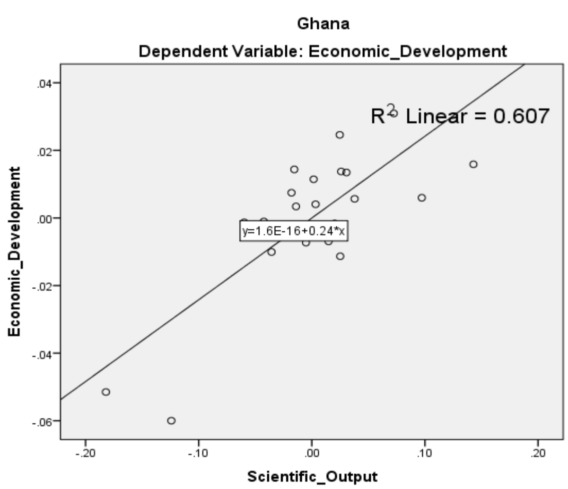
	Ghana		Malaysia	
Variables	**Skewness**	**Kurtosis**	**Skewness**	**Kurtosis**
Total (agricultural) R&D expenditure (%) of GDP	1.320	1.920	0.343	-0.922
Total number of patent applications			-0.670	-1.117
Number of scientific and technical articles	-0.064	-0.317	0.660	-0.113
Trade % GDP	0.207	0.795	-0.309	-0.991
Foreign direct investment (net inflows (%) GDP)	1.414	1.056	0.143	0.398
Tertiary enrollment percentage of gross	1.433	0.654	0.016	-1.344
Secondary enrollment percentage of gross	0.786	-0.615	-0.298	-1.688
Number of kilowatt of electricity consumed	-0.426	-0.755	-0.039	-0.338
Number of telephone users per 100 people	0.105	-1.626	-1.027	0.240
GDP per capita (Constant US$)	0.821	-0.349	-0.166	-0.751

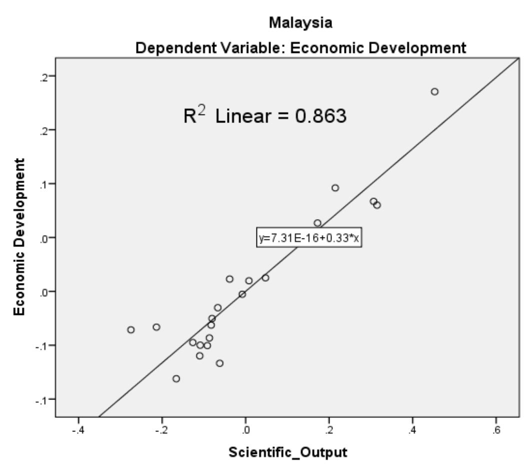
Another implicit assumption of multiple linear regressions is the assumption that the relationship between the outcome variable and the predictor variables is linear. Partial regression plots were therefore made between the outcome variable and all predictor variables using the log transformed data to identify any nonlinear patterns in the data. This was done to also verify any improvements to the models as a result of the log transformations made on the data. The plots in Figure 5.1.1 below are the partial regression plots for the main model, where the outcome variable was Economic Development. The plots show that no evidence of nonlinear trends, therefore the assumption of linearity is not broken since there seems to be some form of linearity between the outcome variable and all the predictor variables. The strength of these linear relationships is shown by the R^2 values on the figures. Furthermore, examination of the plots for Ghana and Malaysia indicated no serious problems with outliers in the data sets for the variables. To be sure, a test for outliers was also done looking at whether any possibility of outliers, exerts any undue influence over the parameters of the model via the Cook's distance. The value for the Cook's distance for both models for Ghana and Malaysia were all less than 1, therefore there was no cause for concern.


Ghana
Dependent Variable: Economic_Development
R2 Linear = 0.196
y=-1.23E-16+-0.19*x
Economic_Development
Innovation_Inputs


Malaysia
Dependent Variable: Economic_Development
R2 Linear = 0.563
y=5.4E-16+0.29*x
Economic_Development
Innovation_Inputs


Malaysia
Dependent Variable: Economic_Development
R2 Linear = 0.192
y=4.58E-16+0.18*x
Economic_Development
Technology_Output


Ghana
Dependent Variable: Economic_Development
R2 Linear = 0.607
y=1.6E-16+0.24*x
Economic_Development
Scientific_Output


Malaysia
Dependent Variable: Economic Development
R2 Linear = 0.863
y=7.31E-16+0.33*x
Economic Development
Scientific_Output

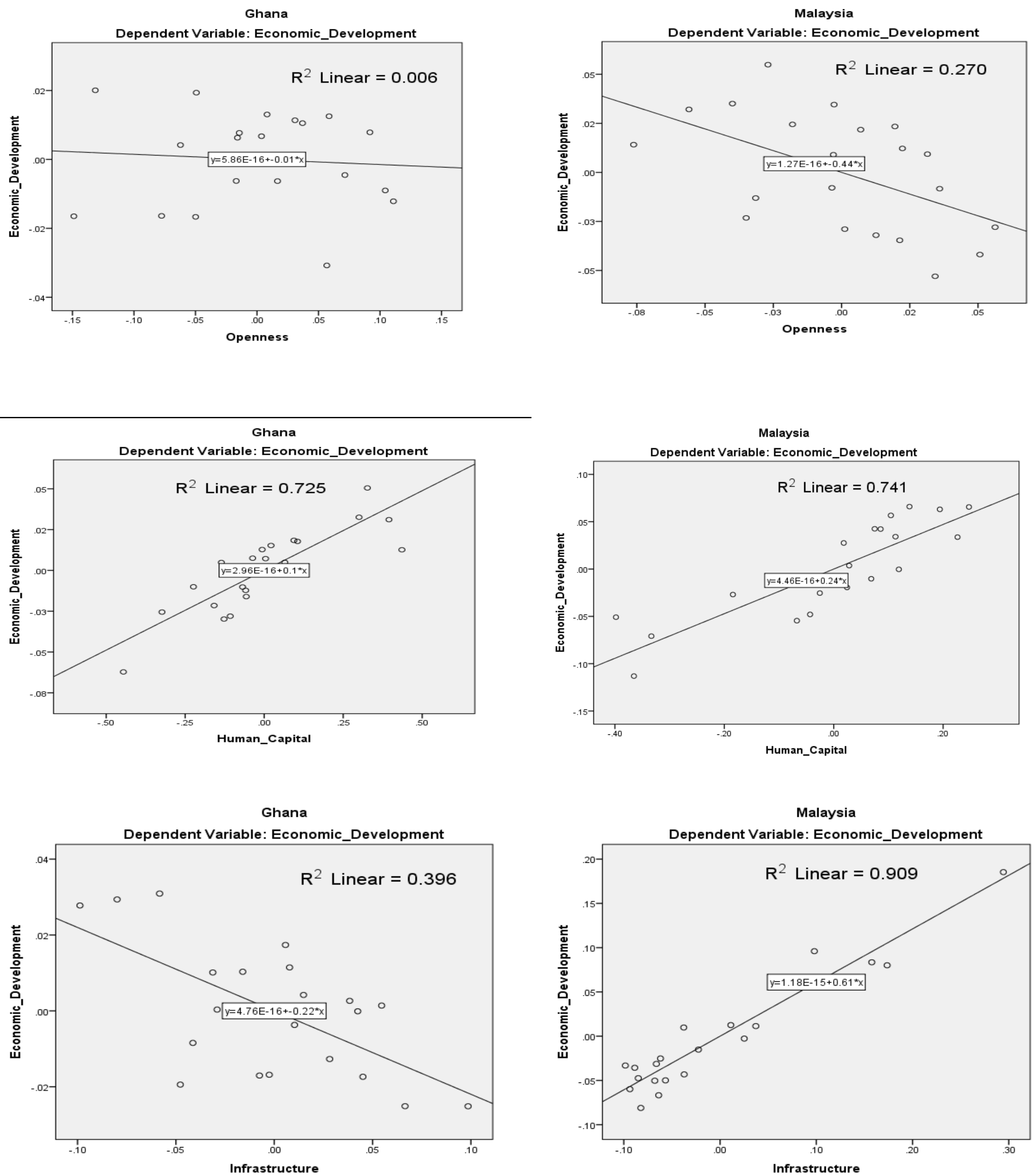


Figure 5.1.1 Partial Regression plots (Test for linearity)

The final assumption discussed in this section is the assumption of Homoscedasticity. This means that the variance of the predictor variables at every level should be the same (Field, 2005). To test for homoscedasticity, the standardized residuals (ZRESID) or errors are plotted against the standardized predicted (ZPRED) values of the dependent variable based on the main model in capter 3. Figure 5.1.2 (A) shows the relationship between the standardized residuals and the standardized residual values for data for Ghana. The figure shows that the assumption for homoscedasticity has not been broken since the plot doesn't have a diamond shape pattern.

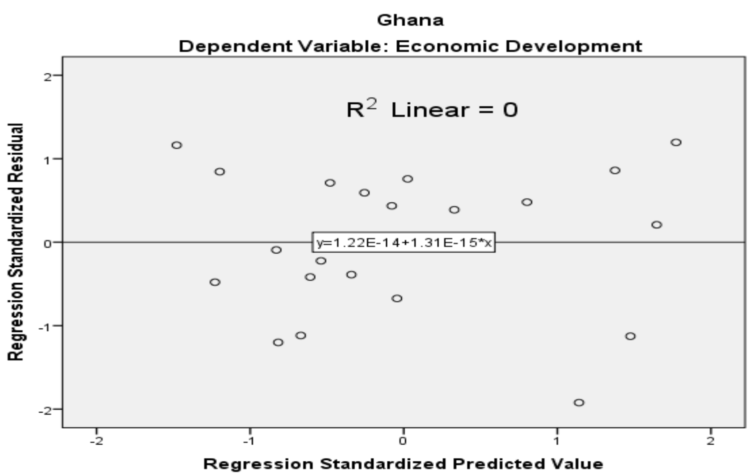


Figure 5.1.2 (A) Test for Homoscedasticity on Ghana Data

The assumption for the data for Malaysia was not broken either, as shown in Figure 5.1.2 (B). There are three plots because the main model for Malaysia was broken down into three models in order to remedy issues of multicollinearity in the data for Malaysia. The assumption of no perfect correlation has been discussed in details in the results chapter (Chapter 6).

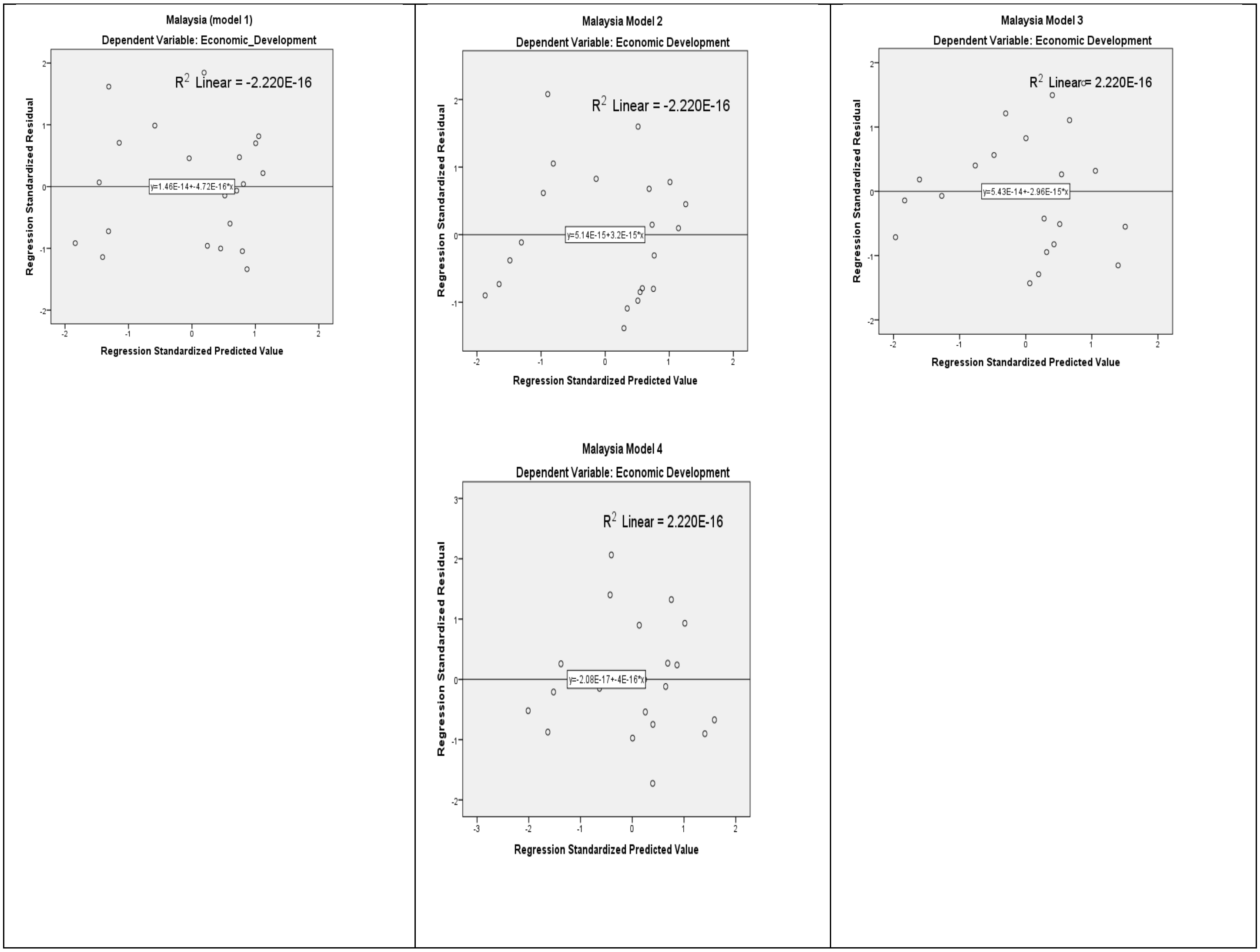


Figure 5.1.2 (B) Test for Homoscedasticity on Malaysia Data

The test for the assumption for no perfect correlation (no multicollinearity) would be reported in the next chapter via the correlation matrixes of the predictor variables for the two countries. According to Field (2005), multicollinearity exists when there is a near perfect correlation between two or more predictor variables in a model, specifically correlation coefficient above 0.80. A second measure of multicollinearity; the variance inflation factor (VIF) which is more statistical would also be used. Therefore instances of lower degrees of multicollinearity are indicated by lower VIF (Less than 10) and tolerance statistics well above 0.2 (Field, 2005; Hair et al., 2010). These guidelines were met for all the models; therefore the assumption ‘no multicollinearity’ was also not broken. Please see appendix C and D for the VIF and tolerance statistics for each model.

5.2 Innovation Inputs & Technological Outputs Ghana vs. Malaysia

Agriculture still remains as the dominant contributing factor to Ghana’s economy, contributing over 30% of total GDP of Ghana. However the transformations experienced by many Asian countries are often as a result of a declining share of agriculture in their GDP’s and the increasing share of manufacturing their transformation process. Figure 5.2.1 shows the Total R&D expenditure (% of GDP) and Total agriculture R&D expenditure (% of GDP) for Malaysia and Ghana respectively. Ghana’s agricultural R&D expenditure was almost 0.6%, in the early years of the 1990’s but experienced a sharp decline after the 1990’s to about 0.4% in 1991 and has remained around that figure until it started rising again in the year 2005. Reach a peak of 0.58% in 2008 but then again declined afterwards. On the other hand, Malaysia’s Total R&D expenditure has been risen from about 0.3% in the 1990’s to about 1% in 2009.

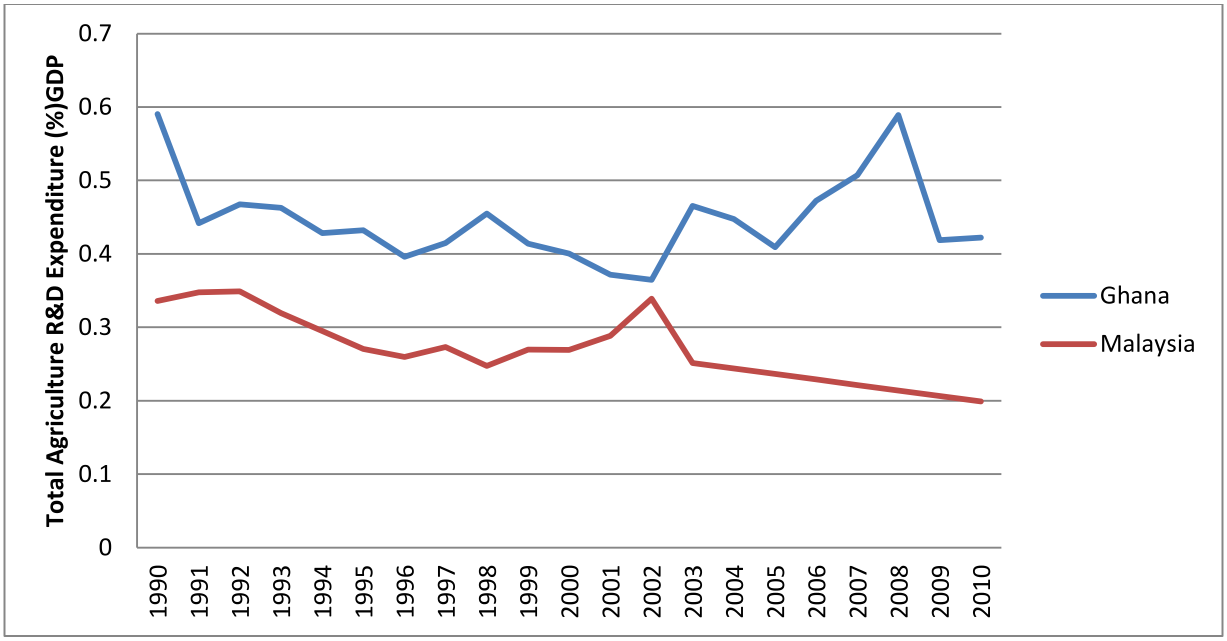


Figure 5.2.1 Innovative Inputs Ghana vs. Malaysia (1990-2010)

Data source: ASTI & MASTIC

Figure 5.2.2 also shows the total number of patent applications, both direct application and applications via Patent Cooperation Treaty (PCT) national phase entries, total count by filing office for Malaysia. Data on total number of patent application for Ghana only exists for the periods of 1980's to the mid 1990's. And because this study is sampling annual data from 1990 to 2010, the study therefore dropped the variable Technology Output for Ghana as a result of lack of Data. On the other hand that of Malaysia has risen from 2,305 in 1990 to over 6000 in 2010. The situation of Ghana may be partly because the patent law in Ghana only became operational in the year 1992 and moreover until 2001, Ghana had no explicit National Science Policy, therefore the patent regime of Ghana is now evolving and likely to be strengthened in years to come (Yawson, 2002).

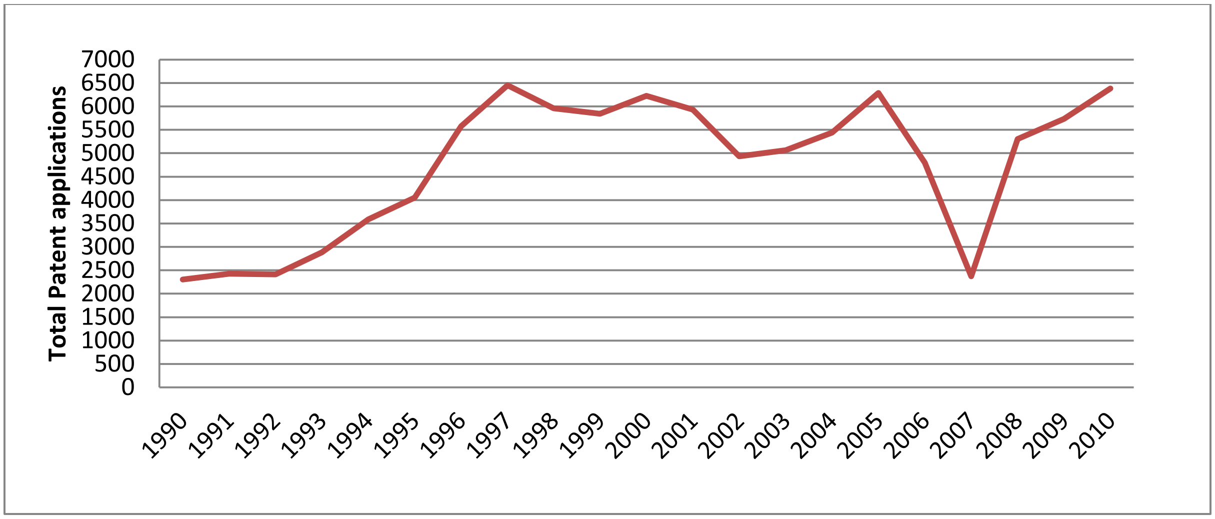


Figure 5.2.2 Technological Output of Malaysia

Data source: WIPO

5.3 Scientific outputs & Human Capital, Ghana vs. Malaysia

Figure 5.3.1 shows the number of scientific and technical articles produced in Ghana and Malaysia for the periods 1990 to 2010. Scientific outputs of Ghana for the past two decades have averaged less than 100 per year. On the other hand scientific output for Malaysia in the year 1990 alone stands at 233 articles, even higher than the current figure for Ghana. Today scientific outputs of Malaysia are about 15 times that of Ghana. On Tuesday 15th November 2011, “the world bank commended the government of Ghana for expanding access to higher education which has served as an inter-link with the economic growth of the country” (Ghana News Agency (GNA), 2011). This was in light of Ghana spending 30% of its budget on education that resulted in increasing the number of public and private tertiary institutions from the year 2004 to 2011.

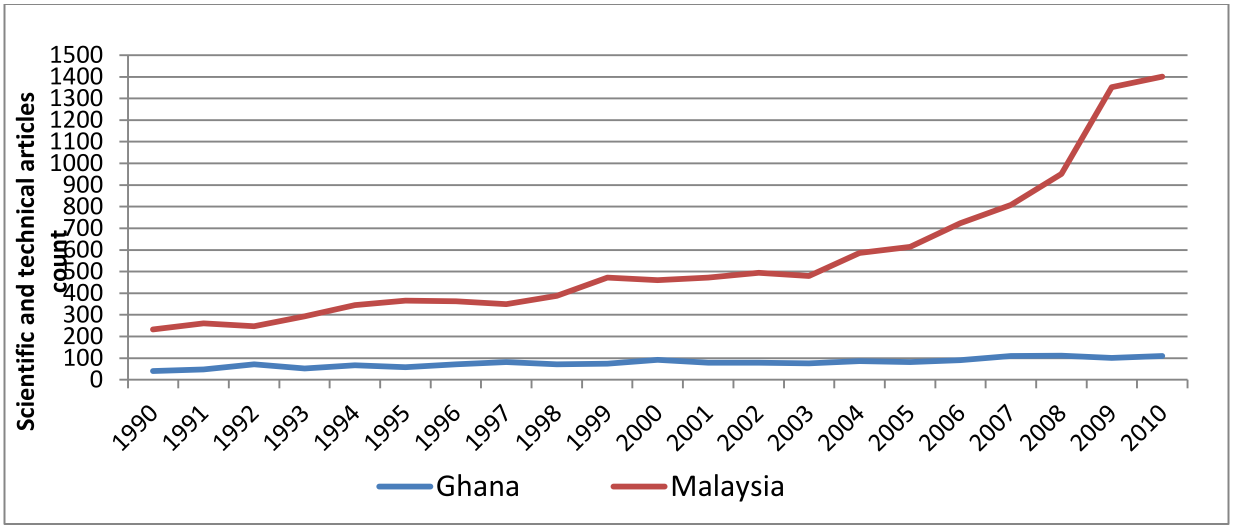


Figure 5.3.1 scientific output Ghana vs. Malaysia

Source: WDI

Figure 5.3.2 also indicates the trends for tertiary enrollment Ghana and Malaysia. However according to UNESCO (2007), tertiary education participation in Ghana is lower compared with the rest of the world, with a gross enrollment ratio of 5% as against global average of 24%. On the other hand that of Malaysia in 2007 was 33%, higher than the global average (see trading economics.com/malaysia/school-enrollment-tertiary-percent-gross-wb-data.html). One could immediately notice the results of the efforts made by the government of Ghana in the year 2004 and beyond via the rising number of enrollment from this period. However there is more room for improvement for Ghana, if it is to attain middle income status like Malaysia.

