Comparative Advantage in the Knowledge Economy:

A National and Organizational Resource

Edited by Dr. Rajib Bhattacharyya

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EDITED BY

RAJIB BHATTACHARYYA

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United Kingdom – North America – Japan – India – Malaysia – China

Emerald Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2021

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-80071-041-2 (Print)
ISBN: 978-1-80071-040-5 (Online)
ISBN: 978-1-80071-042-9 (Epub)

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Table of Contents

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Foreword

The present book on "*Comparative Advantage in the Knowledge Economy: A National and Organizational Resource*" is a timely endeavor to capture the significant role which the knowledge economy plays in the economic growth of a nation. Needless to say, knowledge economy is an umbrella term, which embraces human skill, embodied knowledge in research and development (R&D), information and communications technology (ICT) as an input in the production process, spread and quality of higher education, and so on. As a result, the editor of the book has tried to bring in as many aspects as possible under one fold to give somewhat a holistic picture about the interrelation between knowledge economy and economic growth. This is no small task, and the book has done justice to this.

There are several dimensions which are highlighted in the book – one is country studies like Ghana, Sub-Saharan Africa, or Nordic nations, either in a stand-alone fashion or in a comparative dimension. Another set of papers have discussed the issue in terms of better human capital which a knowledge economy brings through better R&D and digitaliztion to enable faster growth in a nation. The third type of papers has stressed the contribution of specific sectors like education, ICT, banking, agriculture, etc., in accelerating economic growth of a nation. In addition, the open economy implications are captured by a set of papers dealing with foreign direct investment (FDI) which transfer advanced embodied knowledge through production technology. After reading the chapters, the reader will be enriched with a holistic view about the interconnection between evolution of knowledge economy and economic growth of nations.

The editor must be complemented for undertaking such an arduous task of compiling such a diverse range of papers efficiently. The contribution of human capital on economic growth is by now well-documented. However, the additional dimension of the role of the knowledge economy in enhancing the human capital, both theoretically as well as with empirical data–based work, is not available in too many collated works. This book is a welcome addition to this end and will surely help students, researchers, as well as policy planners in organizing their thoughts in this respect.

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Acknowledgment

By choosing carefully an international array of authors who are active researchers in their fields of study, as an editor I have provided my persistent endeavor to develop a theme which happens to be very relevant in the present-day context of "Corona Pandemic." Starting from conceptualization of the theme, selection of papers, editing, and ultimate publication of the proposed edited book entitled "*Comparative Advantage in the Knowledge Economy: A National and Organizational Resource*," it has been a unique compilation. I really feel delighted and hope that I have succeeded in adding value to a considerable literature in the process of making this edited volume. I also expect that this volume will have a high market demand not only to researchers and academicians but also to policymakers and social thinkers. I really feel proud as an editor that the authors of this book have provided immense support, cooperation, and extended their wholehearted helping hand to make this project a successful one. Hence, it would be unjustified if the contributors are not acknowledged for their valuable contributions. I would also like to express my heartiest thanks to other academicians and resource persons of the society associated with this project.

At the first place, I must thank the entire Emerald Publishing team for their able and insightful guidance and support at every stage of this edited volume. Secondly, I express my deep gratitude and respect toward my teacher, mentor, and Ph.D supervisor, Prof. (Dr.) Soumyen Sikdar, Indian Institute of Management (IIM), Kolkata. I also express my heartfelt thanks to Dr. Ajitava Raychaudhuri, Professor and former Head Department of Economics, Jadavpur University, for his advice, guidance, and valuable suggestions that have paved the right way from the beginning to the finish line. I will also remain indebted to my friend Dr. Sudipta Roy, Professor of Finance, St. Francis in Joliet, Illinois, US, for her mental support. I also express my thanks and gratitude to Dr. Partha Gangopadhyay, Professor of Economics, Western Sydney University, New South Wales, Australia, Dr. Ananya Ghosh Dastidar, Associate Professor in the Department of Business Economics, University of Delhi South Campus, New Delhi, India, for their inspiration and valuable comments.

But above all, I am sincerely grateful to my parents, my wife and my daughters, and other relatives and family members for their cooperation, inspiration, and tremendous mental support.