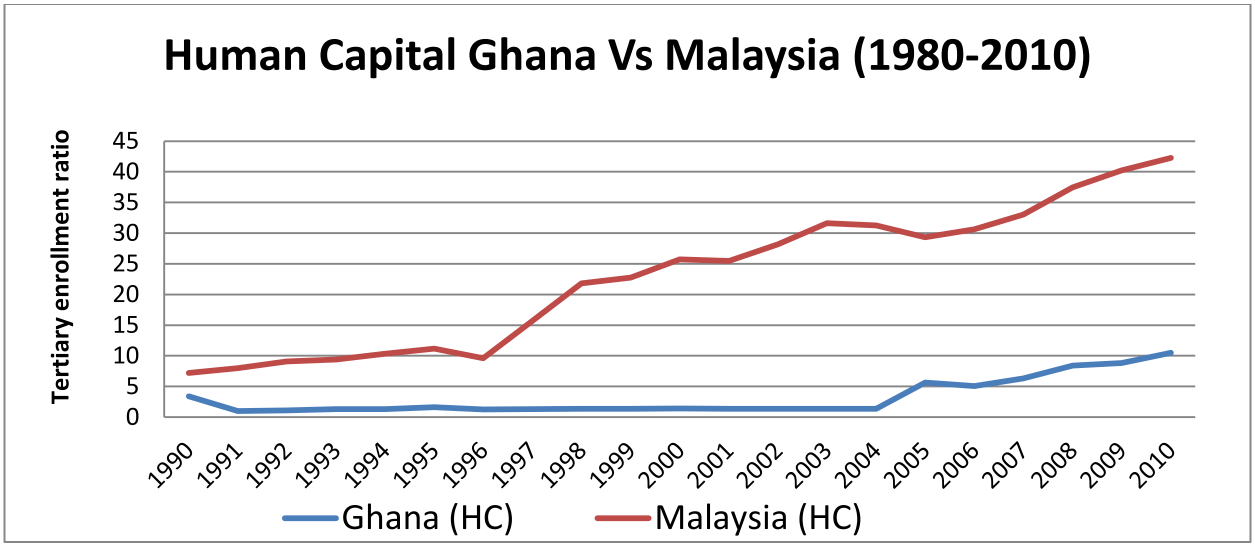


Figure 5.3.2 Human Capital Ghana vs. Malaysia

Source: WDI

Looking at Figures 5.3.1 and 5.3.2 above, one can notice a relationship in the trends of human capital and scientific output for both Ghana and Malaysia. Thus one could infer that as human capital increases for both Ghana and Malaysia, scientific outputs also increases. This hypothesis would be tested in the analysis in the next chapter.

5.4 Openness, Infrastructure & Economic Development, Ghana vs. Malaysia

Trade (%) of GDP was calculated as; ((total exports+ total imports)/GDP)*100. Even though Malaysia's trade figure is about 5 times that of Ghana, referring to Figure 5.4.1 seems to indicate trade figures for Ghana and Malaysia to be increasing at a similar rate from the 1990's, obtained a peak in the 2000,s and then started to decline afterwards. On the other hand figure 5.4.2 also shows that electricity consumption in Ghana has been relatively low without any significant rise over the past two decades. Even worse, the figures in 2011 to date are likely to be lower due to the current energy crises in Ghana. On the other hand, that of Malaysia has increased steadily from 1145.99 Kwh per capita in 1990 to 4117.35 Kwh in 2010. This is an indication that Ghana electricity consumption has not been growing in proportion to the growth of its population and this could be interpreted as a sign of weak energy infrastructure for Ghana.

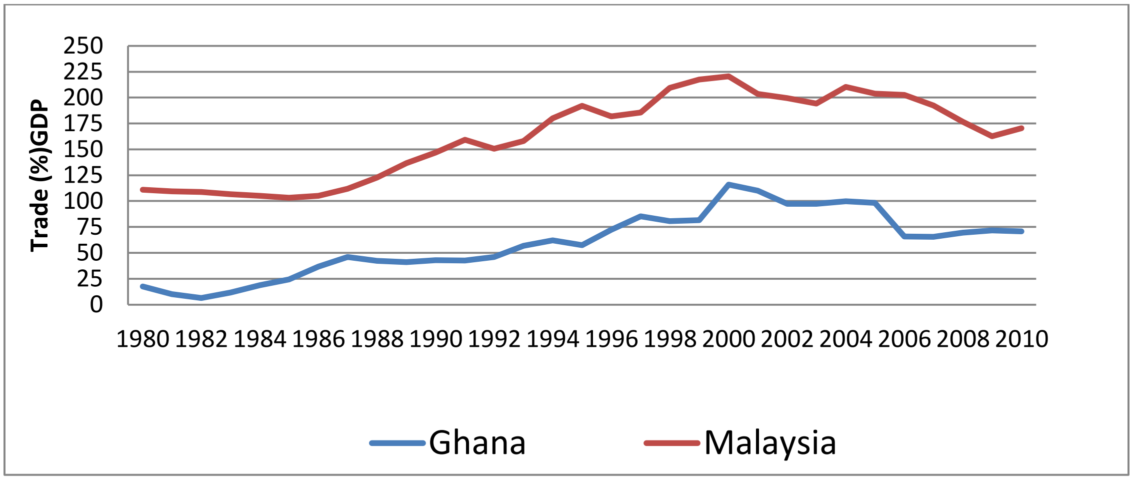


Figure 5.4.1 Openness measured by Trade as a percentage of GDP Ghana vs Malaysia

Source: WDI

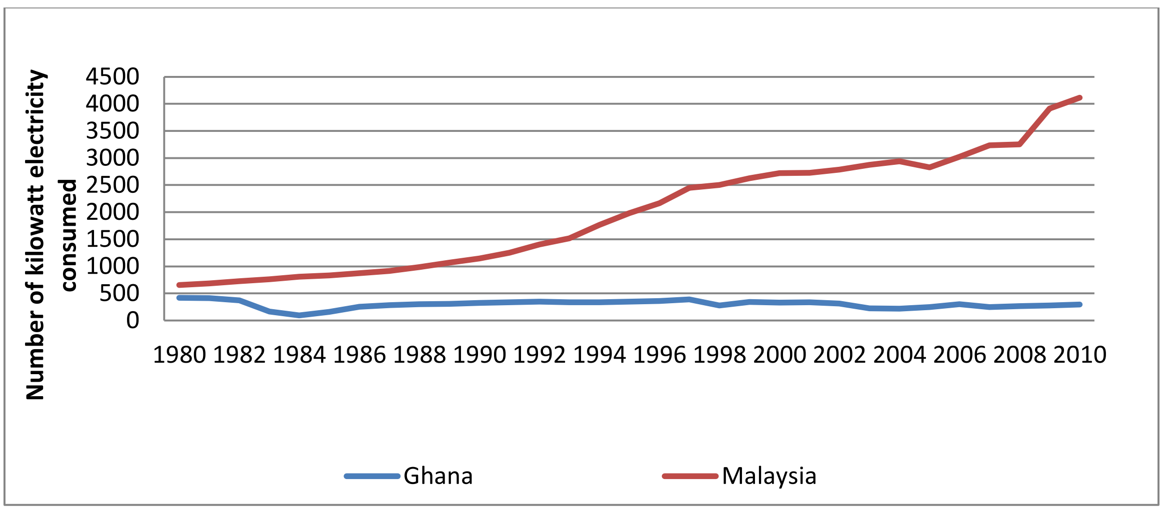


Figure 5.4.2 Diffusion measured by Number of Kilowatt electricity consumed Ghana vs Malaysia

Source: WDI

Furthermore figure 5.4.3 also shows the Level of Economic development of Ghana and Malaysia for the year 1990 through to the year 2010. The average income level of a Ghanaian in the year 1990 was $221.07 and this figure is about ten times less than that of Malaysian in the same year which was about $2592.5. From the 1990's and beyond the income levels of Ghanaians have not changed much. The value in 2010 was 342 representing only 35.3% increase over the past three decades whiles that of Malaysia has increased by approximately 47.1% from the value in 1990 and still increasing at a faster rate. This also shows that the level of income in Ghana has not been responsive to the increase in population over the years.

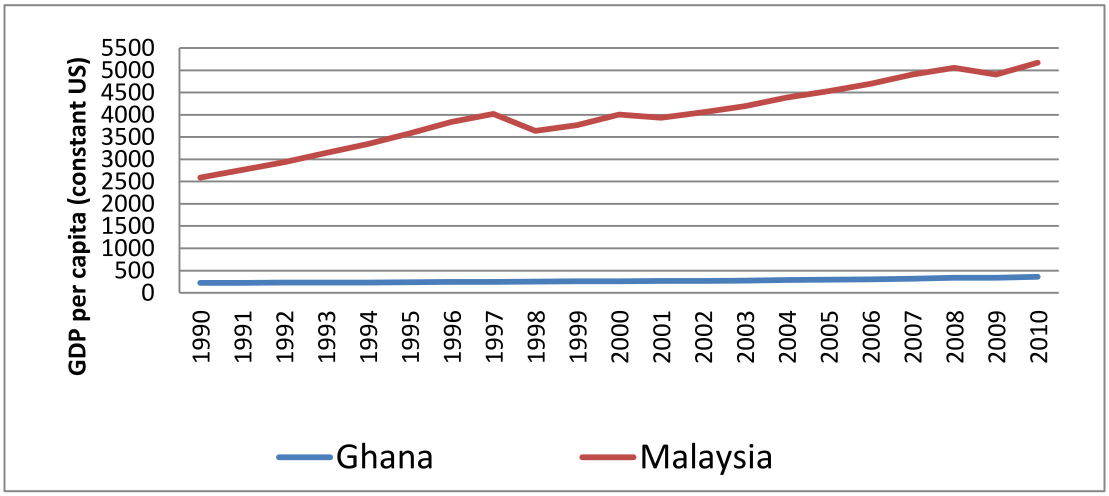


Figure 5.4.3 Economic Development measured by GDP per capita Ghana vs Malaysia

Source WDI

Table's 5.5.1 and 5.5.2 shows the raw data sets used in the empirical analysis and Tables 5.5.3 and 5.5.4 shows the descriptive statistics of the data set for Ghana and Malaysia respectively.

Table 5.5.1 Raw Data Sets for Ghana

Year	R1	R2	R3	X1	X3	X4	X5	X6	Y
1990	0.251309	35.7732	0.299072	0.590203	40	42.72816	1.181778	323.1167	221.0717
1991	0.302887	33.59	0.306339	0.441679	47	42.48832	0.97641	335.8278	226.2823
1992	0.350681	33.52	0.305068	0.467431	72	45.99357	1.11353	350.8593	228.4588
1993	2.094186	33.45	0.302263	0.462705	52	56.66913	1.31156	336.0963	232.8513
1994	4.278079	33.38	0.302068	0.428422	67	62.02115	1.32561	336.276	234.0065
1995	1.647487	35.33149	0.37105	0.432044	58.3	57.42309	1.621622	349.8873	237.2936
1996	1.730856	30.3352	0.446871	0.396282	71.8	72.20495	1.269746	362.4949	242.0583
1997	1.186981	32.3764	0.591053	0.414695	81.9	85.40184	1.328414	387.9531	246.1978
1998	2.237348	34.4176	0.729857	0.454854	71.3	80.59954	1.37139	275.4756	251.7653
1999	3.157508	40.1816	0.858628	0.413875	74.1	81.7051	1.383356	342.6005	256.74
2000	3.329421	40.52343	1.109014	0.400575	92.1	116.0484	1.394906	330.3855	259.9907
2001	1.680567	38.61194	1.246071	0.37153	78.7	110.0459	1.349563	336.5888	263.9615
2002	0.955694	40.6379	1.367376	0.364532	79.3	97.48924	1.365526	311.3199	269.2286
2003	1.791642	42.06077	1.41202	0.46544	75.8	97.28714	1.372948	225.3662	276.4052
2004	1.568105	44.91349	1.483557	0.447644	86.2	99.67033	1.37326	220.2187	284.8492
2005	1.350835	47.20623	1.485808	0.409316	81.3	98.17151	5.65166	246.6288	294.408
2006	3.116129	49.07605	1.607335	0.47242	90.2	65.92301	5.08463	298.2334	305.7511
2007	5.586873	53.66504	1.657724	0.507245	109.4	65.35409	6.32437	247.1777	317.7364
2008	9.516657	56.26766	0.618548	0.588962	111.1	69.51415	8.4115	266.8051	336.3518
2009	9.132693	59.05578	1.122332	0.4188	101.5	71.59284	8.80031	276.1874	341.5523
2010	7.855051	58.912	1.139304	0.4223	109.693	70.63129	10.46993	297.8047	360.3241

Table 5.5.2 Raw Data Sets for Malaysia

Year	R1	R2	R3	X1	X2	X3	X4	X5	X6	Y
1990	5.298123	54.65384	8.708782	0.33625	2305	233	146.9638	7.18927	1145.999	2592.517
1991	8.137869	55.36573	9.711791	0.37	2427	260	159.3126	7.98109	1253.543	2764.201
1992	8.762883	56.11332	10.89132	0.355	2411	247	150.6112	9.07605	1404.284	2932.017
1993	7.482897	55.0829	12.23638	0.34	2882	293	157.9414	9.39622	1516.857	3140.826
1994	5.829422	55.20269	14.17318	0.28	3587	345	179.9059	10.33823	1764.97	3344.568
1995	4.703506	55.17255	16.08261	0.22	4052	365.8	192.1141	11.14913	1982.017	3581.946
1996	5.035523	56.56717	17.74978	0.305	5575	362.2	181.7663	9.588144	2164.248	3842.638
1997	5.127856	57.07934	19.38821	0.39	6451	349	185.6651	15.69629	2447.077	4022.844
1998	2.997426	66.99023	19.64009	0.445	5963	387.1	209.4922	21.80443	2501.831	3636.473
1999	4.921467	66.39524	19.3758	0.5	5842	471.4	217.5709	22.74336	2624.226	3767.637
2000	4.038429	66.16144	19.76518	0.595	6227	459.6	220.4068	25.74357	2721.172	4005.556
2001	0.597029	66.29292	19.65215	0.69	5934	472.4	203.3646	25.44994	2728.939	3933.935
2002	3.176562	66.9078	19.04891	0.66	4937	494.5	199.3562	28.16189	2785.238	4052.879
2003	2.244197	72.41487	18.24233	0.63	5062	479.3	194.1951	31.60761	2872.645	4194.261
2004	3.706798	73.58631	17.3747	0.635	5442	586.1	210.3743	31.24245	2937.736	4385.97
2005	2.734416	70.29899	16.72646	0.64	6286	614.6	203.8548	29.31308	2828.633	4529.601
2006	4.727135	70.27892	16.3321	0.73	4800	724.1	202.5763	30.60403	3021.257	4695.23
2007	4.686803	68.95234	16.08065	0.82	2372	808.1	192.4676	33.04303	3232.876	4905.121
2008	3.27832	69.05814	16.41335	0.915	5303	951	176.6687	37.45536	3254.308	5057.827
2009	0.056694	68.29508	16.1864	1.01	5737	1351.3	162.5587	40.23617	3911.856	4901.547
2010	3.714109	69.09548	16.10154	0.86875	6383	1400.3	170.3323	42.28385	4117.353	5168.686

Table 5.5.3 Descriptive Statistics for Ghana

Variables	N	Minimum	Maximum	Mean	S.D.
INNOVATION INPUT					
Total agricultural R&D expenditure (%) of GDP	21	0.36	0.59	0.45	0.06
SCIENTIFIC OUTPUT					
Number of scientific and technical articles	21	40	111.1	78.60	19.75
OPENNESS					
Trade (export + import) (%) GDP	21	42.49	116.05	75.67	21.49
Foreign direct investment (net inflows (%) GDP)	21	0.25	9.52	3.01	2.78
HUMAN CAPITAL					
Tertiary enrollment percentage of gross	21	0.98	10.47	3.07	3.03
Secondary enrollment percentage of gross	21	30.34	59.06	41.59	9.16
INFRASTRUCTURE					
Number of kilowatt of electricity consumed per capita	21	220.22	387.95	307.49	46.92
Number of telephone users per 100 people	21	0.30	1.66	0.89	0.499
ECONOMIC DEVELOPMENT					
GDP Per Capita (Constant US)	21	221.07	360.32	270.82	41.14

Note: Total agricultural R&D expenditure =Public sector Agriculture R&D+ Government Sector Agriculture R&D+ Higher Education Sector Agriculture R&D

Table 5.5.4 Descriptive Statistics for Malaysia

Variables	N	Minimum	Maximum	Mean	S.D
INNOVATION INPUTS					
Total R&D expenditure (%) of GDP	21	0.22	1.01	0.56	0.23
TECHNOLOGY OUTPUT					
Total number of patent applications	21	2305	6451	4760.86	1492.78
SCIENTIFIC OUTPUT					
Number of scientific and technical journals	21	233	1400.299	554.99	329.91
OPENNESS					
Trade (export + Import) (%) GDP	21	146.96	220.41	186.55	22.08
Foreign direct investment (net inflows (%) GDP)	21	0.057	8.76	4.35	2.16
HUMAN CAPITAL					
Tertiary enrollment percentage of gross	21	7.19	42.28	22.86	12.51
Secondary enrollment percentage of gross	21	54.65	73.59	63.81	6.82
INFRASTRUCTURE					
Number of kilowatt of electricity consumed per capita	21	1145.99	4117.35	2534.15	808.62
Number of telephone users per 100 people	21	8.71	19.77	16.18	3.31
INCOME LEVEL					
GDP Per Capita (constant US)	21	2592.52	5168.68	3974.1	750.4

CHAPTER 6: RESULTS

6.0 Introduction

This Chapter presents the empirical results of the analysis done on annual time series data for the periods 1990 to 2010 for Ghana and Malaysia. The regression models discussed in chapter 3 were utilized in this section using SPSS 21. The results will be presented starting with the correlation matrixes of the predictor variables used in the main model. This was done in order to have first-hand information about the relationships between the variables used and also to investigate any issues of multicollinearity. The results shown in this chapter will be in the same order in which the models in chapter 3 are categorized and arranged. Only the standardized coefficients with the corresponding t-statistics (in parenthesis) are reported in this chapter. The predictive accuracy of each model is its coefficient of determination (R^2) and the test for the hypotheses that the amount of variation explained by the models are more than the baseline prediction (F ratio) are also reported next to the coefficients of each model. The following are the explanations for P values and how significant coefficients are detected. *** Means standardized coefficients significant at a $P < 0.001$, ** means standardized coefficients significant at a $P < 0.01$ and * means standardized coefficients significant at a $P < 0.05$. For the full report of the results, please refer to the appendixes C and D for Ghana and Malaysia respectively.

6.1 Correlation Matrix for Ghana and Malaysia

Tables 6.1.1 and 6.1.2 show the correlation matrixes for the predictor variables of Ghana and Malaysia respectively. The predictor variables for Ghana seem to have no issues of multicollinearity, since all coefficients are below 0.80. However, the correlation coefficients for some of the variables in Table 6.1.2 for Malaysia are above 0.80, indicating evidence of multicollinearity. Referring to Table 6.1.2, high correlation existed between the variables Human capital and Innovation Inputs, Scientific Output and Infrastructure, Scientific Output and Innovation Inputs, scientific output and Human Capital and between Infrastructure and Human capital. Therefore, obviously these variables cannot be used together as predictors in the same model; their impacts would have to be assessed separately.

Table 6.1.1 Pearson Correlation Matrix for Ghana

Variables	Innovation Input	Scientific Output	Openness	Human Capital	Infrastructure
Innovation Inputs (X_1)	1	-0.138	-0.551**	0.378	-0.293
Scientific Output	-0.138	1	0.556**	0.555**	-0.424
Openness	-0.551**	0.556**	1	-0.055	-0.333
Human Capital	0.378	0.555**	-0.055	1	-0.429
Infrastructure	-0.293	-0.424	-0.333	-0.429	1

Note: **correlation is significant at the 0.01 level (2-tailed)

Table 6.1.2 Pearson Correlation Matrix for Malaysia

Variables	Innovation Input	Technological Output	Scientific Output	Openness	Human Capital	Infrastructure
Innovation Inputs	1	0.423	0.855**	0.290	0.900**	0.793**
Technological Output	0.423	1	0.519*	0.709**	0.670**	0.770**
Scientific Output	0.855**	0.519*	1	0.278	0.885**	0.894**
Openness	0.290	0.709**	0.278	1	0.593**	0.627**
Human Capital	0.900**	0.670**	0.885**	0.593**	1	0.955**
Infrastructure	0.793**	0.770**	0.864**	0.627**	0.955**	1

Note: **correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

The correlation matrix for Ghana showed a negative and significant relationship between Innovation Input (Agricultural R&D expenditure) and Openness (Trade as % of GDP). This implies that as trade increases for Ghana, the expenditures for agricultural research decreases.

The correlation between Human Capital (Tertiary enrollment ratio) and Scientific Output (Scientific & Technical articles) was also significantly positive. This is normal since research and publications of articles are made possible when and if people are able to attain higher education. Finally, there was a positive and significant relationship between Openness and Scientific Outputs. This implies that as the economy of Ghana becomes more trade oriented, living standards of people would improve as well and as a result, people are able to acquire higher education and do research.

The correlation matrix for the predictor variables for Malaysia shown in table 6.1.2 above shows a positive and significant relationship between Innovative Inputs and Scientific Output, as well as a positive and significant relationship between all other variables except for the relationship between Innovation Inputs and Technological Output which turned out insignificant. This shows the extent of interaction and links within the national innovation system of Malaysia, as almost every element is contributing significantly to the system. Aside the correlation Matrix of Ghana and Malaysia, a second measure of multicollinearity: the VIF (Variance Inflation Factor) and Tolerant Statistics were also used to detect and remedy issues of multicollinearity for each model.

6.2 Results for National Innovation Capability of Ghana and Malaysia.

The main model in chapter 3 which assesses the impact of the variables for Innovative Capacity, Technology Output, Scientific Output, Openness, Human Capital and Infrastructure on the variable for Economic development of both Ghana and Malaysia is shown below.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2\ \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon_1$$

Table 6.2.1 shows the summary of the results for both Ghana and Malaysia. One would notice that the variable Technology Output has been omitted from this model and all models for Ghana due to insufficient data on this variable as explained in chapter 5. The model for Malaysia were categorized into four; model 1, model 2 and model 3 and model 4 in order to remedy for the likelihood of multicollinearity, since some of the variables for Malaysia were almost perfectly correlated. Moreover, the VIF's for all the models in Table 6.2.1 are all far below 10 and the tolerant statistics are all also well above 0.2. Thus, the researcher can conclude that there were no issues of multicollinearity in these models.

The results for Ghana indicate that Scientific Output and Human Capital significantly and positively impact on Economic Development while Infrastructure significantly impacts negatively on Economic Development. On the other hand, the results for Malaysia show that Innovation Inputs, Scientific Output, Human Capital (tertiary enrollment), Openness and Infrastructure all significantly impact on Economic Development. Examining the R^2's and F ratios for each model in Table 6.2.1 shows that, high percentage of the variation in the dependent variable Economic Development is explained by the predictor variables and the average number of errors in the models were significantly lower.