Dr Rajib Bhattacharyya
Editor

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Introduction

Of late, the issue which has really made a paradigm shift in the landscape of the global economic, social, and political scenario is the transition of world economic order toward a knowledge-based development regime. This has not only being the trend in developed nation, but it is acting as a national, strategic, and organizational resource for emerging, developing, and less developed economies to establish their comparative advantage. "Demographic dividend" has become the popular buzzword in this respect. Globalization and the information and communications technology (ICT) have played a pivotal role revolutionizing in the value creation through the development of human capital formation. The constantly changing needs and structure of the labor market are primarily responsible for conversion of a traditional economy, relying fundamentally on the application of physical abilities like transformation of material resources or exploitation of cheap labor, to a knowledge-based economy relying on ideas, technologies, and innovations. In a knowledge-based economy, knowledge has to created, acquired, developed, transmitted, preserved, and utilized for the improvement of individual, society, and enterprises for the promotion of economic and social welfare.

> When learning is purposeful and creative, it blossoms. When creativity blossoms, thinking emanates. When thinking emanates, knowledge is fully lit. When knowledge is lit, economy flourish.
>
> A.P.J. Abdul Kalam

In recent years, the development and proliferation of ICT has revolutionized the access and transmission of information through knowledge networks, innovations, and adaptation capacity. Due to upgradation of hardware, software, computer memories, and semiconductors getting faster, the ICT prices are falling. Dramatic fall in the costs of data transmission, significant growth in bandwidth, expansion, and multiplication of Internet hosts and growing usage of cellular and iPhone worldwide are all adding to the pace of and capacity for change and innovation. This has resulted in shorter product cycles. In terms of both economic growth and employment, small and medium-size enterprises in the service sector have emerged as increasingly important players. The success of a knowledge-based economy rests on four key pillars: (1) framework of supportive economic and institutional arrangements; (2) educated and skilled labor force; (3) dynamism in

information network for dissemination of information; and (4) research and development (R&D) and innovation in conformity with global needs.

Investment in human capital is critical for economic growth. Particularly important are new technology, its dissemination through education, and related externalities (Barro 1991; Lucas 1988; Mankiw, Romer, & Weil 1992; Romer, 1989). Researchers have documented the external effects of human capital in Austria, China, and Guatemala (Sakellariou, 2001; Winter-Ebmer, 1994; Wang & Mody 1997). They have tied growth to knowledge in Israel and found significant spillover effects of human capital in the Republic of Korea (Bregman & Marom 1993; Feenstraand others 1999). The impact of education on economic growth may be as high as the private returns to education estimated in microeconomic studies (Krueger & Lindahl, 1999; Topel, 1999). The quality of education, and therefore of labor, also affects economic growth (Barro, 2001; Hanushek & Kimko, 2000). Science achievement, for example, has a positive effect on growth. Education also has an important effect on several nonmarket outcomes, including crime reduction, social cohesion, income distribution, charitable giving, and more efficient labor market search. Education has an important effect on female productivity in the labor market. Even more important are the positive effects on female labor supply; the associated declines in fertility; and the improvements in the health, education, and life chances of the children of educated women. There is a strong linkage between mothers' education and children's development. Suciu (2004) considers that knowledge and knowledge economy (KE) are based on other means of managing time and distances: information and knowledge. According to Suciu (2004), KE is characterized by imbalance, instability, fluctuations, chaos, due to the mixture of the following phenomena: the technological revolution (rapid technological progress, particularly with regard to new information and communication technologies) and the acceleration of globalization (the internationalization of a part of the world economy and changes induced in the international financial environment).

The Knowledge Assessment Methodology (KAM), which was formulated and developed by the World Bank Institute, is an interactive tool that highlights the basic assessment of nations' readiness for the KE. To measure KE development, the European Bank for Reconstruction and Development (EBRD) in March 2019 has published the EBRD KE Index, spanning 46 economies – 38 where the EBRD invests and eight comparators (members of the Organization for Economic Co-operation and Development, OECD). The new EBRD KE Index contains 38 indicators divided into four pillars: (1) institutions for innovation, (2) skills for innovation, (3) the innovation system, and (4) the ICT infrastructure. Among the EBRD regions, Estonia scores highest and Turkmenistan lowest. Serbia made the greatest progress between 2011 and 2018.

The present book attempts to incorporate the multidimensional issues related to the concept of the development and sustainability of a KE in a comprehensive manner. A brief summary of the chapters are given below:

Chapter 1 portrays the manner in which knowledge-based economy enhances economic growth and development of human capital through ICT education. It

intends to analyze the progress and challenges faced by Ghana as it strives to build a knowledge-based economy that thrives on innovation and creativity.

Chapter 2 tries to demonstrate that education and knowledge have become the prerequisites for the growth and development of any economy. It tries to investigate whether knowledge and human capital have contributed to the growth of sub-Sahara African (SSA) countries. It has tried to show the low ranking of SSA in terms of knowledge economy index (KEI) and suggests production, use, disseminate and transfer of knowledge, ICT, and science.