Table 6.2.1 Results for National Innovation Capability of Ghana and Malaysia

	Ghana	Malaysia			
Independent Variables	R^2=96% F=63.321***	Model 1 (R^2=78%, F=20.337***)	Model 2 (R^2=86%, F=56.184***)	Model 3 (R^2=96%, F=139.738***)	Model 4 (R^2=93%, F=77.570***
	Beta	Beta	Beta	Beta	
Innovation Inputs (X1)	-0.161 (-1.911)	0.585*** (4.680)			
Technology Output (X2)		0.341 (2.008)	0.151 (1.278)	-0.120 (-1.603)	0.095 (0.928)
Scientific Output (X3)	0.450*** (4.813)				0.776*** (10.370)
Openness (X4)	-0.030 (-0.304)	0.158 (0.986)		0.095 (1.694)	0.287** (3.160)
Human Capital (X5)	0.527*** (6.284)		0.821*** (6.957)		
Infrastructure (X6)	-0.241** (-3.134)			1.116*** (13.888)	

Dependent Variable: Economic Development (Y)

The sensitivity of the findings was checked by using different variables for Openness, Human Capital and Infrastructure (R1, R2 and R3 in chapter 3) to see their impact on the initial results for the same models for Ghana and Malaysia. Therefore, by changing the variables for Openness, Human Capital and Infrastructure, the initial model was modified into the model below and the results obtained are summarized in table 6.2.2. Also, the VIF's are all far below 10 and the tolerant statistics well above 0.2 for these models as well.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2\ \beta_3 X_3 + \beta_4 R_1 + \beta_5 R_2 + \beta_6 R_3 + \varepsilon_1$$

Table 6.2.2 Results for National Innovation Capability of Ghana and Malaysia using different variables for Openness, Human Capital and Infrastructure

	Ghana	Malaysia	
	(R=96% F=80.609***)	Model 1 (R^2=81%, F=17.340***	Model 2 (R^2=91%, F=43.198***
Independent Variables	Beta	Beta	Beta
Innovation Inputs (X1)	-0.037 (-0.587)	0.596*** (4.412)	
Technology Output (X2)		0.130 (0.563)	0.306** (3.324)
Scientific Output (X3)	0.239* (2.331)		0.732*** (5.955)
Openness (R1)	0.082 (0.999)	0.064 (0.478)	0.151 (1.692)
Human Capital (R2)	0.723*** (7.134)		0.131 (1.099)
Infrastructure (R3)	-0.012 (-0.130)	0.395 (1.767)	

Dependent Variable: Economic Development (Y)

The result for Ghana in Table 6.2.2 is similar to the initial findings in Table 6.2.1 in terms of statistically significant variables, except for Infrastructure which turned out to be insignificant. On the other hand, that of Malaysia was also similar in respect of the impact of Innovation Inputs and Scientific Output, but in this instance, Human Capital measured by Secondary enrollment ratio became insignificant while's technology outputs also turned out to be significant. Clearly these findings are not enough as there may be more to the internal workings of the national innovation systems of both countries. Therefore, the next sections of the analyses addresses the impact of these variables on each other when they are analyzed in separate categories utilizing the models in Table 3.2 in chapter 3.

6.3 Dynamics of Innovative Capacity of Ghana and Malaysia

The models utilized in this section are Models A1 to A4 discussed in chapter 3. The results for Ghana summarized in Table 6.3.1 shows a significantly positive bidirectional relationship between Scientific Output and Economic development with R square of 77% for both Model A1 and A4. The high and significant F values for these models imply that knowledge solutions such as scientific and technical articles have a long run impact on economic development of Ghana and the level of economic development of Ghana also impacts on the number of science and technical articles published. However, Model A2 for Ghana showed no significant coefficients and its F ratio was also not significant, therefore this model was not valid and could not be accepted.

Table 6.3.1 Results for Dynamics of Innovative Capability of Ghana (MODEL A's Chapter 3)

	Independent Variables				
Dependent Variable	Economic Development (Y)	Innovation Input (X1)	Scientific Output (X3)	R^2	F Ratio
Model A1 **Economic Development (Y)**		0.189 (1.639)	0.881*** (7.660)	0.766	29.516***
Model A2 **Innovation Input (X1)**	0.689 (1.639)		-0.727 (-1.729)	0.146	1.543
Model A4 **Scientific Output (X3)**	0.868*** (7.660)	-0.196 (-1.729)		0.77	30.081***

Table 6.3.2 Results for Dynamics of innovative capacity of Malaysia (MODEL A's Chapter 3)

	Independent Variables					
Dependent Variables	Economic Development.(Y)	Innovation Input (X1)	Technology output (X2)	Scientific output (X3)	R^2	F Ratio
Model A1 **Economic Development (Y)**		0.028 (0.184)	0.317** (3.400)	0.716*** (4.395)	0.89	46.878***
Model A2 **Innovation Input (X1)**						
Model 1	0.939*** (4.669)		-0.235 (-1.167)		0.63	15.242***
Model 2			-0.28 (-0.193)	0.869*** (6.090)	0.73	24.558***
Model A3 **Technology Output (X2)**	0.933** (3.633)	-0.299 (-1.167)			0.53	10.005**
Model A4 **Scientific Output (X3)**	0.743*** (4.395)	0.341* (2.565)	-0.146 (-1.240)		0.89	45.010***

The results for Model A1 and Model A4 in table 6.3.2 for Malaysia also show a positive and significant bidirectional relationship between Scientific Output and Economic Development with R^2's of 89% for both models. However, unlike Ghana, Model A1 for Malaysia also shows that Economic Development significantly impact on Innovation Input and Technology Output of Malaysia with R^2 of 63% and 53% for model 1 of A2 and model A3 respectively. The significant and high F values for both Model A1 and A2 clearly show that as Malaysia's economy develops, the capability of Malaysia to fund many more research activities also improves. The same could be said about scientific outputs of Malaysia.

Furthermore, unlike the results for Ghana which showed no relationships between the variables for innovative capacity, that of Malaysia indicated a significantly negative bidirectional relationship between Innovation Inputs and Scientific Outputs (see Models A2 and A4). However, there was no significant relationship between Innovation Inputs and Technology Output for Malaysia which goes contrary to the famous linear model in the literature. Therefore, the alternative hypotheses in Chapter 3 for Models A1 and A4 are accepted for Ghana and that of Model A2 is rejected due to the insignificant F ratio of the model. On the other hand, the alternative hypotheses for Models A1, A2, A3 and A4 in chapter 3 are all accepted in the case of Malaysia.

6.4 Dynamics of Absorptive Capacity, Openness and Diffusion Capacity of Ghana and Malaysia (Model B's Chapter 3)

Models B1 to B4 in chapter 3 were utilized in this section to determine the relationships between Absorptive capacity, Openness and Diffusion on Economic Development and also the interaction between Absorptive capacity, Openness and Diffusion. The outcomes of these analyses are summarized in Tables 6.4.1 and 6.4.2 for Ghana and Malaysia respectively. Foremost, the VIF's and tolerant statistics for all the models are well within acceptable limits. Results in Table 6.4.1 show that Openness and Economic Development of Ghana significantly impact on each other in Models B1 and B2 with R^2's of 87% and 53% and significant ($P < 0.001$) F ratios of 37.92 and 6.486. The high and significant F ratios (above 1.0) for both models imply a long run sustaining relationship between Trade and Economic development of Ghana such that when level of trade for Ghana increases, the level of economic development of Ghana also increases and vice versa. There is also significantly positive bidirectional relationship between Human Capital and Economic Development in Model B1 and B3 with R^2's of 87% and 83% and significant ($P < 0.001$) F ratios of 37.92 and 28.53. Furthermore Human capital and Openness for Ghana significantly impact on each other negatively as indicated in model B2 and B3.

Table 6.4.1 Results for Dynamics of Absorptive Capacity, Openness and Diffusion Capacity for Ghana

	Independent Variables					
Dependent Variables	Economic Development (Y)	Openness (X4)	Human Capital(X5)	Infrastructure (X6)	R^2	F Ratio
Model B1 **Economic Development (Y)**		0.353** (3.700)	0.785*** (7.888)	-0.151 (-1.429)	0.87	37.942***
Model B2 **Openness (X4)**	1.265** (3.700)		-1.127** (-3.740)	-0.052 (-0.245)	0.53	6.498**
Model B3 **Human Capital (X5)**	1.000*** (7.888)	-0.401** (-3.740)		0.043 (0.340)	0.83	28.55***
Model B4 **Infrastructure (X6)**	-0.712 (-1.429)	-0.068 (-0.245)	0.158 (0.340)		0.39	3.557*

Table 6.4.2 Results for Dynamics of Absorptive Capacity, Openness and Diffusion Capacity for Malaysia

	Independent Variables					
Dependent Variables	Economic Development (Y)	Openness (X4)	Human Capital(X5)	Infrastructure (X6)	R^2	F Ratio
Model B1 **Economic Development (Y)**						
Model 1		0.035 (0.313)	0.901*** (7.950)		0.850	51.08***
Model 2		-0.068 (-1.012)		1.016*** (15.207)	0.95	175.44***
Model B2 **Openness (X4)**						
Model 1	-0.796 (-1.012)			1.402 (1.783)	0.426	6.671**
Model 2	0.153 (0.313)		0.452 (0.927)		0.355	4.955*
Model B3 **Human capital (X5)**	-0.178 (-0.551)	-0.021 (-0.227)		1.142** (3.348)	0.91	59.76***
Model B4 **Infrastructure (X6)**	0.612*** (6.010)	0.072 (1.465)	0.348** (3.349)		0.97	208.88***

Referring to Table 6.4.2, due to almost perfect correlation between Infrastructure and Human capital for Malaysia, both variables were not put together as predictors in the same model. Therefore, two separate models (model 1 and model 2) under Model B1 were created to accommodate them. The results in Table 6.4.2 indicate that Human capital significantly impacts positively on Economic Development of Malaysia, while Economic Development also significantly impacts negatively on Human capital as shown in model 1 of Model B1 and Model B3 respectively and with R^2's of 85% and 91% respectively. Infrastructure and Economic Development also significantly impact on each other as indicated in model 2 of Model B1 and Model B4 respectively with R^2 of 95% for the former and 97% for the latter. Therefore, Human capital remains an important component of the national innovation systems of both Ghana and Malaysia. The results in Table 6.4.2 further indicate a bidirectional positive and significant relationship between Human capital and Infrastructure. Hence, the alternative hypotheses in chapter 3 for Models B1, B2 and B3 are accepted and B4 rejected in the case of Ghana whereas that of B1, B3 and B4 are accepted and B2 rejected in the case of Malaysia.

6.5 Interrelationships between Innovative Capacity and Absorptive Capacity, Openness and Diffusion of Ghana and Malaysia (Model C's Chapter 3)

Another way of looking at this section could be assessing the extent to which Absorptive Capacity, Openness and Diffusion interact with Innovative capacity (creative capacity). The findings for Ghana in Table 6.5.1 indicate bidirectional negative relationship between Openness and Innovation input as shown in Model C1 and C4 with R^2's of 58% and 54% respectively. Infrastructure also impacts negatively on Innovation Inputs as indicated in Model C1. Human Capital and Scientific Output also significantly impact on each other positively with R^2's of 65% and 52% for Model C3 and Model C5 respectively. The same could be said between Openness and Scientific output with R^2's of 65% and 54% for Models C3 and C4 respectively.

Table 6.5.1 Results for interrelationship between Innovative Capability and Absorptive Capacity, Openness and Diffusion Capacity of Ghana

	Independent Variables						
Dependent Variables	Innovation Input (X1)	Scientific Output (X3)	Openness (X2)	Human Capital (X5)	Infra. (X6)	R^2	F Ratio
Model C1 **Innovation Input (X1)**			-0.699** (-4.055)	0.140 (0.778)	-0.466* (-2.446)	0.58	7.672**
Model C3 **Scientific Output (X3)**			0.600* (3.856)	0.602** (3.704)	0.034 (0.200)	0.65	10.68***
Model C4 **Openness (X4)**	-0.484** (-2.996)	0.489** (3.030)				0.539	10.525**
Model C5 **Human Capital (X5)**	0.463* (2.806)	0.618** (3.744)				0.518	9.683**
Model C6 **Infrastructure (X6)**	-0.359 (-1.809)	0.473* (-2.388)				0.306	3.969

Table 6.5.2 Results for interrelationship between the Innovative Capability and Absorptive Capacity, openness and Diffusion capacity of Malaysia

	Independent Variables							
Dependent Variables	Innovative Input (X1)	Tech. output (X2)	Sci. output (X3)	Openness (X4)	Human Capital (X5)	Infra. (X6)	R^2	F ratio
Model C1 **Innovation Input (X1)**								
Model 1				-0.341 (-2.056)		1.007*** (6.068)	0.69	20.93***
Model 2				-0.376** (-4.109)	1.123** (12.273)		0.90	83.05***
Model C2 **Technology Output (X2)**								
Model 1				0.481* (2.594)	0.385 (2.074)		0.60	13.427***
Model 2				0.373* (2.170)		0.563** (3.121)	0.68	18.897***
Model C3 **Scientific Output (X3)**								
Model 1				-0.381** (-3.720)	1.111*** (10.847)		0.88	64.502***
Model 2				-0.466*** (-5.834)		1.186*** (14.858)	0.93	120.356***
Model C4 **Openness (X4)**	0.254 (0.791)	0.780** (4.011)	-0.344 (1.011)				0.53	6.418**
Model C5 **Human Capital (X5)**	0.556*** (4.405)	0.304** (3.966)	0.252 (1.882)				0.93	72.24***
Model C6 **Infrastructure (X6)**	0.138 (1.134)	0.423*** (5.739)	0.556*** (4.318)				0.93	78.36***

In the case of Malaysia, Model 1 and Model 2 under Models C1, C2 and C3 in Table 6.5.2 were utilized to take care of any issues of multicollinearity that could have occurred in the models due to the high correlation between Infrastructure and Human capital. Meanwhile, the results in Table 6.5.2 shows that Openness impacts negatively on Scientific Output as shown in the results for Model C3 with R^2's of 93%. The is also a positive bidirectional relationship between Human Capital and Scientific Output in Model C3 and Model C5 with R^2's of 88% and 93% respectively. Furthermore, Scientific Output and Infrastructure significantly impact on each other positively with $R^{2'}$s of 88% and 93% for Model C3 and Model C6 respectively, likewise Human Capital and Innovation Inputs with R^2's of 90% and 93% for Models C1 and C5 respectively and for

Infrastructure and Innovation Input for Model C1 and C6 respectively. The statistically significant F ratios for these findings require that the alternative hypotheses for Models C1, C2, C3, C4 and C5 in Chapter 3 are all accepted, except in the case of Ghana, the alternative hypothesis for Model C2 is rejected.

6.6 Testing the Robustness of the Findings of Sub-Models.

To find out the robustness of these empirical findings, the researcher tried to determine how much the findings would change if different variables for Absorptive capacity, Openness and Diffusion were used for both Ghana and Malaysia. Therefore, the variables Foreign Direct Investment for Openness, Secondary enrollment ratio for Absorptive capacity, and Number of telephone users for Diffusion (Variables R1, R2 and R3 in Chapter 3) were used to replace Trade (X4), Tertiary enrollment ratio (X5) and Number of kilowatt of electricity consumed per capita (X6). The findings for these indicators are summarized in Tables 6.6.1, 6.6.2, 6.6.3 and 6.6.4 for Ghana and Malaysia and the models utilized are Models B1 to C6 explained in chapter 3. As can be observed from the tables below, the findings for Models B1, B2, B3 and B4 for both Ghana and Malaysia in terms of statistically significant variables are not different from the initial findings (especially in terms of their impact on Economic Development) leading to the similar hypotheses in Chapter 3 being accepted or rejected as done for the initial results. The correlation matrixes for these set of new variables for both Ghana and Malaysia are shown in the appendix.

Table 6.6.1 Results for Dynamics of Absorptive Capacity, Openness and Diffusion Capacity of Ghana (Robustness check)

	Independent Variables					
Dependent Variables	Economic Development (Y)	Openness (R1)	Human Capital (R2)	Infrastructure (R3)	R^2	F Ratio
Model B1 **Economic Development (Y)**		0.206* (2.835)	0.726*** (8.116)	0.138 (1.843)	0.95	106.1***
Model B2 **Openness (R1)**	1.558* (2.835)		-0.677 (-1.309)	-0.223 (-1.015)	0.62	9.12***
Model B3 **Human Capital (R2)**	1.095*** (8.116)	-0.135 (-1.309)		-0.051 (-0.510)	0.92	68.4***
Model B4 **Infrastructure (R3)**	1.202 (1.843)	-0.256 (-1.015)	-0.295 (-0.510)		0.56	7.2**

Table 6.6.2 Results for Dynamics of Absorptive Capacity, Openness and Diffusion Capacity of Malaysia (Robustness Check)

	Independent Variables					
Dependent Variable	Economic Development (Y)	Openness (R1)	Human Capital (R2)	Infrastructure (R3)	R^2	F
Model B1 **Economic development (Y)**		-0.101 (-0.741)	0.533** (3.275)	0.371* (2.377)	0.74	16.29***
Model B2 **Openness (R1)**	-0.311 (-0.741)		-0.180 (-0.497)	0.022 (0.068)	0.21	1.46
Model B3 **Human Capital (R2)**	0.725** (3.275)	-0.079 (-0.497)		0.057 (0.271)	0.65	10.486***
Model B4 **Infrastructure (R3)**	0.673* (2.377)	0.013 (0.068)	0.076 (0.272)		0.53	6.4**

Table 6.6.3 Results for Interrelationship between Innovative Capability and Absorptive Capacity, Openness and Diffusion Capacity of Ghana (Robustness Check)

	Independent Variables						
Dependent Variables	Innovative Input (X1)	Scientific Output (X3)	Openness (R1)	Human Capital (R2)	Infra. (R3)	R^2	F Ratio
Model C1 **Innovation Input (X1)**			-0.289 (-1.153)	0.918** (2.978)	-0.771** (-2.977)	0.40	3.742*
Model C3 **Scientific Output (X3)**			0.473** (3.059)	0.153 (0.806)	0.409* (2.556)	0.77	18.99***
Model C4 **Openness (R1)**	0.078 (0.503)	0.768*** (4.982)				0.58	12.427***
Model C5 **Human Capital (R2)**	0.306* (2.174)	0.789*** (5.599)				0.65	16.681***
Model C6 **Infrastructure (R3)**	-0.173 (-1.093)	0.702*** (4.433)				0.56	11.305**

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Table 6.6.4 Results for Interrelationship between Innovative Capability and Absorptive Capacity, Openness and Diffusion Capacity of Malaysia (Robustness Check)

	Independent Variables							
Dependent Variables	Innovative Input (X1)	Tech. output (X2)	Scientific output (X3)	Openness (R1)	Human Capital (R2)	Infra (R3)	R^2	F Ratio
Model C1 **Innovation Input (X1)**				-0.240* (-2.212)	0.914*** (7.047)	-0.231 (-1.856)	0.84	28.96***
Model C2 **Technology Output (X2)**				-0.140 (-1.119)	0.033 (0.221)	0.807*** (5.605)	0.78	20.12***
Model C3 **Scientific Output (X3)**				-0.301 (-1.899)	0.656** (3.457)	-0.039 (-0.213)	0.65	10.485***
Model C4 Openness (R1)	-0.261 (-0.692)	-0.167 (-0.730)	-0.253 (-0.633)				0.35	3.087*
Model C5 Human Capital (R2)	0.858*** (4.339)	0.285* (2.375)	-0.123 (-0.588)				0.82	26.137***
Model C6 Infrastructure R3	0.110 (0.482)	0.872*** (6.304)	-0.090 (-0.371				0.76	18.235***

CHAPTER 7: DISCUSSIONS AND CONCLUSION

7.0 Introduction

Tables 7.1 and 7.2 show the summary of the results from chapter 6 for Ghana and Malaysia. The tables show only results for models in chapter 3 with statistically significant coefficients. In addition, the F ratios and R^2's for each model are also reported in the tables. Results in Table 7.1 and 7.2 that do not show the R^2 and F ratio means that those results were extracted from more than one sub-models. For example, the main model for Malaysia was broken down into four models in order to tackle issues of multicollinearity. Therefore, one would have to refer to the original results in chapter 6 for the respective R^2's and F ratios for those models or view the original SPSS output in Appendix C and D.

7.1 Capabilities of National Innovation system (Main model, Chapter 3)

The results for the main model for Ghana indicated that Scientific Output and Human Capital significantly impact positively on Economic Development. On the other hand, Innovation Inputs, Scientific Outputs, Human Capital, Openness and Infrastructure significantly impact positively on the Economic Development of Malaysia. This confirms the findings of Fagerberg and Srholec (2007) and Castellacci and Netera (2013). Meaning that, a 1% rise in the number of scientific and technical articles and tertiary enrollment rate in Ghana may be accompanied by 0.45% and 0.54% rise of GDP per capita for Ghana respectively. On the other hand, 0.59% and 0.78% rise in GDP per capita may occur as a result of 1% rise in the amount of Innovation Inputs and Scientific and technical publications respectively for Malaysia. Furthermore, 1% rise in Human Capital in terms of Tertiary enrollments and 1% rise in Infrastructure of Malaysia

Table 7.1 Summary of findings for Ghana

	Models									
Variables	Main	A1	A4	B1	B2	B3	C1	C3	C4	C5
Economic Dev.			0.868***		1.264**	1.001***				
Innovation Input	-0.161								-0.484**	0.463*
Scientific output	0.450***	0.881***							0.489**	0.618**
Openness				0.35**		-0.40**	0.699**	0.60*		
Human Capital	0.537***			0.79***	-1.127**			0.602**		
Infrastructure	-0.241**						-0.466*			
R^2	96%	77%	77%	87%	53%	83%	58%	65%	54%	51%
F ratio	63.321***	29.516***	30.081***	37.92***	6.486**	28.53***	7.672**	10.68***	10.525**	9.683**

Note: Table 7.1 shows the coefficients of variables in each model at significant levels of: *** standardized coefficients significant at a P value < 0.001,** standardized coefficients significant at a P value < 0.01 and * standardized coefficients significant at a P value < 0.05

Table 7.2 Summary of findings for Malaysia

	Models													
Variables	Main	A1	A2	A3	A4	B1	B3	B4	C1	C2	C3	C4	C5	C6
Economic Dev.			0.939***	0.933**	0.743***			0.612***						
Innovation Input	0.585***				0.341*								0.556***	
Technology output		0.317**										0.780*	0.304**	0.423***
Scientific output	0.776**	0.716***	0.869***											0.556***
Openness	0.287**								-0.376**	0.481*	0.466***			
Human Capital	0.821***					0.901***		0.348**	1.123**		1.111***			
Infrastructure	1.116***					1.016***	1.142**		1.007***	0.563**	1.186***			
R^2		89%	63%	53%	89%		91%	97%				53%	93%	93%
F ratio		46.878***	15.242***	24.558***	45.010***		59.76***	208.88***				6.418**	72.24***	78.36***

Note: Table 7.2 shows the coefficients of variables in each model at significant levels of: *** standardized coefficients significant at a P value < 0.001,** standardized coefficients significant at a P value < 0.01 and * standardized coefficients significant at a P value < 0.05

may be accompanied by 0.82% and 1.12 % increase in GDP per capita respectively for Malaysia.

Malaysia has consistently emphasized on education since 1970 as a tool for nation building and this was further inspired by their Millennium Development Goals for universal education. On the other hand, Ghana's commitment to education was strengthened in the 1980's through the structural adjustment program by the Government of Ghana and was also further inspired by its Vision 2020 and Millennium Development Goals for education. Therefore, both countries acknowledge the importance of education to their economic development and this was reflected in the results of both countries. The results for Ghana indicated that both secondary and tertiary enrollment ratio significantly impacted on economic development of Ghana, while only tertiary enrolment was significant for Malaysia. The possible explanation may be due to the stages of economic development and nature of economy of both countries. Ghana is still an agriculture based economy in the process of transforming into an industrial one, therefore the country requires more skilled and knowledge labor in order to actualize this transformation. Therefore, secondary and tertiary enrollment ratios are significant to its growth; assuming skilled labor is produced by secondary education institutions and knowledge workers are produced by universities. Ghana then needs to re-enforce its commitments to expanding and improving upon these institutions. On the other hand, Malaysia's economy is at the stage where skilled labor has reached its critical mass but knowledge workers are still very critical to its growth, thus the current composition of secondary enrollment ratio of Malaysia was insignificant to its economic development.

Therefore, both countries must expand higher education opportunities in order to boost the number knowledge workers in their economies, specifically in the areas of science and technology research. But Ghana needs to do much more in the area of secondary enrollment, since skilled labor still remains a necessary requirement for its growth. Malaysia restructured its higher education system in the 1990s and just recently in the Eight Malaysia Plan of Malaysia (2000-2005), about 47% of development expenditure for education was assigned to tertiary education (Day & Muhammad, 2011). Ghana too, could take a cue from this.

The contributions of infrastructure of Malaysia on its national innovation system are very remarkable. This is because of the fact that both the number of kilowatt electricity consumed per capita and number of telephone users per 100 people representing the energy and technology infrastructure of Malaysia were both significant to its growth. Malaysia has made large investment into infrastructure in the areas of telecommunication, transport and energy to match up with its industrialization (OECD, 2013) such that Malaysia could boast its infrastructure comparable to that of developed economies, e.g. Kuala Lumpur International Airport, Bakun Hydroelectric Dam etc. On the other hand, Ghana's infrastructure is rather detrimental to its growth. The results for the variable representing energy infrastructure of Ghana recorded a significantly negative coefficient (-0.24) meaning that for every 1% increase in the number of kilowatt electricity consumed per capita in Ghana, economic development for Ghana decreases by 0.24%. The possible explanation is that electricity production in Ghana is mainly based on hydropower generation which is not enough to meet the demand of the continuously rising population; resulting in periodic power blackouts that leave economic activities in the country in despair. Furthermore, the situation has forced the country to rely on expensive oil-based generation and since there is no mechanism for automatic tariff adjustments, the situation generates annual financial losses for the Government (Africa Infrastructure Country Diagnostic (AICD), 2010). Thus, any attempt to increase electricity consumption either leads to more power surges and annual financial losses for the Government. Moreover, Ghana is recently making head way in the development in its telecommunication infrastructure (STIPR, 2011), but this variable, in terms of number of telephone users per 100 people also remained insignificant to economic development of Ghana. In view of these findings, Ghana should seriously start placing much priority on the enhancement of the quantity and quality of its infrastructure endowments.

Research and development expenditure of Malaysia significantly impacts on its economic development, but that was not the case for Ghana probably because of the Agricultural R&D data used as proxy for total R&D expenditure of Ghana and this variable did not include R&D expenditures in other sectors of the economy. In any case, with Ghana still being an agriculture based economy with over 60% of its population still involved in agricultural activities (World Bank, 2012), one would expect that R&D expenditures in agriculture would impact on growth. Meanwhile, the positive impact of the number of scientific and technical articles on GDP per capita for both Ghana and Malaysia is an indication of the important role knowledge innovations is playing in both economies. However, the figures for Ghana are far lesser than that of Malaysia. For example, on average the number of scientific and technical articles produced by Ghana from 1990 to 2010 was about a 1/7th of that produced by Malaysia within the same period. Ghana therefore needs to seriously consider increasing its research activities in order to improve on this indicator and one way of doing this is by placing more emphasis on higher education and research. The government of Malaysia currently aims at spending up to 1% of its GDP on R&D by 2015. This is quiet an effort being made by Malaysia to promote R&D even though the amount is a reduction on the previous target of 1.5% set in the Ninth Malaysia Plan (2006-2010) (Day and Muhammad, 2011). Ghana could also show much commitment to research activities in other ways. Besides, it is also crucial for both countries to have a secured funding base for all science, technology and innovation activities and ensure the presence agencies that could monitor the progress of these activities. The Malaysian Science and Technology Information Center (MASTIC) established in 1992 has been very beneficial in tracking Malaysia's progress in the area of science, technology and innovation research (Day & Muhammad, 2011), however, such an institution is lacking in Ghana.

7.2 Discussion of the results on Dynamics of Innovative Capacity of Ghana and Malaysia (Models A1 to A4, Chapter 3)

Results for this section gives further information on the initial model, specifically detailed information about the internal dynamics of innovative capacity or creative capacity of Ghana and Malaysia, thereby showing the differences in the capabilities of the national innovation systems in both countries to create innovations. The results of the models under discussion here are Models A1 to A4 in tables 6.3.1 and 6.3.2 in Chapter 6. The summarized results in table 7.1 indicate that, not only does Scientific Output impact significantly on Economic Development, but also the level Economic Development has a reverse significant impact on Scientific Output for Ghana. These are shown in Models A1 and A4 respectively. Even though model A1 has a lesser R^2 of 77% compared to the R^2 of 96% for the main model, the coefficient of Scientific Output increased by 95.78% from 0.45 to 0.88. The reverse impact of economic development also means that, for any 1% rise in GDP per capita of Ghana, Scientific and Technical Publications in Ghana would also rise by 0.88%. On the other hand, the findings for Malaysia also indicated that the level of Economic Development significantly impacts positively on Innovation Inputs, Technology Outputs and Scientific Outputs. The reverse is also true for Technology Outputs and Scientific Outputs but not for Innovative Inputs. Technology Output was not significant in the main model but turned out to be significant when variables for Openness, Human Capital and Infrastructure are taken out from the equation. Meanwhile, the coefficient for Scientific Output also dropped by 7.7% from 0.78 for the main model to 0.72 for model A1. Both results for Ghana and Malaysia confirm the findings of Castellacci & Natera (2013) on developing and middle-income economies respectively. Overall, the results imply that the overall performance of the NIS of both countries, in the form of GDP per capita is very vital to enhancing the creative capacity of both countries.

Furthermore all variables measuring the innovative capacity of Ghana showed no significant relationships with each other and this is contrary to the findings of Castellacci & Natera (2013), since their results indicated technological outputs significantly impacting on innovation inputs for developing countries. But the variable for technology outputs measured by patent application for Ghana was omitted from this research due to inadequate data. On the other hand the results for Malaysia indicated significantly positive bidirectional relationship between Innovation Inputs and Scientific Output as can be seen in Models A2 and A4 respectively in Table 7.2, which was totally different from the finding of Castellacci & Natera (2013) for middle-income countries. The possible explanation for this may be due to the Malaysian government's increasing focus on patent research within institutions of higher learning and government research institutes and the use of incentive schemes by the government to induce research in Malaysia (Day & Muhammad, 2011). Moreover according to Day & Muhammad (2011), a little bit of attention should be shifted from building stronger research base within universities to enhancing linkages between industry and academia since that is one of the most effective ways of enhancing quality of research and developments, thereby enhancing a nation's creative or innovative capacity. Therefore, as Ghana improves upon its research capacity and its industries; it could also focus on promoting collaborations between them.

7.3 Discussion of the results for Dynamics of absorptive Capacity, Openness and Diffusion Capacity for Ghana and Malaysia (Models B1 to B4, Chapter 3)

The discussion in this section gives a clearer picture of the dynamics of Absorptive Capacity, Openness and Diffusion when variables of Innovative Capacity are taken out of the equation, thereby giving more information on the main model, and also information about the similarities and differences in the absorptive capacity, diffusive capacity and openness of the national innovation system of both countries. The results in table 7.1 indicate that Openness (Trade, FDI) has no significant relationship with Economic Development of both Ghana and Malaysia for the main model. However, the results for Ghana shown in model B1 indicate that both variables for Openness, i.e. Trade as % of GDP and FDI, significantly impact on Economic Development of Ghana. This confirms the results of Fagerberg and Srholec (2007) and Castellacci and Netera (2013). The latter implied that for every 1% rise in trade may be accompanied by 0.35% rise in GDP per capita and the former implied that 1% rise in FDI may also be accompanied by 0.21% increase in GDP per capita of Ghana. On other hand, both indicators still showed no significant relationship with Economic Development of Malaysia, which makes sense, since FDI is no more an important contributor to Malaysia's growth even though it was once the main inducer of Malaysia's Industrialization in the 1970's and 1980's (OECD, 2013). Therefore, openness of the national innovation system of Ghana cannot be ignored at this stage of Ghana's development. Furthermore, Ghana is at a stage of economic development where the role of trade and FDI needs to be emphasized if it is to catch up with the likes of Malaysia. The structural transformation of Malaysia from an agricultural economy towards manufacturing and export-oriented economy in the 1970's, coupled with generous incentives, tax reliefs and subsidized investment loans was what did the trick for Malaysia. Ghana, on the other hand, after failing an industrialization attempt under the Kwame Nkrumah's Seven-Year Development Plan (1963-1970) has remained an agriculture-based economy till today. Therefore, Ghana needs to place more emphasis on the role of FDI and International trade in its quest to transforming its economy.

The impact of Human Capital on Economic Development still remained significant for Ghana and unchanged from the results in the main model. Nevertheless, the coefficient increased by 47.1% from 0.54 to 0.79. On the other hand, the results for Malaysia also remained unchanged from the results in the main model with Human Capital significantly impacting on Economic Development. Furthermore, the results also indicated that the level of Economic Development for both countries also significantly impacts on Human Capital and Openness for Ghana and on Human capital and Infrastructure for Malaysia. This completely confirms the findings of Castellacci and Netera (2013) in the case of Ghana, but only confirms partially for Malaysia with regards to Economic Development impacting on Infrastructure. This implies that overall, the good performance of the national innovation system of Ghana would attract even more FDI, increase trade and enhance education enrollments. That of Malaysia would also enhance education enrollment and further improve its infrastructure.

Finally, in terms of the relationship between Human Capital, Openness and Diffusion, Human Capital and Openness significantly impact on each other negatively for Ghana and Human Capital and Infrastructure significantly impact on each other positively for Malaysia. The finding for Malaysia completely confirms the results of Castellacci and Netera (2013) on middle-income countries. The possible explanation for Ghana's situation is that, since the economy of Ghana is still largely agriculture-based, a bigger percentage of international trade done by the country is on agricultural products, which over 60% of the population in Ghana are engaged in. To increase this kind of trade means that many more people would have to forfeit higher education and to increase higher education enrollment would also mean that many more people would have to leave the farms to schools. Therefore, seemingly the way out for Ghana is to focus on transforming its economy towards a manufacturing and industrial economy as Malaysia did in the 70's. This way, Ghana could still increase trade and higher education enrollments without compromising one for the other. Malaysia's case is quite obvious, since better infrastructure attracts more high technology industries that require more skilled human resources, thus increasing the need for higher education.

7.4 Discussion on the results for Interrelationships between Innovative Capacity and Absorptive Capacity, Openness & Diffusion capacity of Ghana and Malaysia (Model C1 to C6, Chapter 3)

This section gives more information on the interrelationships between the variables for Innovative Capacity and the variables for Absorptive Capacity, Openness and Diffusion for both countries. The summary of results for Ghana in Table 7.1 for Model C1 indicates that Openness significantly impacts negatively on Innovation Inputs and Infrastructure significantly impacts negatively on Innovative Inputs. On the other hand, Malaysia's result in Table 7.2 for model C1 indicates that Openness, Human Capital and Infrastructure all significantly impact on Innovative Inputs and all impact positively, except for Openness. The reverse is only true for Human Capital, however only the impact of Innovation Inputs on Infrastructure confirms the findings of Castellacci and Netera (2013). Trade and R&D expenditure having a significant negative relationship for both Ghana and Malaysia may imply that increasing trade between catching up and developed countries could be a disincentive for catching-up countries in pursuing local research and developments. For example, Ghana normally exports raw agricultural products and natural resources to its developed partners in exchange for manufactured and high technology products. This trend harms the development of local industries that otherwise would have engaged in R&D's in the country. For Malaysia, the results seem less problematic since the country is already into high tech exports. But in actual fact, the R&D expenditure of Malaysia used in this study was only public R&D expenditures that exclude R&D expenditures made by manufacturing and high technology companies operating in Malaysia. Besides, most of these companies are foreign based, implying that their research and developments might not be done in Malaysia at all. Therefore, even though Malaysia may be exporting high technological products, it may not mean that its local companies are involved.

Meanwhile, Openness and Infrastructure also showed a bidirectional relationship with Technological Outputs of Malaysia as shown in Model C2, C4 and C6 for Malaysia thus confirming the results of Castellacci and Netera (2013). Such findings were not realized for Ghana since the variable Technology Output was omitted from the analysis. This is not surprising since Ghana's energy infrastructure still remains a huge challenge for the country and the lack of data on technology outputs for Ghana even complicates the problems since the contributions of industries in Ghana are not known. Ghana must therefore improve on its infrastructure in order to attract these industries in the first place. Finally, Openness and Human Capital significantly impact positively on Scientific Output and vice versa for Ghana in models C3, C4 and C5. On the other hand, Openness, Human Capital and Infrastructure also impact positively on Scientific Output for Malaysia and the reverse is only true for Infrastructure. Therefore, as discussed earlier, higher education and research institutions linked to industries and enhancement of Infrastructure may be the ways forward for Ghana since these variables complement each other.

7.5 Conclusions

This study has argued that aside from some geographic and sociocultural similarities between Ghana and Malaysia, both countries were roughly at the same level of economic development at the time of gaining independence from the British. Today, however, the level of divergence between Ghana and Malaysia is so wide that the former was categorized as a lower income country and the latter an upper-middle income country. However recently, the Ghana Statistical Service in 2010 rebased the national accounts of Ghana by changing the base year, methodologies and also did some data revisions (Kwakye, 2012). This exercise elevated Ghana's status to a lower-middle income country in the 2012 list of economies by the World Bank. This recent development has generated a lot of debate relating to the middle-income status qualification for Ghana. As a result, this study has maintained Ghana's status as lower-income country throughout all of its chapters, but also aimed to verify the middle-income status claim by Ghana via the comparisons of the results for Ghana with the findings in the literature.

This study aimed at assessing the creative, absorptive and diffusive capabilities of the NIS's of Ghana and Malaysia in order to ascertain evidence of paths and performance to their economic development. This is in order to draw lessons for Ghana based on Malaysia's experience. Based on the conceptual framework inferred from the literature, the study made use of indicators measuring innovative capacity, absorptive capacity, openness, diffusion and economic development using annual time series data of 21 years in the period 1990 to 2010 for both Ghana and Malaysia and assessed the impact of innovative capacity, absorptive capacity, openness and diffusion on economic development of Ghana and Malaysia. The study also further explored the extent to which these factors sustain the growth of one another in order to gain more information on the interaction within both systems and system differences. The statistical technique utilized was a series of multiple linear regressions models. The variables that were statistically significant attracted the attention of the researcher in respect of their role in the NIS and the extent to which they help understand the divergence between the two countries. The models in chapter 3 for this research were tested and established, and accordingly statistical inferences were made, resulting in a series of conclusions as summarized in Table 7.5 below.

Table 7.5.1 Summary of Conclusions

Variables	Conclusions for Ghana	Conclusions for Malaysia
Economic Development	Is driven by Scientific Output, Human Capital, Openness, but hindered by Infrastructure.	Is driven by Innovation Inputs, Scientific Outputs, Human Capital, Openness and Infrastructure
Innovation Inputs	Is hindered by Openness and Infrastructure	Is driven by level of Economic Development, Human Capital, scientific Outputs and Infrastructure but hindered by Openness.
Technology Output	Omitted from the analysis due to lack of data.	Is driven by Level of Economic Development, Scientific Outputs, Openness and Infrastructure
Scientific Output	Is driven by level of Economic Development, Openness and Human Capital	Is driven by level of Economic Development, Innovation Inputs, and Human Capital, but hindered by and Openness.
Openness	Is driven by level of Economic Development and Scientific outputs, but hindered by Human Capital and Innovation Inputs	Is driven by Scientific Outputs
Human Capital	Is driven by the level of Economic Development, Innovation Inputs and Scientific Outputs, but hindered by Openness	Is driven by Infrastructure, Innovation Inputs and Technology Outputs.
Infrastructure	Is driven by Scientific Outputs but hindered by Innovation Inputs	Is driven by level of Economic Development, Human Capital, Technological Output and Scientific Outputs.

The overall inference from these conclusions is that the national innovation system of Ghana lacks the capability to diffuse innovations and even though it has some capability to create and utilize innovations, these cannot be match to that of Malaysia in terms of the impact of the elements and the level of interaction in the national innovation system of Malaysia.

The impact of Human Capital and Scientific Output on the national innovation systems is similar in both countries but since the numbers and quality of Human Capital and Scientific Outputs produced by Malaysia are better Ghana, Ghana could draw lessons from Malaysia's experiences in this regard. The main difference between the two countries relates to the intensity of diffusion of innovations, i.e. the role played by infrastructure of both countries. The bottom line is, the national innovation system of Malaysia has the capability to diffuse innovations while that of Ghana does not and this is one of the possible explanations for the divergence between the two countries. This, thus, supports the assertion by Dagaba (2012) that the difference in Ghana's and Malaysia's development trajectories could be attributed, in greater part, to the emphasis on the role of technology and knowledge in its industrial policies and the pursuance of the knowledge based development model pursued by Malaysia which Ghana did not. Therefore, for Ghana to catch up to the likes of Malaysia, it must also start focusing on the role of technology and knowledge in its economy by investing heavily into knowledge and technology creation activities, specifically in the areas of human capital developments, research and infrastructure. Furthermore, Ghana should also pay particular attention to its power and Information Communication Technology (ICT) infrastructures. Table 7.5.2 shows a summary of major policies or path strategies that have brought Malaysia this far, which could give Ghana some perspectives.

Table 7.5.2 Summary of Malaysia's Major Success Strategies

Target	Strategy
Diversification and Export-led growth	Malaysia diversified its agricultural sector by raising the productivity and diversification from tin and rubber into oil palm and further diversified from agriculture to manufacturing industries, thus focusing on the export of manufactured products.
Openness	Malaysia focused on international trade and long-term capital flows via aggressive promotion of FDI's, granting generous fiscal incentives, establishment of Free Trade Zones
Human Capital	Large investments into education and education sector transformations, coupled with encouragement of the private sector with more emphasis on 60: 40 ratio in favor of science-based studies at doctoral level.
Industrial policies and Infrastructure	Supported industrial policies with large investments into infrastructure such as industrial estates, telecommunications, transport and power.
Governance	A united government vision with detailed plans targeting all sectors, political commitment and focus on equitable distribution of wealth.
Innovation Inputs	The establishment of science and technology funding systems such as the Science Fund, the Strategic Thrusts of Research Areas program and the TechnoFund.
Scientific Outputs and Technology Outputs	Implementation of incentive schemes for patent research within institutions of higher learning's and government research institutions and establishment of science and technology research centers and high-tech clusters.

Source: Yusof, (2010); OECD, (2013) and Day and Muhammad, (2011)

Moreover, the findings also indicated the extent to which elements of the NIS's of both countries depend on each other, thus any change in one component in the NIS impacts on other components in the system. This shows that interactions and links within the national innovation system of Ghana and Malaysia are different and each system might be unique. This confirms the findings of Fagerberg and Srholec (2007) and Castellacci and Netera (2013) on the differences in the national innovation systems of middle income and developing countries. In addition, even though Ghana was recently considered a lower middle income country, the findings for Ghana as confirmed by the work of Fagerberg and Srholec (2007) and Castellacci and Netera (2013) indicate that the country at the present still has some features of a developing country.

The study therefore cautions that even though Ghana draws lessons from Malaysia's experience or any other country for that matter, or even when policy makers are formulating solutions for Ghana, they should try as much as possible to take into consideration the network effects of such policies since situations and conditions in Ghana may be different from other countries. It is therefore concluded that the research has achieved the objectives that it set forward. In the future, a holistic study of the national innovation systems of Ghana and Malaysia should be done separately based on a survey to collect more representative data on science, technology and innovation activities of both countries, which are not available in this research.

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APPENDIX: ADDITIONAL INFORMATION

Appendix A: National Innovation System of Ghana

A1.0 Introduction

Ghana as a nation has great potential of achieving good growth in the long term future according to the analytical works of Bogeti et al., (2008). Ghana's economy is still classified as "factor driven by the 2012-2013 Global Competitiveness Report of The World Economic Forum. This means that Ghana has a "minimal capacity to innovate and do not add much value to the goods and services they produce, have unsophisticated local enterprises with limited managerial and organizational capacity and minimal commercial and technological links to the global economy, and uses low-wage, poorly educated, unskilled labor to produce and export unprocessed raw materials" (STIPR, 2011 p.19). Even though some of these descriptions may be over exaggerated in reference to Ghana, the fact still remains that Ghana needs to improve on its productivity and competiveness or shift its economy to efficiency or innovation driven if it needs to accelerate its growth and achieve its medium term development plan (Vision 2020: "modern economy based on the development of science and technology" by the national development planning of Ghana). Table 1.0 show shows Ghana's rank in terms competitiveness by the World Economic Forum, Global Competitiveness Report 2009–2013

Table 1.0: Ghana's Competitive Rankings

Pillars	Ranking in 2008 (out of 134)	Ranking in 2009 (out of 133)	Ranking in 2010 (out of 133)	Ranking in 2011 (out of 142)	Ranking in 2012 (out of 144)
Basic Requirements					
Institutions	63	68	67	61	75
Infrastructure	82	87	106	110	110
Macro-Economic stability	121	129	136	139	108
Health and Primary education	115	115	122	124	112
Efficiency Enhancers					
Higher Education and training	111	108	108	109	107
Goods market efficiency	97	91	75	72	76
Labor Market efficiency	108	100	93	79	97
Financial market sophistication	69	59	60	61	59
Technological readiness	115	112	117	113	108
Market size	86	86	83	81	70
Innovation and Sophistication Factors					
Business Sophistication	98	98	97	99	102
Innovation	114	115	99	98	95

Source: World Economic Forum, Global Competitiveness Report 2009–2013. Note: The top ranking is 1, which means more competitive.

A2.0 Main Actors in the National Innovation System of Ghana

The current state of Ghana's NIS is comprised of at least 20 research and development (R&D) institutes, 7 public universities, 40 private universities, 10 public polytechnics, many technical institutes, several technology support and regulatory agencies, and standardized intellectual property (IP) legislation which was recently amended in December 2009[3] (NSTIP, 2010).

[3] Copyright Act, 2005 (Act 690), a copy could be downloaded from http://www.wipo.int/wipolex/en/details.jsp?id=9790

A2.1 R&D Institutions

Research and developments in Ghana have predominantly been responsive to problems in Ghana such as sanitation, road accidents, Natural disasters, employment, environment etc. The CSIR in particular have made very significant contributions to R&D's in the Agricultural sector of Ghana in terms of agricultural Innovations. However the links between these research institutions and industries are not very encouraging (STIPR, 2011). Table 2.1.1 shows the bulk of agricultural technologies generated in Ghana identified through desk review and scientific survey by Rheenen et al., (2012). Most of the 109 agricultural technologies identified were developed by CSIR Ghana.

Table 2.1.1 Agricultural Technologies generated in Ghana in 2011

Institution	No. of agricultural Technology	Percentage (%)
CSIR	99	91.8
University of Ghana	5	4.6
KNUST	2	1.8
UDS	2	1.8
UEW	1	0.9
Total	109	100

Source: Rheenen et al., (2012)

All other sectors normally look up to the research institutions for solutions but these institutions (showed in Table 2.1.2 and 2.1.3) do not have the financial strength to carry out the most needed research in Ghana (Toprah, 2011). Tables 2.1.2 and 2.1.3 shows a list of various research institutions in Ghana, however table 2.1.2 shows the list of research institutions that operate under the Center for scientific and Industrial Research in Ghana (CSIR).

Table 2.1.2 Research Institutions under the Center for Scientific and Industrial Research Ghana (CSIR)

Research Institution	URL	Year Est.	Divisions
Science and Technology Policy Research Institute (TPRI)	www.csirstepri.org	1981	-Agriculture, -Medicine and Environment Division (AMED) -Industry and Services Division (ISD) -Commercialization and Information Division (CID)
Animal Research Institute (ARI)	www.csirari.org	1957	
Crop Research Institute (CRI)	www.cropsresearch.org	1964	-Cereals division -Legumes division -Roots and tubers division -Horticultural crops division -Plantain and Banana division -Tropical fruits division -Vegetables division -Industrial crops division
Food Research Institute (FRI)		1963	-Food Microbiology -Food Chemistry -Food Processing and Engineering -Business Development and Information
Oil Palm Institute (OPI)	www.csir.org.gh		
Savannah Agricultural Research Institute (SARI)	www.csir.org.gh	1947	
Building and Road Research Institute (BRRI)	www.brri.org	1952	-Materials -Geotechnical Engineering -Structures, Planning and Design -Traffic and Transportation -Construction -Commercialization & Information
Institute for Scientific and Technological Information (ISTI)	www.csir.org.gh	1968	
Soil Research Institute (SRI)	http://www.csir-soilresearch.org	1962	-Soil Genesis, Survey and Classification -Soil Chemistry, Fertility and Plant Nutrition -Soil and Water Management -Soil Microbiology -Laboratory Analytical Services -Commercial and Information
Plant Genetic Resources Centre (PGRC)	www.csir.org.gh	1964	
Forestry Research Institute of Ghana (FRIG)	csir-forig.org.gh	1962	
Water Research Institute (WRI)	www.csir-water.com	1996	-Commercialization & Information -Environmental Chemistry Division -Fishery Division -Surface Water Division -Ground Water Division -Environmental Biology & Health

Source: CSIR Ghana Website

Table 2.1.3 Other Government Research Institutions

Research Institution	URL	Year Established.
Ghana Atomic Energy Commission	http://www.gaecgh.org	**1963**
Cocoa Research Institute of Ghana	http://www.cocobod.gh/ cocoa_research.php	**1938**
Marine Fisheries Research Division	http://mofa.gov.gh/site/?page_id=244	**1962**
Ghana Space Science and Technology Center		**2012**
Noguchi Memorial Institute For Medical Research	http://www.noguchimedres.org/	**1979**
Ghana Regional Appropriate Technology Industrial Service (GRATIS)		**1987**
Foundation, the Ghana Institute of Clinical Genetics, and the Centre for Scientific Research into Plant Medicine (CSRPM)		**1975**
Environmental Protection Agency (EPA)	http://www.epa.gov.gh/	**1974**

Source: ASTI Ghana website; STIPR, (2011)

Public R&D's are also conducted in the public universities in Ghana such as the University of Ghana, Kwame Nkrumah University of Science and Technology (KNUST), University of Cape Coast (UCC), University of Mines and Technology at Tarkwa (UMAT), and the Ghana Telecom University College (GTUC) and these universities in some cases work closely with the CSIR and the other public R&D institutions.