Chapter 3 attempts to assess whether the new knowledge has real merits vis-à-vis the old knowledge of central banking. It also highlights the potential dangers of using untested new knowledge and its economic consequences. It contributes to the literature on central bank independence by introducing analytical methods and has uncovered the presence of high mobility in economic variables that is unexplained by changes in central bank independence.

Chapter 4 describes the way in which lockdown due to Covid-19 virus has provided the much-needed impetus to reshape higher education in India. It emphasizes the implementation of a blended learning model supported by the adoption and use of learning management systems. It strongly stresses the role of corporations in channeling their unused corporate social responsibility funds to support ICT needs at educational institutions.

Chapter 5 explores the potential consequences of technological transition in the KE brought about by the introduction of virtual system backed by Internet and software innovations. It speaks in terms of skill augmentation, wage inequality, and highlights the overall impact on welfare. It develops a model on small open economy to find out the possible impacts of such disruptive technology on the higher education sector of India

Chapter 6 focuses on the KE as an alternative to production-based economy and brick-and-mortar economy. It tries to develop a model to check whether KE has the ability to support arbitrage process. The result shows that there are positive probabilities of the KE in providing arbitrage premium for individual which can fire the growth of the economy.

Chapter 7 attempts to explain that the knowledge gained by investors is also a part and parcel of an applied KE in a broader dimension. It demonstrates how investors adapt through "learning by doing" is a big issue in the present context, and this is exactly what the paper targets to articulate – how knowledge gained on something unknown can help investors to track down a bubble when the literature actually stated no such existence of formation of a "bubble" component during the US subprime crisis in the Indian stock market.

Chapter 8 evaluates the evolution of e-marketing as a natural outcome of technological changes and marketing innovations resulting from the advent of information technology and the consequent access to Internet. Conscious customers have been increasing their purchase through e-marketing as it has a lot of benefits. It has opened a huge business opportunity for marketers. It attempts to examine the changing consumer perception and environment of e-marketing in rural India for consumer durables based on a primary survey.

Chapter 9 tries to find out the impact of ICT on human development for selected high HDI and medium HDI countries during 2001–2018. Applying panel data technique result shows that ICT has a positive and significant impact on human development. The selected countries are Australia, Denmark, Germany, Iceland, Ireland, Netherland, Norway, Singapore, Sweden, Switzerland, India, Bangladesh, Namibia, Morocco, South Africa, Philippines, Bolivia, Egypt, Iraq, and Maldives.

Chapter 10 demonstrates the role of FDI in developing the knowledge base of an economy. It seeks to analyze both short-run as well as long-run interactions between status of knowledge and FDI in the form of inflow of FDI and proportion of gross domestic product (GDP) used for R&D activities accounting for possible development of knowledge in BRICS (Brazil, Russia, India, China, and South Africa) nations. As panel data analysis support long- and short-run causality running from FDI to knowledge in all BRICS nations, the paper suggests more FDI in development of knowledge-related activities as well as increase in proportion of GDP spent on R&D in BRICS nations.

Chapter 11 reviews the current conditions of ICT use by the students in higher education in India. The major objectives of the study are: (1) assessment of the use of computer and Internet by the students of higher education in India and (2) to find the determinants of use of ICT by the students in India. The study uses the NSSO 71st Round, 2014, Unit Level Data on Social Consumption: Education Survey. The findings from logit analysis suggest the determinants of ICT use by the students in higher education in India are: regional disparities, gender, education levels of households, type of courses pursued by the students, type of institutions, access to computer and Internet facility, consumption levels of households, and students' residence type.

Chapter 12 attempts to investigate the ramifications of foreign trade regime on the technological front in relation with the impact of trade liberalization on the process of skill formation in dual economy setting and thereby, the wage dynamics facing the skilled and unskilled labor. It tries to analyze the consequence of free trade on KE (wherein, the knowledge essentially purports to technical skill, proficiency in various aspects of work and perhaps, to some extent, the case of innovation) and additionally, what it impinges on welfare and economic development for less developed countries.

Chapter 13 aims at evaluating the role of FDI in knowledge transition through improvement in the human development index (HDI), particularly its education index in the context of India and other South Asian Association for Regional Cooperation (SAARC) countries. To study the KE as well as human capital, Intellectual Property Rights (IPRs) are used. Whether the role of FDI is still there in transition to KE or not, relationship between FDI confidence index and education index is taken into consideration. It concludes that the importance of FDI in export promotion in the services sector in India should be pursued as a long-term policy objective.

Chapter 14 attempts to examine the relationship between human capital and artisanal innovation. It was based on a study conducted in 2018 on 73 craft economic units located in Jalisco, Colima, and State of Mexico. Using the

Pearson's chi-square technique and applying the Statistical Package for the Social Sciences (SPSS) program, the qualitative relationship between innovation and human capital was analyzed. The result shows a positive relationship between human capital and innovation.