A2.2 Education

According to Dzisah (2006), the education system of Ghana had focused on producing graduates for the agricultural sector, the civil service and training of missionaries because it was designed to satisfy the intent of the colonial government. Thus scientific and technical education that would lead to innovation was not then, the priority of the colonial government. This structure remained unchanged until 1987 when the then Provisional National Defense Council (PNDC) government implemented policies that increased the number of enrollment and also placed emphasis on technical education. Even though the number of enrollments has increased, the Global Competitiveness report (2008-2011) illustrates that in terms of technology readiness and innovation, Ghana is still ranked above 100. Implying that Ghana still lacks the most important skills in science, mathematics and engineering that could boost creative innovations.

As of the year 2009, the total number of accredited public and private tertiary institution by the National Accreditation Board (NAB) of Ghana stands at126. Table 2.2.1 shows the number of these instructions in Ghana.

Table 2.2.1: List of Accredited Tertiary Education Institutions as of February, 2009

Type of Institution	Total Number
Public Universities	6
Other Public Tertiary Institutions	2
Chartered* Private Tertiary Institutions	4
Private Tertiary Institutions	45
Polytechnics (all public)	10
Public Teacher Training Colleges**	38
Private Teacher Training Colleges	1
Public Nursing Training Colleges	14
Private Nursing Training Colleges	4
Total	124

*granted Presidential authority to award qualifications, **Now colleges of Education

Source: NAB 2009, retrieved from World Bank Report on Ghana, 2008.

Table 2.2.2 shows the list of public universities and their proportions of science and technology enrollments to arts.

Table 2.2.2 List of public institutions and proportions of enrollments 2003-2009

Year	2002/2003		2003/2004		2004/2005		2005/2006		2006/2007		2007/2008	
Institution	ARTS	SCI	ARTS	SCI	ARTS	SCI	ARTS	SCI	ARTS	SCI	ARTS	SCI
University of Ghana	14331	3562	19665	4233	22686	4728	23467	5015	22249	5987	22627	6293
Univ. of Sci & Tech.	3438	8538	3946	9445	6245	9901	7001	12922	8633	13927	9892	13974
Univ. of Cape Coast	9331	2306	9913	2822	11031	2510	13116	3974	12730	4242	12436	4399
Univ. Coll. Of Education	7927	1982	7461	2454	6004	5492	8338	4124	8227	4860	9830	5548
Univ for Dev. Studies	748	1048	1250	1515	1846	2102	2533	2731	3211	3418	3787	4104
UMaT	0	684	0	872	0	863	0	857	0	961	0	1083
Total	35775	18120	42235	21341	47812	25596	54455	29623	55050	33395	58572	35401

Source: Ministry of Education of Ghana (MoE), Education Sector Performance Report, 2010

Higher education enrollment in Ghana has shifted heavily in favor of the humanities despites the government's attempt to achieve a ratio of 60:40 for science and humanities education respectively by the year 2020 (MoE, Education Sector Performance Report, 2010). This was still the case in the year 2008. Figure 2.2.1 shows a breakdown of the output structure of Ghana's Universities from 2001 to 2004.

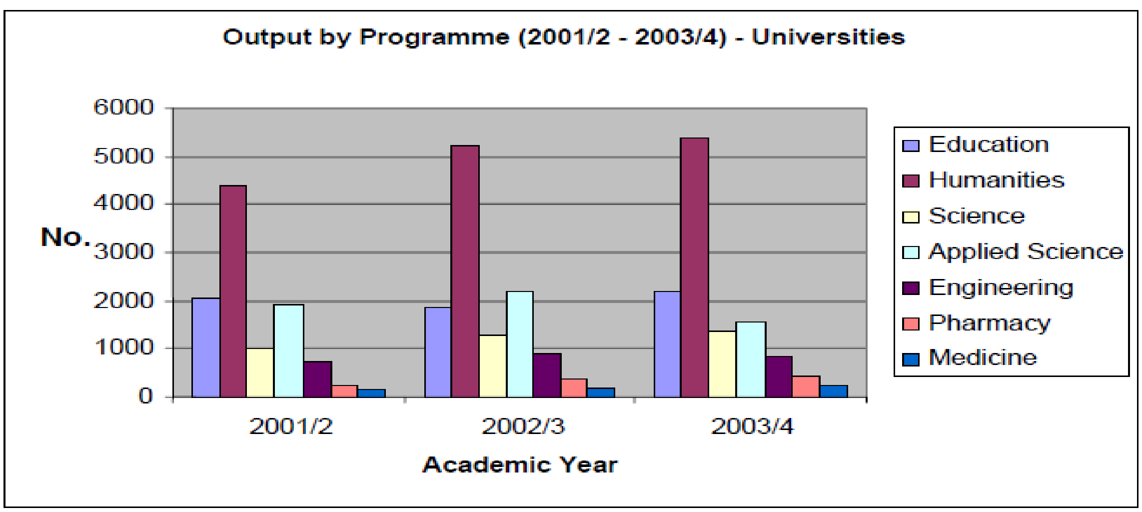

Fig 2.2.1 University Output by field of Study in Ghana (2001-2004)

Source: Gondwe & Walenkamp (2011)

Below is the list of polytechnics in Ghana;

- Kumasi Polytechnic

- Sunyani Polytechnic
- Koforidua Polytechnic
- Ho Polytechnic
- Takoradi Polytechnic
- Cape Coast Polytechnic
- Accra Polytechnic
- Wa Polytechnic
- Bolgatanga Polytechnic
- Tamale Polytechnic
- Archbishop Porter's Polytechnic

The situation is not different for the polytechnics in Ghana even though they were established with a main mandate to promote science and technical education. This is further explained in Figure 2.2.2

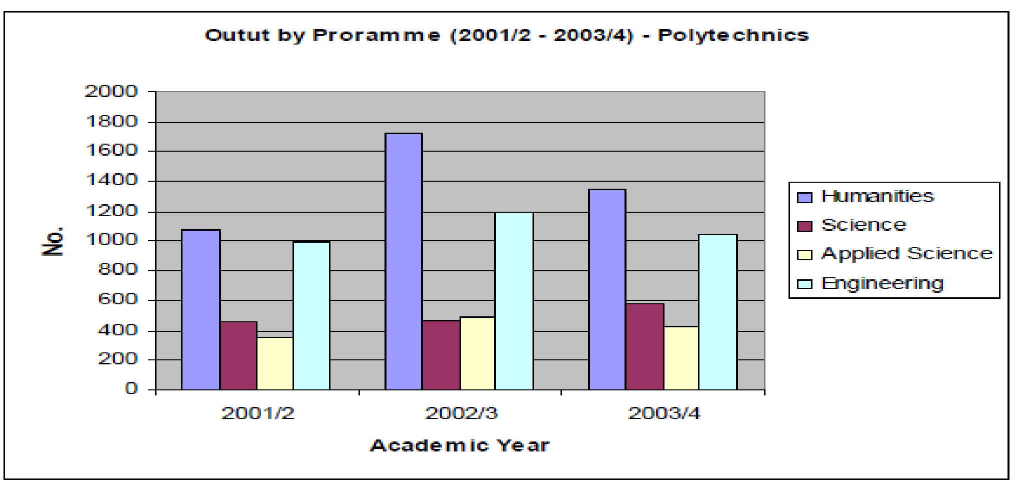

Figure 2.2.2 Polytechnics output by field of study (2001-2004)
Source: Gondwe & Walenkamp (2011)

According to the Education Sector Performance Report, 2010 of the Ministry of Education of Ghana, total enrollment of 64,155 for the year 2010 was recorded for both public and private

Technical and Vocational Institutions in Ghana and there are over 290 of these institutions in country, however they have been categorized into the following;

- GES Technical Institute
- NVTI Centers
- Integrated Community Centers for employable skills (ICCES)
- Social Welfare Centers
- Leadership Training Institutes
- Opportunities Industrialization Centers (OIC)
- Community Development Centers
- Agriculture Training Institute
- Roads & Transport Training centers

In conclusion, the major problem in the Ghanaian tertiary education system is how to manage the increasing number of enrollments. The public universities are under continuous pressure to absorb the increasing number of student populations and this has largely affected the quality of education and research in these institutions (STIPR, 2011).

A2.3 Infrastructure

Ghana may currently have advanced infrastructure platform compared with other low-income countries in Africa, however since the country is now a lower middle income country, it will need to focus more on upgrading its infrastructure indicators in line with that benchmark. According to Africa Infrastructure Country Diagnostic (AICD) (2010), Ghana already spends a share of 7.5% of its GDP on Infrastructure every year and for the period 2003 to 2007; Ghana infrastructure added just over 1% point to its per capita growth. This indicates the poor state of

Ghana infrastructure as it currently playing very little role in the nations development. Most the problems with Ghana infrastructure are associated with power and water with the former alone causing the country about $ 1.1 billion each year due to inefficiencies mostly associated with power underpricing. Furthermore according to AICD (2010) addressing Ghana's infrastructure challenge will cost the country 20% of its GDP every year, which would be very difficult to attain under the current situation. Nonetheless raising the country's infrastructure to the level of that of middle income countries could boost annual growth of Ghana's GDP by more than 2.7 percent according to AICD (2010)

A2.4 Industry

The Industrial sector of Ghana comprises of mining and quarrying, manufacturing, service and construction subsectors (STIPR, 2008) and according the Ghana Investment Promotion Center (GIPC), the number of manufacturing firms from 1994 to 2004 with foreign ownership and presence in Ghana were 300, constituting 27.68 % of manufacturing firms in Ghana. Table 2.4.1 shows the distribution of manufacturing in Ghana by the Ghana statistical service (2002), retrieved from Mohammed & Alorvor (2004)

Table 2.4.1 Manufacturing Distribution in Ghana (2002)

Sector	Percentage (%)
Non-ferrous metal basic industries	10
Chemical products other than petroleum	7
Petroleum	19
Sawmill & wood	7
Textile, Wearing apparel & Leather	14
Tobacco	8
Beverages	8
Food	16
Others	11

Source: Ghana Statistical service (2002), Retrieved from Mohammed & Alorvor (2004)

Data from the World Bank website indicates that the industrial sector of Ghana accounted for approximately 24.3% of the total GDP of Ghana in the year 2011, whiles the same sector and manufacturing sector experienced 42.6 % and 3.4 % respectively. This figures compared to other middle income countries are very low and needs to be improved. However the major problems facing the manufacturing sector of Ghana mostly has to do with the country's inefficient infrastructure endowments mainly in the energy sector, resulting to continuous energy crises in the country associated with frequent power cuts. Moreover foreign investors are discouraged by the high taxes and the imports of cheap goods from countries like china and India that are normally killing the Ghanaian Industries (STIPR, 2011).On the other hand, the service sector of Ghana in relation to the manufacturing sector is performing well, comprising 47.4% of the total GDP in the year 2011 and a growth rate of 6% in the same year according to data from the world bank. This sector is made up of the finance, tourism and insurance subsectors.

A3.1 Ghana's National Innovation system SWOT

STRENGTHS	WEAKNESSES
1. Political stability, openness and improved democratic governance 2. Good macroeconomic conditions and performance 3. Existence of R&D institutes 4. Existence of several technology support and regulatory agencies 5. A wide range of implicit innovation policies exist 6. Bilateral FDI agreements increasing 7. Existence of vibrant financial institutions 8. Increasing number of small and medium scale enterprises and presence of good foreign companies	1. Inadequate attention given to S&T and innovation issues by government 2. Economy relies on narrow range of traditional exports 3. R&D institutes under-resourced 4. Technology support and regulatory agencies not adequately funded and linked to R&D institutes 5. Lack of explicit innovation policy 6. Lack of strategy and institutional leadership to link up to systems abroad for technology transfer 7. Financial institutions are not strategically involved in or linked to R&D and technology programs
OPPORTUNITIES	THREATS
1. Presidential special initiatives are good basis for economic diversification and increasing FDI flows 2. Newly established S&T endowment fund 3. Government recognizes the need to strengthen institutions 4. Efforts to renew science and technology policy made. 5. Initiative such as NEPAD, AU and CAAST-Net focusing on Ghana and improving conditions for FDI and technology cooperation 6. Education and training system being reformed to put emphasis on science and engineering	1. Impact of global economic recession and financial crises 2. Lack of clear strategy and institutional leadership to build or improve R&D institutes 3. Absence of specific budgets dedicated to institutional strengthening 4. Weak institutional leadership of MEXT and lack of institutional leadership from Ghana to tap the regional and internal opportunities 5. No budget dedicated to science and engineering training and no clear strategy to improve infrastructure for R&D and engineering. 6. Poor physical infrastructure

Source: Science and Technology Policy Review of Ghana, UNCTAD, (2011, p. 53)

A4.1 Institutional Framework of Ghana's National Innovation system

The ministry of Environment, Science and Technology (MEXT) is the government body in charge of the management of science, technology and innovation in Ghana. The Ministry provides leadership to other ministries and science organizations in areas of science, technology and innovation (STI) development and application and also responsible for the management and implementation of all science, technology and innovation (STI) related policies. The Nerve center of MEXT is the Policy, Planning, Monitoring and Evaluation (PPME) directorate, which is responsible for policy formulation and the development of strategies for monitoring and evaluation of these policies. The directorate is also responsible for managing the process of the preparation of the ministry's budget. MEXT achieves its goals by working through the following departments and agencies:

- Council for Scientific and Industrial Research (CSIR)
- Ghana Atomic Energy Commission (GAEC)
- Environmental Protection Agency and; (EPA)
- Town and Country Planning Department (TCPD)

There is also an apex science Technology and Innovation (STI) body in Ghana in charge of promoting strong support for STI. The body serves as a Think Tank institution that provides the power for the formulation of national STI policies. The apex STI body is made up of actors that represent STI institutions in Ghana; these include government; research Institutions, Universities, the private sector and other relevant Institutions. The powers and authority of the apex STI body is not to undermine the powers of MEXT but rather to work together with MEXT to ensure that STI objectives are achieved. Figure 4.1 shows the breakdown of the science, technology and innovation framework of Ghana.

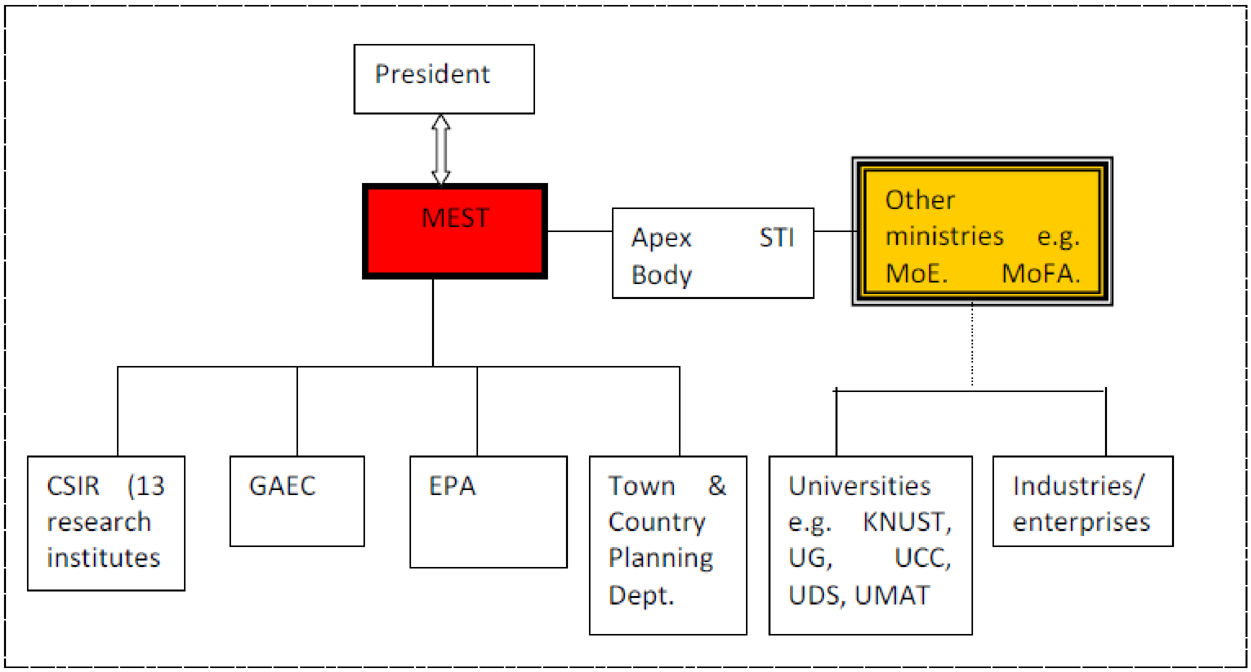

Fig 4.1: The Science, Technology and Innovation Framework of Ghana

Source MEXT, 2012

The National science, technology and innovation system of any country and for Ghana in this regard relies heavily on appropriate arrangement for funding. To ensure the availability of funds, the government of Ghana aside many arrangements, (such as promoting support to development in science and technology, strengthening and modifying STI institutions, promoting private sector participation etc.) is only able to ensure the allocation of an far below 1% of the total GDP of Ghana to support the science and technology sector. This amount is not enough to support any meaningful science and technology activity in Ghana. However other stakeholder institutions such as the GET-Fund and other research institutions are also important sources of funding.

A5.1 Linkages and Technology Transfer Institutions

The institutions responsible for technology support and regulations in Ghana are the Ghana Standards Board (GSB), Food and Drugs Board (FDB) and the Environmental Protection Agency (EPA). All manufacturing of food related products, pharmaceuticals, cosmetics and other useful chemicals are regulated by the FDB before they are being placed on the Ghanaian market. The GSB on the other hand is in charge of management of standardization issues in Ghana. Thus the GSB is responsible for the promotion of quality standards in Ghana. Another agency that plays a key role in supporting the development of technologies and innovative activities in Ghana is the Ghana Investment Promotion Center (GIPC).The GIPC promotes both foreign and domestic investors to engage in innovative entrepreneurial activities by disseminating information about investment opportunities and sources of investment capital. In general the GIPC is responsible for coordinating and monitoring all investment activities in Ghana. Also in terms of the management of all intellectual properties information and the enforcement of the Intellectual property laws of Ghana is the responsibility of the Registrar-General's Department in Ghana. The Ghana Free Zones Board (GFZB) is also in charge of the transfer of foreign technologies and innovations into Ghana and their diffusion. Furthermore in the area of supporting local innovative entrepreneurial activities (Micro and small-scale enterprises) is the responsibility of the National Board for Small-Scale Industries. Other institutions for technology support and regulation in Ghana are the Public Utilities Regulatory Commission (PURC), Ghana National Procurement Agency (GNPA), Ghana Export and Promotion Council etc.

A6.1 Science and Technology Policy regimes of Ghana

The promotion of science and technological activities were the least priorities of the colonial administrations, especially within the African colonies, nevertheless they established some research institutions which were to serve a number of the colonial territories and in this case, the British colonial territories. Ghana which was then called the Gold coast was lucky to be one of the locations for such institutions. After independence in 1957, Ghana was able to nationalize these institutions and they became the basis for scientific research (mostly agricultural and plant sciences). The first of these research institutions was the Aburi Agricultural Station (ABS), which was established in 1890 (see Tables 2.1.2 & 2.1.3 for rest of institutions). Ghana's plan to pursue the development of science and technology activities came soon after independence. For instance in the 1960's, a seven year development plan was formulated among others that laid emphasis modernization of agricultural activities and the rapid expansion of industrial activities and the complete improvement of the educational system to suit all sectors of the economy (see Ghana's Seven Year Development Plan, 1964). However as identified by Aryeetey et. al., (2001), these optimism and hope in the development of science and technology in Ghana was soon destroyed due to political interference by the military in its numerous coup d'états coupled by the poor economic performance up to the early 1980s.

For a nation to develop in the area of science and technology requires knowledge from different sectors of its economy. This means the responsibility to promote and develop science and technology activities does not lie on one single ministry. However one important trend of most African countries during the 1970s and 1980s was the establishments of a single ministry (Ministry of science and technology) for the managing and development of science and technology activities. (UNCTAD, 2007). For example, Ghana initially started the integration of science and technology into its national development plans through the establishment of the National Research council (NRC) on 14th February 1959, under the Research act of 1958 (No. 21).

However in September 1979, the Ministry of Industries, science and technology (MIST) was established which increased the organization of science and technology activities by bringing the Council for scientific and Industrial Research (CSIR) from under the Ministry of Finance and Economic planning (MFEP) to that of MIST. Later, MIST was renamed to Ministry of Environment, science and Technology (MEST) in 1990's and to Ministry of Environment and science (MES) in 2009. Currently, MES has been completely dissolved and the name changed to Ministry of Education, Science and Sport (MOESS). This clearly demonstrates the level of confusion in the policy direction and institutional governance structure for science and technology in Ghana. "*Indeed the frequency of changing the names of ministries and reassigning research-performing institutes under different ministries repeatedly has been very disruptive to a proper governance system."*(STIPR, 2011)

In the 1990s the government of Ghana started placing much priority on Science and technology developments through the adoption of the "Ghana-Vision 2020" whose policies are referred to as "The First Step" has the goal of making Ghana a middle-income country by the year 2020 (see The First Step: 1996-2000). A science and Technology policy document was further adopted by the parliament of Ghana in 2000 and a working paper document was prepared for its management, but this policy was not implemented until March 2004 that specific activities were spelt out for implementation. The implementation was however disrupted when the then Ministry of Environment, Science and Culture was absorbed by the current Ministry of Education, Science and Sports. The new National Science, Technology and Innovation Policy (NSTIP) was crafted and adopted in the year 2010 aimed at "integrating Science technology and Innovation (STI) into the national development strategies of Ghana in order to build a science and technology capacity that would achieve national objectives for poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth" (NSTIP, 2010 p. 16). The policy covers the major sectors of Ghana's economy including Agriculture, Health, Education, Environment, Energy, Trade, Industry, Natural Resources, Human Settlements and Communication.

Appendix B: National Innovation System of Malaysia

B1.0 Introduction

According to the World Bank (2007), impressive performance of Malaysia's economy is a true reflection of good macroeconomic management and political stability, as the country was able to manage very well the inflow of foreign direct investments (FDI's) that played a major role in its industrialization. With reference to figure 1 (GDP growth rate of Malaysia) in chapter 3, Malaysia was able to maintain an impressive 9% GDP growth rate in the late 1980's to the mid 1990's and this according to the world bank, (2007) contributed tremendously to improving the standard of living of Malaysians. Thus Malaysia was considered to be among the three most successful East Asian countries alongside South Korea and Taiwan. Moreover Malaysia still maintains a study growth even after the Asian financial crises in 1997 to 1998. Malaysia now ranks ahead of most OECD and East Asian countries in terms competitiveness. Table 1.1.0 shows Malaysia's rankings as published by the world Economic Forum, Global Competitiveness Repots.

Table 1.0 Malaysia's Competitive Ranking

Pillars	Ranking in 2008 (out of 134)	Ranking in 2009 (out of 133)	Ranking in 2010 (out of 133)	Ranking in 2011 (out of 142)	Ranking in 2012 (out of 144)
Basic Requirements					
Institutions	30	43	42	30	29
Infrastructure	23	26	30	26	32
Macro-Economic stability	38	42	41	29	35
Health and Primary education	23	34	34	33	33
Efficiency Enhancers					
Higher Education and training	35	41	49	38	39
Goods market efficiency	23	30	27	15	11
Labor Market efficiency	19	31	35	20	24
Financial market sophistication	16	6	7	3	6
Technological readiness	34	37	40	44	51
Market size	28	28	29	29	28
Innovation and Sophistication Factors					
Business Sophistication	22	24	25	20	20
Innovation	22	24	24	24	25

Source: World Economic Forum. Global Competitiveness Report 2009–2013. Note: The top ranking is 1, which means more competitive.

B2.1 Actors and Linkages of the National Innovation system of Malaysia

According to the OECD, (2013), Malaysia's national innovative system comprises of main actors such as organizations in the R&D sector, innovation support centers, institutes in the financing sector, education and training institutes, commercial enterprises and government agencies. Figure 2.1 shows an overview of the actors and linkages in national innovation system of Malaysia.

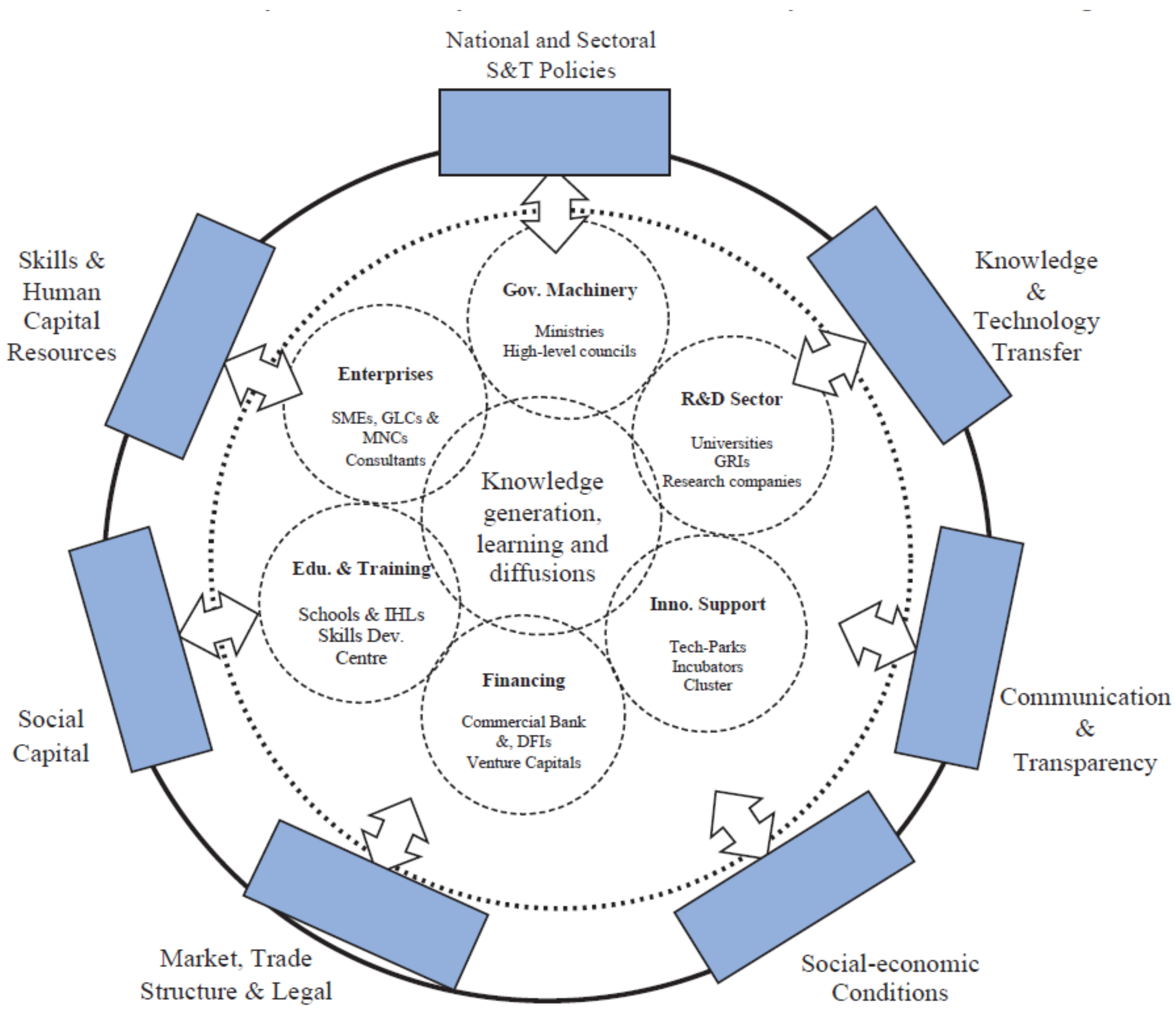

Figure 2.1: A Birds Eye View of the National Innovation System of Malaysia: actors & linkages (OECD, 2013)

B3.1 Malaysia's National Innovation System SWOT

STRENGTHS	WEAKNESSES
1. Presence of multinational enterprises in electronics and automotive 2. Research capabilities in agricultural commodities 3. High competitiveness ranking and ease of doing Business 4. Relatively young population and natural resource endowments 5. Economic and political stability 6. A new vision under the Tenth Malaysia Plan 7. Substantive Investment in telecommunications infrastructure	1. Poor quality education and inadequate supply of skilled labor 2. Declining private investment and low productivity growth in domestic economy 3. Stagnant R&D and innovative capacity and few industry links to public research 4. Low absorptive capacity of SMEs and little technology transfer from foreign to domestic firms 5. Little entrepreneurship and venture capital 6. Uncoordinated national S&T policy and weak implementation strategies
OPPORTUNITIES	**THREATS**
1. Increasing focus on high-technology exports to developed countries 2. International reputation as center for Islamic banking and Finance 3. Burgeoning service sector including expansion of tourism industry 4. Diversification of trade and production towards more knowledge-intensive goods/ services 5. Increasing engagement of SMEs in more innovation-driven strategies	1. Impacts of regional and global economic downturns 2. Increasing competition from Asian economies for trade and foreign investment 3. Increasing brain drain 4. Racial polarization and religious extremism

Source: OECD, (2013, p. 32)

B4.1 Institutional Framework for the National innovation system of Malaysia

In Malaysia, the Ministry of Science, Technology and Innovation (MOSTI) is the general administrator of science and technology policy in Malaysia, responsible for providing grants for research, formulating various science and technology (S&T) programs, allocation of STI budget and the integration of STI plans. Other ministries that also play a role in the STI development of Malaysia are; The Economic Planning Unit (EPU), Public services Department (PSD) responsible for the implementation of S&T policies, Malaysian Agricultural Research and Development Institute (MARDI), Ministry of Plantation Industries (MPI) and Palm Oil Board (POB) responsible for research. For technology transfer the Ministry of International Trade and Industry claims that responsibility. The Malaysia-Industry High Technology Group (MIGHT) under the prime minister's office provides advisory services and the Malaysian Science and Technology Information Center (MASTIC) is the official center for statistics on S&T. Not forgetting the just recently revamped National Science and Research Council (NSRC) established in 2011 to replace the National Council for Scientific Research and Development (NCSRD) (OECD, 2013).

B5.1 Structural Transformation of Malaysia

Over the years, Malaysia have shift from an agricultural based economy to a manufacturing economy and since 1980's the industrial sector of Malaysia has led its growth (OECD, 2013). According to Asgari (2007) the historical path of Malaysia, revealed through institutional and structural changes in the 1960's through to the 2000's are the most important factors for Malaysia's current competitiveness. This is evident in industry share of GDP increasing from 14% in 1970 to about 42% in 2010, while agriculture and mining share of GDP decreased from 43% in 1970 to only about 10-15% in 2010 (OECD, 2013). The paths of Malaysia have evolved around two major policies; the New Economic Policy (NEP) and the Look East Policy (LEP). The former was launched in the 1970's which laid down the foundations of a developmental state in Malaysia and this was done through state intervention to achieve economic growth. On the other hand the LEP was launched in 1982 which sought to mark the end of the NEP by the adoption of Malaysia Incorporated, under the guidelines of Japan Incorporated. This was another form of state intervention in the economy practiced by Japan which encouraged more private sector involvement. It is important to note that, both the NEP and the LEP did not resort to the nationalization as done by many countries, but rather sort to use more state enterprises. Therefore these policies did not negatively affect the inflow of foreign direct investment (FDI), which was by the 1980's crucial to Malaysia's economic development (Ping, 2008).

B6.1 Policy orientation and Industrial policies of Malaysia

The developmental paths and innovation-related policies in the form of industrial policies are sketched out in Figure 4.12.1. Meanwhile the First National Science and Technology Policy (FNSTP) of Malaysia were formulated in 1986 as part of the 5th Malaysia Plan (1986-1990). This was followed by Malaysia's Vision 2020 in 1990 which, which was made up of the blueprint for a knowledge economy-based economy for Malaysia (OECD, 2013). According to Meerman (2008), Malaysia's industrial policies have not been consistent over the past years but were mainly directed along these lines; from 1960's the government of Malaysia rewarded import substitution, this shifted to support for public enterprises and state capitalism and gradually towards export oriented in the 1970's. In the 1980's Malaysia became export oriented and placed much emphasis on the role of FDI in promoting its industrialization process. In the 1990's started the formation of a business class in Malaysia who were to make much of the investments that would create employment and in the 2000's the Malaysian government headed towards privatization and world-Market integration. Figure 6.1 shows a summary of the industrial policies and development paths taken by Malaysia.

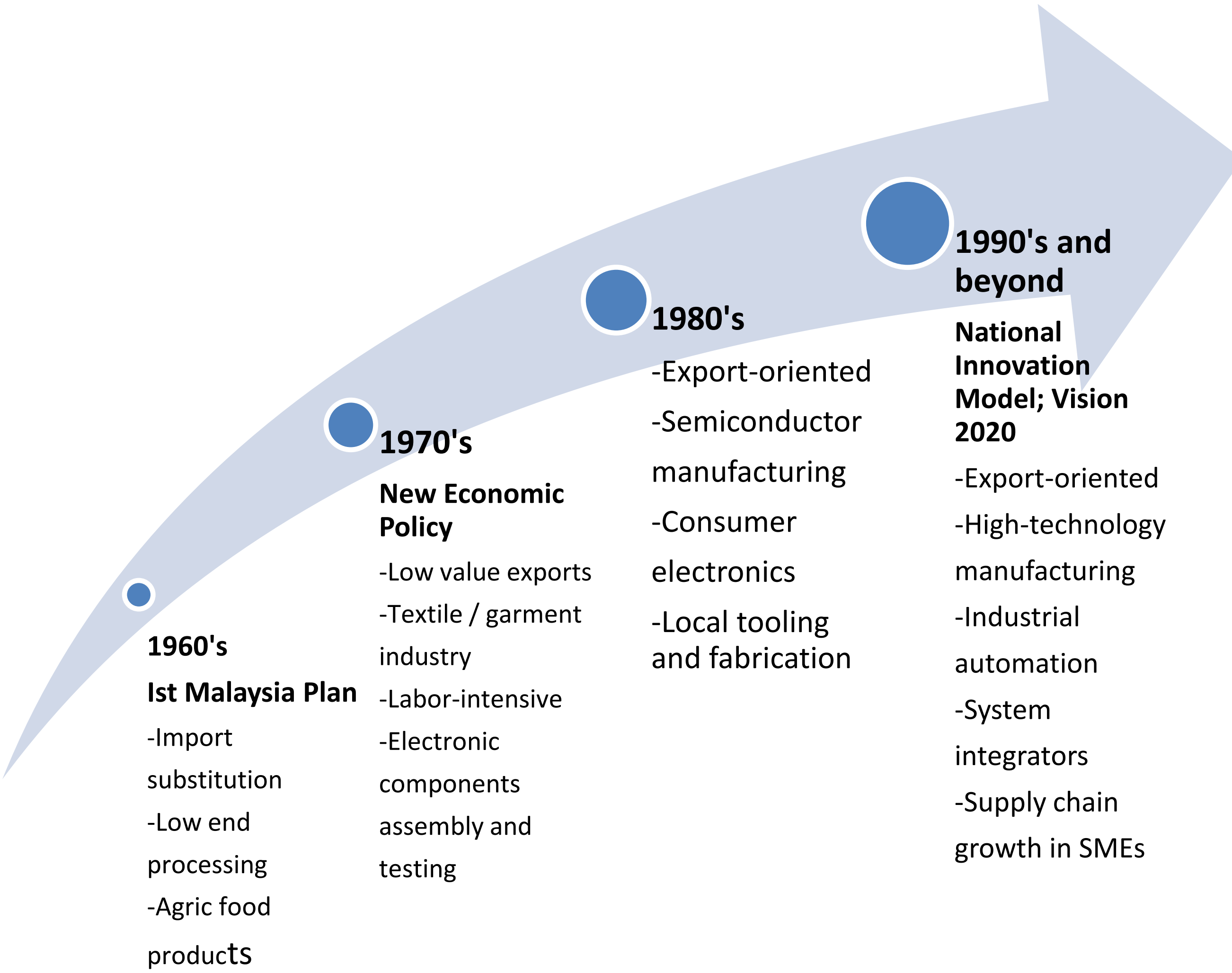

Fig 6.1 Summary of Malaysia's Industrial Policies and development paths from1960's to date

Source: Meerman, 2008; UNIDO, 2011

APPENDIX C: COPY OF STATISTICAL RESULTS FOR GHANA

C1: Results for National Innovation Capability of Ghana (Main Model, Chapter 3)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.977[a]	.955	.940	.015575542180950

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.077	5	.015	63.321	.000[b]
	Residual	.004	15	.000		
	Total	.080	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.445	.214		11.442	.000		
Innovation Inputs	-.190	.099	-.161	-1.911	.075	.423	2.363
Scientific Output	.242	.050	.450	4.813	.000	.345	2.895
Openness	-.015	.049	-.030	-.304	.765	.308	3.248
Human Capital	.098	.016	.537	6.284	.000	.413	2.420
Infrastructure	-.220	.070	-.241	-3.134	.007	.509	1.965

a. Dependent Variable: Economic Development

C2.0 Results for Dynamics of Innovation capability, Ghana (Model A's, Chapter 3)

C2.1 Model A1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.875[a]	.766	.740	.032316126067905

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.062	2	.031	29.516	.000[b]
	Residual	.019	18	.001		
	Total	.080	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.615	.120		13.478	.000		
Innovation Inputs	.222	.135	.189	1.639	.119	.981	1.019
Scientific Output	.474	.062	.881	7.660	.000	.981	1.019

a. Dependent Variable: Economic Development

C2.2 Model A2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.383[a]	.146	.051	.0524790

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.008	2	.004	1.543	.241[b]
	Residual	.050	18	.003		
	Total	.058	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.150	.589		-1.953	.066		
Scientific Output	-.332	.192	-.727	-1.729	.101	.269	3.724
Income Level	.585	.357	.689	1.639	.119	.269	3.724

a. Dependent Variable: Innovation Inputs

C2.3 Model A4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.877[a]	.770	.744	.059638

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.214	2	.107	30.081	.000[b]
	Residual	.064	18	.004		
	Total	.278	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.191	.525		-4.172	.001		
Income Level	1.614	.211	.868	7.660	.000	.995	1.005
Innovation Inputs	-.429	.248	-.196	-1.729	.101	.995	1.005

a. Dependent Variable: Scientific Output

C3.0 Results of Absorptive Capacity, Openness and Diffusion Capacity of Ghana (Model B, Chapter 3)

C3.1 Model B1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.933[a]	.870	.847	.024797293156386

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.070	3	.023	37.942	.000[b]
	Residual	.010	17	.001		
	Total	.080	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.395	.288		8.321	.000		
Openness	.174	.047	.353	3.700	.002	.841	1.189
Human Capital	.143	.018	.785	7.888	.000	.772	1.296
Infrastructure	-.137	.096	-.151	-1.429	.171	.688	1.453

a. Dependent Variable: Economic Development

C3.2 Model B2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.731[a]	.534	.452	.095092677273697

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.176	3	.059	6.494	.004[b]
	Residual	.154	17	.009		
	Total	.330	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-3.976	2.291		-1.735	.101		
Human Capital	-.415	.111	-1.127	-3.740	.002	.302	3.313
Infrastructure	-.095	.389	-.052	-.245	.809	.617	1.622
Economic Development	2.561	.692	1.265	3.700	.002	.235	4.263

a. Dependent Variable: Openness

C3.3 Model B3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.913[a]	.834	.805	.153873

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.028	3	.676	28.552	.000[b]
	Residual	.403	17	.024		
	Total	2.431	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-11.509	2.896		-3.975	.001		
Infrastructure	.213	.629	.043	.340	.738	.619	1.617
Economic Development	5.499	.697	1.000	7.888	.000	.606	1.651
Openness	-1.087	.291	-.401	-3.740	.002	.849	1.177

a. Dependent Variable: Human Capital

C3.4 Model B4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.621[a]	.386	.277	.059169648315155

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.037	3	.012	3.557	.037[b]
	Residual	.060	17	.004		
	Total	.097	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	4.437	1.111		3.995	.001		
Economic Development	-.781	.547	-.712	-1.429	.171	.146	6.871
Openness	-.037	.151	-.068	-.245	.809	.468	2.138
Human Capital	.032	.093	.158	.340	.738	.167	5.998

a. Dependent Variable: Infrastructure

C4.0 Results for Relationship between Innovative Capability and Absorptive capacity, Openness and Diffusion capacity of Ghana (Model C's, Chapter 3)

C4.1 Model C1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.758[a]	.575	.500	.0380943

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.033	3	.011	7.672	.002[b]
	Residual	.025	17	.001		
	Total	.058	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.081	.442		2.444	.026		
Openness	-.293	.072	-.699	-4.055	.001	.841	1.189
Human Capital	.022	.028	.140	.778	.447	.772	1.296
Infrastructure	-.361	.148	-.466	-2.446	.026	.688	1.453

a. Dependent Variable: Innovation Inputs

C4.2 Model C3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.808[a]	.653	.592	.075304

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.182	3	.061	10.675	.000[b]
	Residual	.096	17	.006		
	Total	.278	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.639	.874		.731	.475		
Openness	.551	.143	.600	3.856	.001	.841	1.189
Human Capital	.204	.055	.602	3.704	.002	.772	1.296
Infrastructure	.058	.292	.034	.200	.844	.688	1.453

a. Dependent Variable: Scientific Output

C4.3 Model C4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.734[a]	.539	.488	.091912758210333

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.178	2	.089	10.525	.001[b]
1	Residual	.152	18	.008		
	Total	.330	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.450	.341		1.321	.203		
Innovation Inputs	-1.154	.385	-.484	-2.996	.008	.981	1.019
Scientific Output	.533	.176	.489	3.030	.007	.981	1.019

a. Dependent Variable: Openness

C4.4 Model C5

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.720[a]	.518	.465	.255045

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	1.260	2	.630	9.683	.001[b]
1	Residual	1.171	18	.065		
	Total	2.431	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.029	.946		-2.145	.046		
Innovation Inputs	2.998	1.069	.463	2.806	.012	.981	1.019
Scientific Output	1.829	.488	.618	3.744	.001	.981	1.019

a. Dependent Variable: Human Capital

C4.5 Model C6

5. **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.553[a]	.306	.229	.061113994829212

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.030	2	.015	3.969	.037[b]
	Residual	.067	18	.004		
	Total	.097	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.845	.227		12.553	.000		
Innovation Inputs	-.463	.256	-.359	-1.809	.087	.981	1.019
Scientific Output	-.279	.117	-.473	-2.388	.028	.981	1.019

a. Dependent Variable: Infrastructure

C5.0 Robustness of Results for Ghana

C5.1 Correlation Matrix for New Variables

Variables	Innovation Inputs	Scientific Output	Openness	Human Capital	Infrastructure
Innovation Inputs	1	-.138	-.028	.198	-.270
Scientific Output	-.138	1	.758**	.747**	.726**
Openness	-.028	.758**	1	.660**	.448*
Human Capital	.198	.747**	.660**	1	.687**
Infrastructure	-.270	.726**	.448*	.687**	1

C5.2 Main Model

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.982[a]	.964	.952	.013872071669299

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.078	5	.016	80.609	.000[b]
1	Residual	.003	15	.000		
	Total	.080	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.358	.148		9.173	.000		
Innovation Inputs	-.044	.075	-.037	-.587	.566	.594	1.684
Scientific Output	.129	.055	.239	2.331	.034	.227	4.413
Openness	.012	.012	.082	.999	.334	.356	2.813
Human Capital	.503	.070	.723	7.134	.000	.233	4.297
Infrastructure	.003	.020	.012	.130	.898	.292	3.428

a. Dependent Variable: Economic Development

C5.3 Model B1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.974[a]	.949	.940	.015487523974148

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.076	3	.025	106.128	.000[b]
	Residual	.004	17	.000		
	Total	.080	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.612	.100		16.157	.000		
Openness	.029	.010	.206	2.835	.011	.564	1.772
Human Capital	.504	.062	.726	8.116	.000	.373	2.682
Infrastructure	.031	.017	.138	1.843	.083	.528	1.893

a. Dependent Variable: Economic Development

C5.4 Model B2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.785[a]	.617	.549	.298417209574246

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.436	3	.812	9.120	.001[b]
	Residual	1.514	17	.089		
	Total	3.950	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-20.949	5.884		-3.561	.002		
Human Capital	-3.299	2.520	-.677	-1.309	.208	.084	11.876
Infrastructure	-.347	.342	-.223	-1.015	.325	.467	2.142
Economic Development	10.916	3.851	1.558	2.835	.011	.075	13.396

a. Dependent Variable: Openness

C5.5 Model B3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.961[a]	.924	.910	.027378694488959

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.154	3	.051	68.419	.000[b]
	Residual	.013	17	.001		
	Total	.167	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.211	.470		-4.704	.000		
Infrastructure	-.016	.032	-.051	-.510	.616	.447	2.237
Economic Development	1.576	.194	1.095	8.116	.000	.247	4.047
Openness	-.028	.021	-.135	-1.309	.208	.422	2.370

a. Dependent Variable: Human Capital

C5.6 Model B4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.748[a]	.560	.482	.20536592250137

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.912	3	.304	7.206	.002[b]
	Residual	.717	17	.042		
	Total	1.629	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-11.736	4.530		-2.591	.019		
Economic Development	5.410	2.936	1.202	1.843	.083	.061	16.444
Openness	-.164	.162	-.256	-1.015	.325	.406	2.460
Human Capital	-.921	1.805	-.295	-.510	.616	.078	12.877

a. Dependent Variable: Infrastructure

C5.7 Model C1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.631[a]	.398	.291	.0453568

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.023	3	.008	3.742	.031[b]
	Residual	.035	17	.002		
	Total	.058	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.235	.292		-4.226	.001		
Openness	-.035	.030	-.289	-1.153	.265	.564	1.772
Human Capital	.542	.182	.918	2.978	.008	.373	2.682
Infrastructure	-.146	.049	-.771	-2.977	.008	.528	1.893

a. Dependent Variable: Innovation Inputs

C5.8 Model C3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.878[a]	.770	.730	.061309

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.214	3	.071	18.987	.000[b]
	Residual	.064	17	.004		
	Total	.278	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.547	.395		3.918	.001		
Openness	.126	.041	.473	3.059	.007	.564	1.772
Human Capital	.198	.246	.153	.806	.432	.373	2.682
Infrastructure	.169	.066	.409	2.556	.020	.528	1.893

a. Dependent Variable: Scientific Output

C5.9 Model C4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.762[a]	.580	.533	.303609215909009

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-4.930	1.126		-4.379	.000		
Innovation Inputs	.640	1.272	.078	.503	.621	.981	1.019
Scientific Output	2.896	.581	.768	4.982	.000	.981	1.019

a. Dependent Variable: Openness

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.291	2	1.146	12.427	.000[b]
	Residual	1.659	18	.092		
	Total	3.950	20			

C5.10 Model C5

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.806[a]	.650	.611	.056953245450589

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.108	2	.054	16.681	.000[b]
	Residual	.058	18	.003		
	Total	.167	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.644	.211		3.051	.007		
Innovation_Inputs	.519	.239	.306	2.174	.043	.981	1.019
Scientific_Output	.611	.109	.789	5.599	.000	.981	1.019

a. Dependent Variable: Human_Capital

C5.11 Model C6

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.746[a]	.557	.508	.20026175353122

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.907	2	.453	11.305	.001[b]
	Residual	.722	18	.040		
	Total	1.629	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-3.651	.743		-4.917	.000		
Innovation Inputs	-.917	.839	-.173	-1.093	.289	.981	1.019
Scientific Output	1.700	.383	.702	4.433	.000	.981	1.019

a. Dependent Variable: Infrastructure

APPENDIX D: COPY OF STATSTICAL RESULTS FOR MALAYSIA

D1.1 Results for National Innovation Capability of Malaysia (Main Model, chapter 3)

1.1.1 Model 1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.884[a]	.782	.744	.0479195489525

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.140	3	.047	20.337	.000[b]
	Residual	.039	17	.002		
	Total	.179	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.427	.444		5.468	.000		
Innovation Inputs	.294	.063	.585	4.680	.000	.821	1.219
Technology Output	.182	.091	.341	2.008	.061	.445	2.245
Openness	.257	.260	.158	.986	.338	.497	2.012

a. Dependent Variable: Economic development

1.1.2 Model 2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[a]	.862	.847	.0370683184645

ANOVA[a]

Model 2		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.154	2	.077	56.184	.000[b]
	Residual	.025	18	.001		
	Total	.179	20			

Coefficients[a]

Model2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.925	.198		14.739	.000		
Technology Output	.081	.063	.151	1.278	.217	.551	1.814
Human Capital	.286	.041	.821	6.957	.000	.551	1.814

a. Dependent Variable: Economic Development

1.1.3 Model 3

Model Summary

Model 3	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.980[a]	.961	.954	.0202645735465

ANOVA[a]

Model 3		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.172	3	.057	139.738	.000[b]
	Residual	.007	17	.000		
	Total	.179	20			

Coefficients[a]

Model 3	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.685	.116		14.505	.000		
Technology Output	-.064	.040	-.120	-1.603	.127	.407	2.457
Infrastructure	.630	.045	1.116	13.888	.000	.355	2.818
Openness	.019	.011	.095	1.694	.108	.727	1.376

a. Dependent Variable: Economic Development

1.1.4 Model 4

Model Summary

Model 4	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.980[a]	.961	.954	.0202645735465

ANOVA[a]

Model 4		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.172	3	.057	139.738	.000[b]
	Residual	.007	17	.000		
	Total	.179	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.685	.116		14.505	.000		
Technology Output	-.064	.040	-.120	-1.603	.127	.407	2.457
Infrastructure	.630	.045	1.116	13.888	.000	.355	2.818
Openness	.019	.011	.095	1.694	.108	.727	1.376

a. Dependent Variable: Economic Development

D2.0 Results for Dynamics of Innovative Capacity of Malaysia

D2.1 Model A1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945[a]	.892	.873	.0337102633367

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.160	3	.053	46.878	.000[b]
1	Residual	.019	17	.001		
	Total	.179	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.152	.229		9.414	.000		
Innovation Inputs	.014	.077	.028	.184	.856	.268	3.729
Technology Output	.170	.050	.317	3.400	.003	.730	1.371
Scientific Output	.305	.070	.716	4.395	.000	.239	4.186

a. Dependent Variable: Economic Development

D2.2 Model A2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.793[a]	.629	.587	.121031

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.447	2	.223	15.242	.000[b]
1	Residual	.264	18	.015		
	Total	.710	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-6.088	1.050		-5.795	.000		
Technology Output	-.250	.214	-.235	-1.167	.259	.509	1.963
Economic Development	1.871	.401	.939	4.669	.000	.509	1.963

a. Dependent Variable: Innovation Inputs

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.855[a]	.732	.702	.102867

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	.520	2	.260	24.558	.000[b]
	Residual	.190	18	.011		
	Total	.710	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.166	.476		-4.555	.000		
Technology Output	-.029	.152	-.028	-.193	.849	.731	1.368
Scientific Output	.738	.121	.869	6.090	.000	.731	1.368

a. Dependent Variable: Innovation Inputs

D2.3 Model A3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.726[a]	.526	.474	.128402691885048

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.330	2	.165	10.005	.001[b]
	Residual	.297	18	.016		
	Total	.627	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.694	1.777		-1.516	.147		
Innovation Inputs	-.281	.241	-.299	-1.167	.259	.399	2.504
Economic Development	1.744	.480	.933	3.633	.002	.399	2.504

a. Dependent Variable: Technology Output

D2.4 Model A4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942[a]	.888	.868	.0805

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.875	3	.292	45.010	.000[b]
1	Residual	.110	17	.006		
	Total	.985	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.775	1.183		-2.346	.031		
Innovation Inputs	.402	.157	.341	2.565	.020	.371	2.694
Economic Development	1.741	.396	.743	4.395	.000	.230	4.341
Technology Output	-.183	.148	-.146	-1.240	.232	.474	2.112

a. Dependent Variable: Scientific Output

D3.0 Results for Dynamics of Absorptive Capacity, Openness and Diffusion for Malaysia

D3.1 Model B1

Model Summary

Model 1	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.922[a]	.850	.834	.0386091381092

ANOVA[a]

Model 1	Sum of Squares	df	Mean Square	F	Sig.

	Regression	.152	2	.076	51.085	.000[b]
	Residual	.027	18	.001		
	Total	.179	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.052	.388		7.871	.000		
Openness	.057	.184	.035	.313	.758	.648	1.542
Human Capital	.314	.039	.901	7.950	.000	.648	1.542

a. Dependent Variable: Economic Development

Model Summary

Model 2	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.975[a]	.951	.946	.0220367212504

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.170	2	.085	175.439	.000[b]
2	Residual	.009	18	.000		
	Total	.179	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.899	.193		9.844	.000		
Openness	-.110	.108	-.068	-1.012	.325	.607	1.647
Infrastructure	.574	.038	1.016	15.207	.000	.607	1.647

a. Dependent Variable: Economic Development

D3.2 Model B2

Model Summary

Model1	R	R Square	Adjusted R Square	Std. Error of the Estimate

	.652[a]	.426	.362	.046664628198272

ANOVA[a]

Model 1	Sum of Squares	df	Mean Square	F	Sig.
Regression	.029	2	.015	6.671	.007[b]
Residual	.039	18	.002		
Total	.068	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.379	.867		2.745	.013		
Infrastructure	.489	.274	1.402	1.783	.092	.052	19.390
Economic Development	-.491	.485	-.796	-1.012	.325	.052	19.390

a. Dependent Variable: Openness

Model Summary

Model 2	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.596[a]	.355	.283	.049449570956622

ANOVA[a]

Model 2	Sum of Squares	df	Mean Square	F	Sig.
Regression	.024	2	.012	4.955	.019[b]
Residual	.044	18	.002		
Total	.068	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.802	.957		1.883	.076		
Economic Development	.094	.301	.153	.313	.758	.151	6.640
Human Capital	.097	.105	.452	.927	.366	.151	6.640

a. Dependent Variable: Openness

D3.3 Model B3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.956[a]	.913	.898	.08665598

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	1.346	3	.449	59.760	.000[b]
1	Residual	.128	17	.008		
	Total	1.474	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.894	1.917		-1.510	.150		
Economic Development	-.511	.927	-.178	-.551	.589	.049	20.493
Openness	-.099	.438	-.021	-.227	.823	.574	1.741
Infrastructure	1.849	.552	1.142	3.349	.004	.044	22.813

a. Dependent Variable: Human Capital

D3.4 Model B4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.987[a]	.974	.969	.029546220668110

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.547	3	.182	208.878	.000[b]
	Residual	.015	17	.001		
	Total	.562	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.259	.625		-2.013	.060		
Economic Development	1.084	.180	.612	6.010	.000	.150	6.676
Trade	.206	.141	.072	1.465	.161	.645	1.551
Human Capital	.215	.064	.348	3.349	.004	.144	6.957

a. Dependent Variable: Infrastructure

D4.0 Results for Interrelationship between Innovative Capacity and Absorptive Capacity, Openness and Diffusion of Malaysia

D4.1 Model C1

Model Summary

Model 1	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.836[a]	.699	.666	.108929

ANOVA[a]

Model 1	Sum of Squares	df	Mean Square	F	Sig.
Regression	.497	2	.248	20.927	.000[b]
Residual	.214	18	.012		
Total	.710	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.615	.954		-1.693	.108		
Openness	-1.100	.535	-.341	-2.056	.055	.607	1.647
Infrastructure	1.132	.187	1.007	6.068	.000	.607	1.647

a. Dependent Variable: Innovation Inputs

Model Summary

Model 2	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.950[a]	.902	.891	.062110

ANOVA[a]

Model 2	Sum of Squares	df	Mean Square	F	Sig.
Regression	.641	2	.320	83.052	.000[b]
Residual	.069	18	.004		
Total	.710	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.455	.624		2.332	.032		
Openness	-1.213	.295	-.376	-4.109	.001	.648	1.542
Human Capital	.780	.064	1.123	12.273	.000	.648	1.542

a. Dependent Variable: Innovation Inputs

D4.2 Model C2

Model Summary

Model 1	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.774[a]	.599	.554	.118202725096370

ANOVA[a]

Model 1	Sum of Squares	df	Mean Square	F	Sig.
Regression	.375	2	.188	13.427	.000[b]
Residual	.251	18	.014		
Total	.627	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.020	1.187		.017	.987		
Openness	1.458	.562	.481	2.594	.018	.648	1.542
Human Capital	.251	.121	.385	2.074	.053	.648	1.542

a. Dependent Variable: Technology Output

Model Summary

Model 2	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.823[a]	.677	.642	.105981961431982

ANOVA[a]

Model 2	Sum of Squares	df	Mean Square	F	Sig.
Regression	.425	2	.212	18.897	.000[b]
Residual	.202	18	.011		
Total	.627	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-.826	.928		-.890	.385		
Openness	1.130	.521	.373	2.170	.044	.607	1.647
Infrastructure	.566	.181	.536	3.121	.006	.607	1.647

a. Dependent Variable: Technology Output

D4.3 Model C3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.937[a]	.878	.864	.0818

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.864	2	.432	64.502	.000[b]
	Residual	.121	18	.007		
	Total	.985	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	4.796	.822		5.833	.000		
Trade	-1.447	.389	-.381	-3.720	.002	.648	1.542
Human Capital	.908	.084	1.111	10.847	.000	.648	1.542

a. Dependent Variable: Scientific Output

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.965[a]	.930	.923	.0617

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	.916	2	.458	120.356	.000[b]
	Residual	.069	18	.004		
	Total	.985	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.397	.540		2.586	.019		
Trade	-1.768	.303	-.466	-5.834	.000	.607	1.647
Infrastructure	1.570	.106	1.186	14.858	.000	.607	1.647

a. Dependent Variable: Scientific Output

D4.4 Model C4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729[a]	.531	.448	.043387647589189

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.036	3	.012	6.418	.004[b]
	Residual	.032	17	.002		
	Total	.068	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.593	.294		5.413	.000		
Innovation Inputs	.079	.099	.254	.791	.440	.268	3.729
Technology Output	.257	.064	.780	4.011	.001	.730	1.371
Scientific Output	-.090	.089	-.344	-1.011	.326	.239	4.186

a. Dependent Variable: Openness

D4.5 Model C5

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.963[a]	.927	.914	.07941420

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	1.367	3	.456	72.237	.000[b]
1	Residual	.107	17	.006		
	Total	1.474	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.006	.539		-1.868	.079		
Innovation Inputs	.802	.182	.556	4.405	.000	.268	3.729
Technology Output	.466	.117	.304	3.966	.001	.730	1.371
Scientific Output	.308	.164	.252	1.882	.077	.239	4.186

a. Dependent Variable: Human Capital

D4.6 Model C6

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.966[a]	.933	.921	.047212073869234

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	.524	3	.175	78.359	.000[b]
1	Residual	.038	17	.002		
	Total	.562	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.819	.320		2.559	.020		
Innovation_Inputs	.123	.108	.138	1.134	.273	.268	3.729
Technology_Output	.401	.070	.423	5.739	.000	.730	1.371
Scientific_Output	.420	.097	.556	4.318	.000	.239	4.186

a. Dependent Variable: Infrastructure

D5.0 Robustness of Results for Malaysia

D5.1 Correlation Matrix for New Variables

	Innovation Inputs	Technology Output	Scientific Output	Openness	Infrastructure	Human Capital
Innovation Input	1	.423	.855**	-.547*	.402	.873**
Technology Output	.423	1	.519*	-.408	.872**	.584**
Scientific Output	.855**	.519*	1	-.562**	.456**	.758**
Openness	-.547*	-.408	-.562**	1	-.314	-.416
Infrastructure	.402	.872**	.872**	-.314	1	.610**
Human Capital	.873**	.584**	.758**	-.416	.610**	1

5.1.1 Main Model

6. **Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.901[a]	.813	.766	.0458102777022

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.146	4	.036	17.340	.000[b]
	Residual	.034	16	.002		
	Total	.179	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.978	.282		10.572	.000		
Innovation Inputs	.299	.068	.596	4.412	.000	.641	1.559
Technology Output	.069	.123	.130	.563	.581	.220	4.540
Openness	.013	.027	.064	.478	.639	.649	1.540
Infrastructure2	.364	.206	.395	1.767	.096	.234	4.270

a. Dependent Variable: Economic Development

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.957[a]	.915	.894	.0308031578507

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	.164	4	.041	43.198	.000[b]
	Residual	.015	16	.001		
	Total	.179	20			

Coefficients[a]

Model 2	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.664	.323		5.156	.000		
Scientific Output	.312	.052	.732	5.955	.000	.351	2.852
Technology Output	.164	.049	.306	3.324	.004	.624	1.603
Openness	.030	.018	.151	1.692	.110	.661	1.512
Human_Capital2	.262	.238	.131	1.099	.288	.373	2.681

D5.2 Model B1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.861[a]	.742	.696	.0521440996704

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.133	3	.044	16.294	.000[b]
	Residual	.046	17	.003		
	Total	.179	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.266	.517		2.449	.025		
Openness	-.020	.027	-.101	-.741	.469	.821	1.218
Human Capital	1.066	.325	.533	3.275	.004	.572	1.748
Infrastructure	.341	.144	.371	2.377	.029	.624	1.604

a. Dependent Variable: Economic Development

D5.3 Model B2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.452[a]	.205	.064	.456353757504036

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.911	3	.304	1.458	.261[b]
	Residual	3.540	17	.208		
	Total	4.451	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	9.186	4.768		1.927	.071		
Human Capital	-1.793	3.611	-.180	-.497	.626	.356	2.810
Infrastructure	.099	1.450	.022	.068	.946	.468	2.136
Economic Development	-1.549	2.089	-.311	-.741	.469	.266	3.754

a. Dependent Variable: Openness

D5.4 Model B3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.806[a]	.649	.587	.03043008

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.029	3	.010	10.486	.000[b]
	Residual	.016	17	.001		
	Total	.045	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	.473	.332		1.427	.172		
Infrastructure	.026	.097	.057	.272	.789	.470	2.128
Economic Development	.363	.111	.725	3.275	.004	.421	2.376
Openness	-.008	.016	-.079	-.497	.626	.807	1.239

a. Dependent Variable: Human Capital

D5.5 Model B4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729[a]	.532	.449	.0763013024072

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.113	3	.038	6.443	.004[b]
	Residual	.099	17	.006		
	Total	.212	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1.721	.775		-2.222	.040		
Economic Development	.731	.307	.673	2.377	.029	.344	2.908
Openness	.003	.041	.013	.068	.946	.796	1.257
Human Capital	.165	.607	.076	.272	.789	.352	2.838

a. Dependent Variable: Infrastructure

D5.6 Model C1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.915[a]	.836	.807	.082688

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.594	3	.198	28.958	.000[b]
	Residual	.116	17	.007		
	Total	.710	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-6.288	.820		-7.670	.000		
Openness	-.096	.043	-.240	-2.212	.041	.821	1.218

Human Capital	3.636	.516	.914	7.047	.000	.572	1.748
Infrastructure	-.423	.228	-.231	-1.856	.081	.624	1.604

a. Dependent Variable: Innovation Inputs

D5.7 Model C2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.883[a]	.780	.741	.090012170495021

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.489	3	.163	20.116	.000[b]
	Residual	.138	17	.008		
	Total	.627	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.781	.892		1.996	.062		
Openness	-.053	.047	-.140	-1.119	.279	.821	1.218
Human Capital	.124	.562	.033	.221	.828	.572	1.748
Infrastructure	1.389	.248	.807	5.605	.000	.624	1.604

a. Dependent Variable: Technology Output

D5.8 Model C3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.806[a]	.649	.587	.1426

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.639	3	.213	10.485	.000[b]
	Residual	.345	17	.020		
	Total	.985	20			

Coefficients[a]

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-2.684	1.413		-1.899	.075		
Openness	-.142	.075	-.301	-1.899	.075	.821	1.218
Human Capital2	3.075	.890	.656	3.457	.003	.572	1.748
Infrastructure2	-.084	.393	-.039	-.213	.834	.624	1.604

a. Dependent Variable: Scientific Output

D5.9 Model C4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.594[a]	.353	.238	.411698018170646

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	1.570	3	.523	3.087	.055[b]
1	Residual	2.881	17	.169		
	Total	4.451	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.391	2.792		1.215	.241		
Innovation Inputs	-.652	.943	-.261	-.692	.499	.268	3.729
Technology Output	-.444	.609	-.167	-.730	.475	.730	1.371
Scientific Output	-.537	.849	-.253	-.633	.535	.239	4.186

a. Dependent Variable: Openness

D5.10 Model C5

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.907[a]	.822	.790	.02168631

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.037	3	.012	26.137	.000[b]
	Residual	.008	17	.000		
	Total	.045	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.658	.147		11.273	.000		
Innovation Inputs	.216	.050	.858	4.339	.000	.268	3.729
Technology Output	.076	.032	.285	2.375	.030	.730	1.371
Scientific Output	-.026	.045	-.123	-.588	.564	.239	4.186

a. Dependent Variable: Human Capital

D5.11 Model C6

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.873[a]	.763	.721	.0543105954216

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.161	3	.054	18.235	.000[b]
	Residual	.050	17	.003		
	Total	.212	20			

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-.517	.368		-1.404	.178		
Innovation Inputs	.060	.124	.110	.482	.636	.268	3.729
Technology Output	.506	.080	.872	6.304	.000	.730	1.371
Scientific Output	-.042	.112	-.090	-.371	.715	.239	4.186

a. Dependent Variable: Infrastructure2

APPENDIX E: INITIAL FRAMEWORK AND MODEL FOR THIS THESIS

Below is the initial conceptual framework and model for this study but was abandoned due to data constraints for both Ghana and Malaysia. Generally larger samples for Structured Equation Models (SEM) produce more valid results that are more likely to be generalized. According to Fair et al. (2010), the more complex a model, the bigger the sample size required. They suggested a minimum sample size of 300 for a model as complex as the one in this framework. The annual time data for this research exists for 50 years for both Ghana and Malaysia, thus the sample size does not meet the guidelines provided by Fair et al. (2010). Furthermore the various indices providing evidence of model fit such as the GFI, TLI, RMSEA, AIC, CMIN etc, were all not favorable when the model was run with the sample size of 50. Therefore the researcher has no choice but to drop this model since there was no other way to increase the sample size. In any case, this framework and model would be pursued in the future when the researcher has been able to collect adequate data based on a survey or the scenario could change in terms of the countries under study replaced with countries whose data are available such as OECD countries.,

E1.1 Conceptual Frame work

It is the purpose of this research is to study the National Innovation systems of Ghana and Malaysia, present evidence of the paths and performance to growth of both systems, and ascertain replicable lessons for Ghana as the country moves forward based on the Innovation system of Malaysia. Understanding of national innovation systems of both countries can help identify important aspects of the system that needs improvements. According to the OECD (1997), an understanding of national innovation system can help identifying mismatches within the system that can impede on innovations. National innovation systems demonstrate features just like any system. In general conception, a system is a “complex of interacting components together with their relationships among them that permit the identification of a boundary-maintaining entity or process.” (Laszlo & Krippner, 1998). Thus the national innovation system is composed of sectors, components or sub-system embedded in an environment with a boundary. The components, sectors or subsystems of the national innovation system represent the actors and they include the government, Education institutions, Industry, Research institutions, financial institutions, infrastructure, economic and market conditions culture. These elements exist and interact with each other in the environment which is depicted as the economic and social environment that also interacts with the other elements. Figure E1.1 explains the relationships among the elements of national innovation system, taking into consideration the broad and narrow concepts of national innovation discussed in chapter 2. All the elements in the circle (Education, Industry, Research and government) depicts the narrow view because they are directly related to the innovation process of a country, whiles the elements outside the circle (Financial, culture, infrastructure and economic/ market factors) depicts the broad view. They the elements that are indirectly related to the innovation process but exist within the environment and impact on the innovation process. All other elements outside the boundary of a national innovation system but affects it would be classified as its global environment which is beyond the scope of this study.

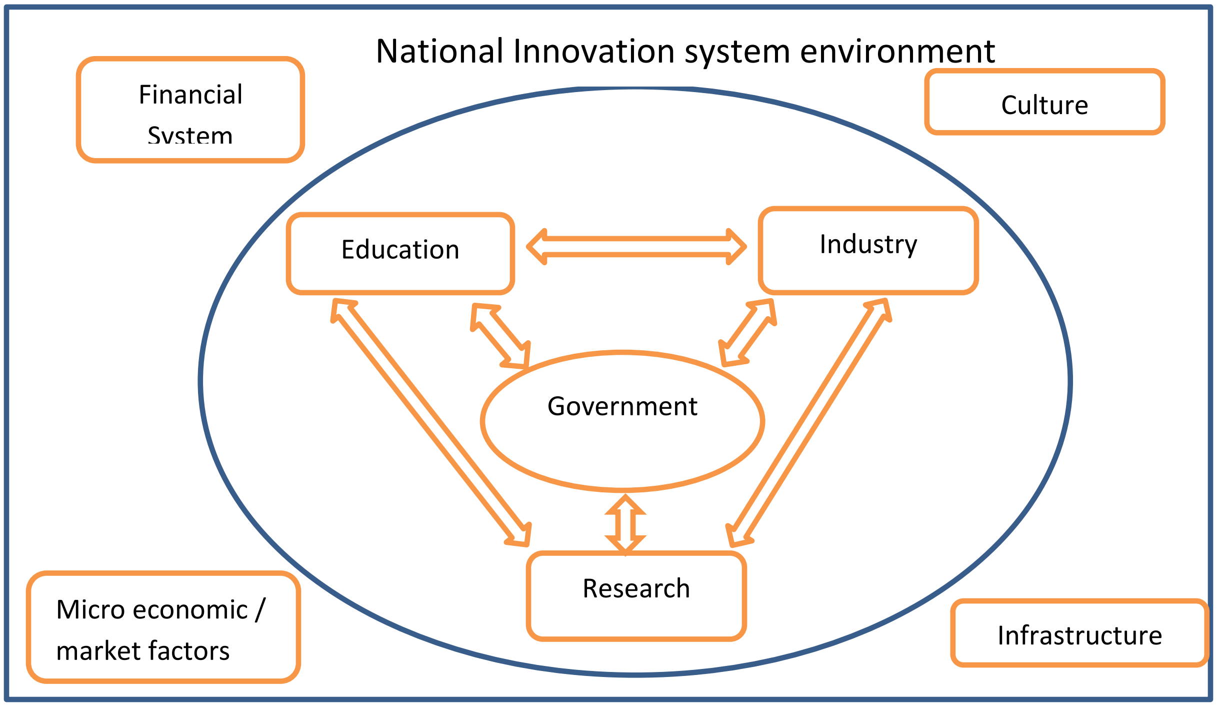

Figure E1.1 Elements of National Innovation System

(Source: Modified from Sarawitz, 2003)

The following properties of systems also apply to National Innovation system;

1. Each element has an effect on the functioning of the whole
2. Each element is affected by at least one other element in the system
3. All possible subgroups of elements also have the first two properties

(Ackoff, 1981, pp. 15-16, retrieved from Laszlo & Krippner, 1998)

Understanding the interrelationships among the elements requires the selection of variables or indicators from the literature that would be used to measure the performance. This research borrows the model presented by Nasierowski & Arcelus (1999), by also treating the national innovation system as a sector of the economy that requires inputs, moderating factors and outputs. The inputs are the domestic technological efforts, human capital and technology borrowed from abroad. Moderating factors are the factors that impact the process of generating outputs by the combination of inputs, such as the country's socio-economic structure. Thus either facilitating or inhibiting the performance of the inputs and outputs. Therefore if one is to trace the measuring indicators to each element, it becomes possible to measure the function or performance of each element, and each element could also serve as either an input variable, moderating variable, output variable or the combination of input, moderating and output variable for the entire system. Table E1.1 shows the elements and their corresponding measuring variables or indicators selected from the literature while Table 2.4 shows a description of the selected variables and the sources from which date on them is going to be collected.

Table E1.1: National Innovation System Elements and Indicators for Measurement

ELEMENTS	INDICATORS FOR MEASUREMENT
Education	Primary education enrollment
	Secondary education enrollment
	Tertiary education enrollment
	Vocational education enrollment
	Total education expenditure
Infrastructure	Telephone lines (per 100 people)
	Internet Users per 100 people
	Mobile cellular subscriptions
	Electricity production
	Roads paved (% of total roads)
	Total Roads Network
Financial	Ownership of banks
	Gross domestic savings (%) GDP
	Domestic credits to private sector (%)GDP
	Credit market regulations
Research	Gross agricultural R&D expenditure
	Total number of researchers in agricultural sector
	Scientific and technical journal articles
Industry	ISO 9001 applications
	Industrial design application
	Manufacturing value added (%) of GDP
	Market capitalization of listed companies
Government	Impartial courts
	Business freedom
	Protection of property rights
	Freedom from corruption

	Size of government
Economic /market factors	Purchasing power parity
	GDP (constant US)
	Size of a country's labor force
	Foreign Direct Investment
	Trade freedom
	Mechanized Imports
Culture	Power distance index
	Masculinity index
	Individualism index
	Uncertainty avoidance Index

The national innovation system requires inputs for the present and future development of a country and these inputs can be categorized into human resource and capital. The Education sector of a country is responsible for the training and supply of the former. Innovation being the process of change that either improves performance or adds value is not something that institutions do, but rather are done by the people within those institutions (Group of Eight, 2011). The education institutions of a country, especially universities provides the opportunities for people to show their intellectual, social and cultural potential and this is what makes them central to the innovation process and relevant to the national innovation system. For example universities play the role of bringing together the stock of human capital in a country, interact with the governance framework and also initiate a culture of learning into people (Gunasekara, 2005). In measuring the education element in the national innovation system, six indicators were identified based on the literature (see Table E1.1). These indicators are primary education enrollment, secondary education enrollment, tertiary education enrollment, vocational education enrollment, teacher pupil enrollment in primary education and last but not the least is expenditure on education. The combination of these indicators measures the absorptive capacity of the national innovation system as mentioned by Feinson (2003, p.19) that the "development of human capital via education and training is essential for fostering absorptive capacity."

The state of the human beings involved in R&D activities in a country could be represented by employment in technology-oriented programs and the number of engineers/scientists in R&D programs. However due to the lack of data on these variables for Ghana and Malaysia, the focus is only placed on each country current state in the development of future human resources as developers of technologies and consumers as well (Nasierowski & Arcelus, 1999). These would be accessed through the education expenditure of each country. Moreover enrollment rates in primary, secondary, vocational and tertiary levels of education are also considered in order to narrow down policy implications. According to Lall (1992), enrollment rates for education alone may be misleading, thus drop-out rate, the technical orientation of the students, and the quality of teaching also needs to be considered. However due to the lack of data on these variables, only the teacher pupil ratio in primary education would be used as a measure of quality of teaching. On the other hand the technical orientation of students has already been considered through the enrollments in vocational education variable. According to Fagerberg and Srholec (2007), the education variables have been identified with the term "social capability" coined by Abramovitz.

The role of research institutions in the national innovation system has generated some debate in the literature due to the similar role played by universities. However the distinction is that research institutions conduct mainly applied research while universities conduct mainly basic research (Arnold et al., 2007). "A good science infrastructure in a country can provide the knowledge base necessary for entering into key industries of growth" (Albquerque, 1999, p.4, retrieved from Feinson, 2003, p. 19) Research institutions in this paper represent both research institutions in the universities and outside the universities since most research institutions in Ghana and Malaysian are linked to the existing universities in those countries. This element and indicators identified measures the R&D Capability of a country, by taking into consideration the inputs in the form of human resource and capital and output which is in the form of scientific and technical articles and Patents.

Indicators used in measuring capabilities of research in a country are R&D expenditure, Number of researchers and patent counts at the national level. However due to the lack of data on these indicators at the national level for both Ghana and Malaysia, agricultural R&D expenditure and the number of researchers in the agricultural Sector would be used as proxy. Moreover Patents are more of a short term solutions to investments made by companies in a country and developing countries such as Ghana for this matter is lagging behind. Due to the incomplete of data on patents by residents for both Ghana and Malaysia, this indicator would be excluded from the measurements. On the other hand the knowledge base category of outputs is more of long term in nature in terms of building a country R&D knowledge base of a country (Nasierowski & Arcelus, 1999). Therefore scientific and technical articles/ journals counts could be used as R&D outputs instead of patents in this context and according to Fagerberg and Srholec (2007, p. 13), they reflect the "quality of a country's science base on which invention and innovation activities" depend.

The industry sectors of national innovation system comprise of enterprises and their R&D laboratories, which used to play a role in R&D of a nation. However the shift from the linear approach of innovation to the innovation system has led to a fundamental change in the composition of the industry sectors (Galli & Teubal, 1996). According to Galli & Teubal, (1996) these changes ranges from links between firms customers and suppliers, spread of R&D contractors and engineering, consulting, and information service companies etc. The contributions of the industry sector is accessed through the following selected indicators;

Manufacturing value added (%) of GDP, ISO 9001 applications, Industrial design application, Market capitalization of listed companies and Trademark applications.

In the literature of national innovation system, much emphasis has been placed on knowledge infrastructures such as universities, Research institutions, technical training institution etc., probably because they are directly related to the innovation process. However physical infrastructures such as roads, electricity, communication infrastructures have been neglected. Physical infrastructure needs to be considered as an element of national innovation system because of its economic effect and the network externalities that they provide (Smith, 2002).Smith (2002 p.9) defines infrastructure as “public sector capital, or as some combination of capital stock for “producers of government services”, electricity, gas and water, and transport and communication structures.” One of the main roles of national innovation system is to diffuse innovations and infrastructural is “an essential precondition for the diffusion of major technologies.” (Smith, 2002, p.14). The indicators identified for the measurement of infrastructure are found in table E1.1. The justification for these indicators is explained in the analysis by Smith (2002, p.14). i.e. “the internal combustion engine and the automobile required road and highway construction; the electricity power generation and supply network was a precondition for diffusion of industrial and consumer electrical products; the fax machine requires a telephone system; diffusion of advanced information technology requires internationally-compatible telecommunication networks etc.”

Given the complexity of national innovation systems, the government plays a role in a form of providing good governance to ensure that it is managed effectively. This is done by improving coordination among institutions; consciously seek to improve policy developments and service, creating conditions for innovation by managing the economy responsibly, regulating effectively and making responsible investments on all the other elements of national innovation system (Commonwealth of Australia, 2009). The importance of governance can be demonstrated in three categories, such as “quality of governance” and “character of political system.” (Fagerberg & Srholec, 2008, p.5). To measure the quality of governance in a country, the following indicators based on the literature were selected; protection of property rights, business freedom and freedom from corruption and impartial courts in a country. On the other had to measure the character of political system, the only indicator selected was only the size of government due to lack of data on the other measuring indicators.

A good financial system of a nation also plays a major role in the national innovation system by providing firms and other institutions with the resources to fund innovative activities (Filippetti & Archibugi, 2010). Innovations do not happen in a vacuum, they require funds in order to happen and the character of a country’s financial system is a precondition. The indicator selected measures the characteristics of the financial system of a nation (see table E1.1).

The one element which is in fact beyond the control people and governments because of the difficulty or impossibility to change through policy interventions is culture (Fagerberg &Srholec, 2008). The indicators selected for the measurement of culture is the famous Hofstede’s cultural dimensions (see table E1.1) According to Fagerberg & Srholec (2008), such indicators are necessary in order avoid the mistake of attributing the effects of such exogenous factors beyond the control of man to man-made capabilities.

Finally the economic and market conditions of a nation also impacts heavily on its national innovation system. Among the indicators selected to measure economic and market conditions, trade freedom and foreign direct investment measures the “openness” of the national innovation system (Fagerberg & Srholec, 2008). For example foreign direct investment and (merchandise) imports reflect foreign sources of technology in a country's national innovation system (Nasierowski & Arcelus, 1999). However over reliance on FDI has a tendency of replacing domestic efforts. This is because FDI is only a means of transferring the results of innovation, but not the innovation process (Lall, 1992). Nevertheless the diffusion of technology is found in trade and FDI (Fagerberg & Srholec, 2007). Furthermore, the level of economic development of a country also promotes innovations. This is in terms of the economic wealth of a country (Nasierowski & Arcelus, 1999). Therefore purchasing power parity and the GDP level of a country were selected measure this. GDP level refers to the size of a country's economy which is also an important variable used to measure a country's ability to absorb and generate new technologies whiles purchasing power parity shows the country's ability to pay for technological progress (Nasierowski & Arcelus, 1999). Market size has been described by Lall (1992) as an incentive for technological capability of a country, however according to Nasierowski and Arcelus (1999) high unemployment, illiteracy and children in many countries of sample, especially developing countries brings about problems in measuring market size as they reduce the attractiveness of consumer goods. Therefore they support size of a countries labor force as an alternative.

In conclusion, outputs of national innovation systems are the resulting technologies emanated from the application and interaction of elements within the system, and they could be categorized into three sets; solutions, knowledge base and productivity (Nasierowski & Arcelus, 1999). Solutions are the results of short term investments into innovative activities by a nation and they are in the form of patents whiles knowledge base are more long term and comprise of publications and citations which are also indications of R&D outputs (Nasierowski & Arcelus, 1999). On the other hand productivity refers to the overall contribution of a country's innovative activities to its economic development or growth. A country may decide to choose between investing in short term path to technology development (solutions) or long term paths (knowledge based), however the most important thing is that these efforts should lead to economic growth (Nasierowski & Arcelus, 1999, Kutlaca, 2008). Thus the overall contribution of Innovative activities is measured through gross domestic product per capita (GDP per capita).

Table E1.2: Description of Indicators and Source of Data

Symbol	Indicators	Description	Source of Data
E1	Primary education enrollment	Measurement of human capital	World Bank (WDI)[a]
E2	Secondary education enrollment	Measure of human capital	World Bank (WDI)
E3	Tertiary education enrollment	Measure of human capital	World Bank (WDI)
E4	Vocational education enrollment	Measure of technical orientation	World Bank (WDI)
E5	Total education expenditure	Measure of past commitment to education (human capital)	World Bank (WDI)
I1	Telephones Lines (per 100 people)	Measure of communication infrastructure (telecommunications)	World Bank (WDI)
I2	Internet Users per 100 people	Measure of communication infrastructure (Internet diffusion)	
I3	Electricity production	Measure of energy infrastructure	World Bank (WDI)
I4	Mobile Cellular subscriptions	Measure of communication Infrastructure (rate of communication)	World Bank (WDI)
I5	Roads paved (% of total roads)	Measure of efficiency of basic transport infrastructure	World Bank (WDI)
F1	Bank capital to assets ratio (%)		World Bank (WDI)
F2	Gross domestic savings (%) GDP	Measure of national savings rate as a percentage to GDP	World Bank (WDI)
F3	Domestic credits to private sector (%) of GDP	Measure of access to finance by businesses and individuals	World Bank (WDI)
F4	Credit market regulations	Measure of flexibility of credit market	Economic freedom of the world (EFW)Index
R1	Gross agricultural R&D expenditure	Measure of capability to develop new technology (agricultural sector)	ASTI & IFPRI[c]
R2	Total number of researchers in agricultural sector	Measure of human capability to develop new technologies (agricultural sector)	ASTI & IFPRI

R3	Scientific and technical journal articles	Measure of knowledge based innovations	World Bank (WDI)
R4	Total Patent applications		WIPO
IN1	ISO 9001 applications	Measure of refinements in production capabilities (quality standards)	ISO Surveys (ISO)[d]
IN2	Industrial design application	Measure of innovations in production capabilities	WIPO
IN3	Manufacturing value added (%) of GDP	Measure of contributions of manufacturing industries	World Bank (WDI)
IN4	Services, etc., value added (% of GDP)	Measure of performance of companies	World Bank WDI
IN5	Trade Mark Applications Total		World Bank (WDI)
G1	Impartial courts	The degree to which legal framework is trusted to challenge government actions and regulation for private businesses (Fagerberg & Srholec, 2008)	Economic freedom of the world (EFW) Index
G2	Business freedom	Measure of how easy it is to start and operate a business (business regulations)	Heritage Foundation (Index of economic freedom)[e]
G3	Protection of property rights	"The degree to which a country's laws protect private property and the degree to which government enforces these laws" (Fagerberg & Srholec, 2008 p. 13)	Economic freedom of the world (EFW) Index
G4	Freedom from corruption	The degree to which a nation is free from corruption	Heritage Foundation (Index of economic freedom
G5	Size of government	Measure of character of political system	Economic freedom of the world (EFW) Index
EM1	Purchasing power parity	Measure of a country's ability to pay for technological progress	Economic Research, Federal reserve Bank of St. Louis
EM2	Size of a country's labor force	Measure of market size of a country	World Bank (WDI)
EM3	Foreign direct investment (FDI)	A measure of foreign sources of technologies (openness)	World Bank (WDI)
EM4	Trade (%) GDP	Measure of openness	World Bank (WDI)
EM5	Merchandized Imports	A measure of foreign sources of technologies (openness)	World Bank (WDI)
C1	Power distance Index	Measure of the extent to which unequaled distribution of power in institutions and organizations is accepted by society	The Hofstede Center[f]
C2	Masculinity index	The extent to which a society is driven by	The Hofstede

		competition, achievement and success.	Center
C3	Individualism index	The degree of interdependence a society maintains among its members	The Hofstede Center
C4	Uncertainty avoidance index	The extent to which the members of a culture feel threatened by ambiguous or unknown situations and have created beliefs and institutions that try to avoid these.	The Hofstede Center
OUTPUT	GDP per capita (Constant US)	Measures the overall performance of NIS	World Bank (WDI)

Source:

a) http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators#c_g

b) http://www.freetheworld.com/datasets_efw.html

c) http://www.asti.cgiar.org/home

d) http://www.iso.org/iso/home/standards/certification/iso-survey.htm

e) http://www.heritage.org/index/explore?view=by-region-country-year

f) http://geert-hofstede.com/the-hofstede-centre.html

E2.1Model Development

The model selected for the analysis is a combination of confirmatory factor analysis and regression analysis. “Factor analysis is a statistical method to find small set of unobserved variables (also called latent variables, or factors) which can account for the covariance among larger set of observed variables (also called manifest variables).” (Albright & Park, 2009, p. 2). Confirmatory factor analysis and exploratory factor are the two major a approaches used when conducting factor analysis. With exploratory factor analysis, the researcher has very little knowledge concerning the theory the data available as a result the researcher “finds the factors that best reproduce the variables under maximum likelihood conditions”, making this approach more of a theory generating approach. On the other hand, confirmatory factor analysis is utilized when the researcher already has an understanding of the "constructs that underlie that data, as a result can be used to test "specific hypothesis regarding the nature of the factors making the approach more of a theory testing approach (Roberts, 1999, p.4). Confirmatory factor analysis was chosen because it is capable of testing factor structure that the research has predetermined. (Roberts, 1999). Therefore supporting the concept of this study where the national innovation system in theory, is preconceived to include a number of elements (factors) whose performance are reflected by a number of indicators (variables). Moreover "Confirmatory factor analysis is powerful because it provides explicit hypothesis testing for factor analytic problems and it is the more theoretically important- and should be the much more widely used of the two major factor analytic approaches" (Gorsuch, 1983, p. 134, retrieved from Roberts, 1999).

The confirmatory factor analysis model can be given as;

$$X = \Lambda\xi + \delta$$

Where X could be a number of *k* observed variables, ξ (Ksi) represents a number of *m* factors or latent variables such that $m<k$, Λ (lambda) is a $k \times m$ matrix of weights, also called factor loadings or communality representing the proportion of variance in the observed variable that is explained by the latent variable and δ is a vector of k observed variables which represent "random measure of error and indicator specificity" because the affect only a single observed variable (Albright & Park, 2009, Anderson & Gerbing, 1984, p.155). The assumption is this model is that the "error terms have a mean of zero, $E(\delta) = 0$, and the common and unique factors are uncorrelated, $E(\xi\delta') = 0$" (Albright & Park, 2009, p. 4). According to Blunch (2008) p. 128, confirmatory factor analysis follows the following rules;

1. Manifest variable are only connected with some pre-specific latent variables-the ideal being that every manifest variable is an indicator for one and only one factor.
2. Some error terms may be allowed to correlate.
3. Some of the parameters may be constrained to certain values or may be constrained to have some values as other parameters.

Another important aspect of confirmatory factor analysis is ensuring that the model is identified. According to Albright & Park (2009 p.5), the model is unidentified if the "number of unknown parameters to be estimated is smaller than the number of pieces of information provided." Thus to make the model identified, "every factor must be assigned a scale, either by fixing its variance or by fixing one of its regression weights and the same goes for error terms." (Blunch, 2008, p. 129).Confirmatory factor analysis can be done using statistical software packages such as; AMOS, LISREL, EQS, SAS etc (Roberts, 1999). However Amos was chosen for the purpose of this paper because of its easy-to-use graphical user interface and its ability to accept multiple models in one analysis. The model for this study goes beyond just confirmatory factor analysis to include analysis of the covariance structures among the factors and also a causal model where the factors are act as independent variable against a dependent variable.

Figure E2.1 is a graphical model of the national innovation system is going to be analyzed in this study using AMOS. The model comprises of three components; a measurement model linking a set of observed variables or indicators (see table E1.2) to a smaller set of latent variables (Education, Financial, Infrastructure, Research, Industry, Government, Econmkt and culture). A structural model linking the latent variables showing their covariance and relationships and finally a causal model that links the latent variables to another observed variable and dependent variable named 'output' (GDP per capita US constant). The model is identified as every factor has at least one of its regression weights fixed and the error terms for all observed variables have also been fixed. Moreover satisfies the three-indicator rule mentioned by Blunch (2008, p.129);

1. Every factor has at least three indicators
2. No manifest variable is indicator for more than one factor.
3. The error term are not correlated

The measurement model is to determine which of the indicators of the national innovation system are most influenced by their corresponding elements, whiles the structural model is to show the links and interrelationships among the various elements within the system and thus the links in the system as a whole. Finally the causal model is to determine performance of the entire system by identifying statistically significant contribution of each element to the overall output of the system. This can then be traced back to the important indicators influenced by each element which could then be used to drive or advice policies formulations.

Fig. 3.2: Analysis Model of National Innovation System

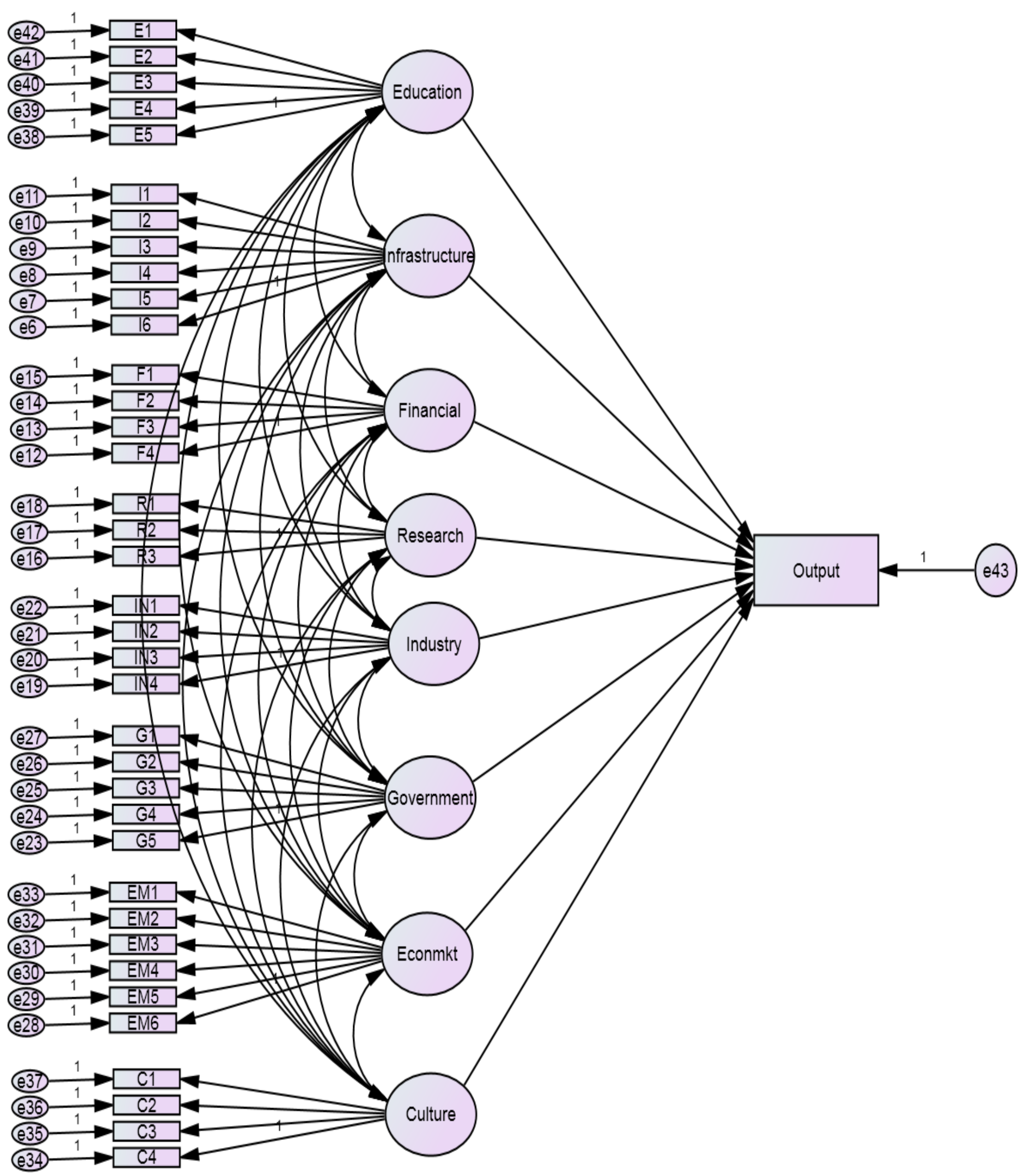

Figure E2.1 Model of National Innovation System

Figure E2.1 can also be rewritten into the following equations based on equation for confirmatory factor analysis “X=Λξ+δ”.

$E1 = \lambda_{42} Education + \varepsilon_{42}$

$E2 = \lambda_{41} Education + \varepsilon_{41}$

$E3 = \lambda_{40} Education + \varepsilon_{40}$

$E4 = \lambda_{39} Education + \varepsilon_{39}$

$E5 = \lambda_{38} Education + \varepsilon_{38}$

$I1 = \lambda_{11} Infrastructure + \varepsilon_{11}$

$I2 = \lambda_{10} Infrastructure + \varepsilon_{10}$

$I3 = \lambda_{9} Infrastructure + \varepsilon_{9}$

$I4 = \lambda_{8} Infrastructure + \varepsilon_{8}$

$I5 = \lambda_{7} Infrastructure + \varepsilon_{7}$

$I6 = \lambda_{6} Infrastructure + \varepsilon_{6}$

$F1 = \lambda_{15} Financial + \varepsilon_{15}$

$F2 = \lambda_{14} Financial + \varepsilon_{14}$

$F3 = \lambda_{13} Financial + \varepsilon_{13}$

$F4 = \lambda_{12} Financial + \varepsilon_{12}$

$R1 = \lambda_{18} Research + \varepsilon_{18}$

$R2 = \lambda_{17} Research + \varepsilon_{17}$

$R3 = \lambda_{16} Research + \varepsilon_{16}$

$IN1 = \lambda_{22} Industry + \varepsilon_{22}$

$IN2 = \lambda_{21} Industry + \varepsilon_{21}$

$IN3 = \lambda_{20} Industry + \varepsilon_{20}$

$IN4 = \lambda_{19} Industry + \varepsilon_{19}$

$G1 = \lambda_{27} Government + \varepsilon_{27}$

$G2 = \lambda_{26} Government + \varepsilon_{26}$

$G3 = \lambda_{25} Government + \varepsilon_{25}$

$G4 = \lambda_{24} Government + \varepsilon_{24}$

$G5 = \lambda_{23} Government + \varepsilon_{23}$

$EM1 = \lambda_{33} Econmkt + \varepsilon_{33}$

$EM2 = \lambda_{32} Econmkt + \varepsilon_{32}$

$EM3 = \lambda_{31} Econmkt + \varepsilon_{31}$

$EM4 = \lambda_{30} Econmkt + \varepsilon_{30}$

$EM5 = \lambda_{29} Econmkt + \varepsilon_{29}$

$EM6 = \lambda_{28} Econmkt + \varepsilon_{28}$

$C1 = \lambda_{37} Culture + \varepsilon_{37}$

$C2 = \lambda_{36} Culture + \varepsilon_{36}$

$C3 = \lambda_{35} Culture + \varepsilon_{35}$

$C4 = \lambda_{34} Culture + \varepsilon_{34}$

The causal model in figure 3.2 can also be rewritten in the following regression equation;

$$OUTPUT = \beta_{0+}\beta_1 Education + \beta_2 Infrastructure + \beta_3 Financial + \beta_4\, Research$$
$$+ \beta_5 Industry + \beta_6 Government + \beta_7 Econmkt + \beta_8 Culture + \varepsilon_{43}$$