Chapter 15 focuses on the agricultural knowledge system in ensuring food security in India. The objective of the paper is to show that educated and trained people can acquire new skills and technologies required for growing agricultural output to meet the domestic demand. It is based on a sample survey in the Hooghly district of West Bengal with an aim to examine whether welfare of the economy falls or not if rationing system is completely abolished.

Chapter 16 seeks to develop a theoretical construct in the field of evolution of knowledge asset with a view to explore the concept of knowledge asset and the need for its management in modern day life. It further aims to investigate through an empirical study the qualitative disclosure of knowledge assets in terms of selected attributes for the Indian Pharmaceutical and IT Industries based on their annual reports. Content analysis technique has been used to analyze the degree of disclosure of knowledge assets in terms of attributes.

Chapter 17 tries to explore the satisfaction of the students of the University of North Bengal from the perspective of outcome or services provided by the institution which is essential for its long-run sustenance. . Given that education is an experience good, its efficacy can be measured by evaluating its effect on users, that is, students. This study is based on primary data collected from the structured questionnaire and logistic regression model as a tool. The analysis emphasize on the fact that traditional system in higher education must be revised in light of more market-oriented new KE structure to get better result.

Chapter 18 intends to examine the role of trade liberalization and knowledge exchange programs with regard to soft power connectivity between India and South Korea. The study tries to explore the role of "soft power" diplomacy in India–South Korea relations and also the significance of knowledge-based programs. The study is based on secondary data and uses content analysis and observation methods to arrive at its conclusion.

Chapter 19 concentrates on the impact of knowledge flows and FDI on intraindustry trade in Asian region. It shows how in the postindustrial age, the knowledge is replacing the capital, which is the primal source of economic growth and development. The study highlights the role of R&D as fundamental for the production of knowledge, which leads to create innovation through scientific research, transferred through the basic education and training and dispersed through ICT.

Chapter 20 investigates the enhancement of digitization in India in comparison to countries of Nordic regions like Norway, Sweden, Denmark, and Finland in terms of Digital Economy and Social Index (DESI). It attempts to analyze the comparative advantage Nordic countries has over India in terms of Internet Usage and Mobile Phone Subscription. The data for the model were based on the Word Development Indicator of the World Bank. The study observes that India should try to incorporate the factors which lead to faster digitalization in the Nordic region.

Chapter 21 emphasizes on the role of investment on higher education as a source of knowledge creation and income generation. It hints on the development of a modern and dynamic higher education framework to achieve long-run sustainable growth. The study examines the interplay between the percentage of educational expenditure in total expenditure and per capita Net State Domestic Product (NSDP) of eight selected metro city states of India during the period 2005–2006 to 2015–2016. The result shows strong positive impact of educational expenditure on per capita NSDP. Therefore, the study suggests increasing the percentage share of educational expenditure in total expenditure.

Chapter 22 focuses on the application of ICT and its relation with urbanization in India. For analyzing the development of ICT sector in India, the variables taken are e-infrastructure, telephone density per 100 persons, mobile subscribers per 100 persons, mobile subscribers with Internet, schools with computers and e-participation. The analysis reveals that apart from some exceptions, the relatively economically developed and urbanized states of India are found to have a developed ICT sector.

Chapter 1

Knowledge-Based Economy: Enhancing Economic Growth and Development of Human Capital Through Information and Communications Technology Education

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Abstract

Globalization and the rapid development of Information and Communications Technology (ICT) have advantaged economies which have invested in (re)skilling their human capital in technical knowledge. Similarly, ICT have spearheaded the growth and development of industrial and service sectors in emerging economies. This accounts for the progress of some Asian economies and the lagging behind of many sub-Saharan African countries, including Ghana. Primarily, reorientation of economic development strategy and human development policy in tandem with the demands of knowledge-based economy (KBE) and related development in ICT explain the differences among the world's economies. Our chapter discusses the extent to which ICT has been incorporated into the educational system to transform it from traditional education in order to reskill human capital in postprimary schools to support the creation and growth of KBE in Ghana. Moreover, the chapter assesses whether ICT infrastructure and syllabuses at postprimary schools meet the challenges of a KBE and an enhanced growth development in Ghana. Using the theories of evolutionary economic change, new growth, technology and knowledge gap, we intend to analyze the progress and challenges faced by Ghana as it strives to build a KBE that thrives on innovation and creativity, which in turn drive economic growth and development. In this respect, we examine postprimary schools in Ghana.

Comparative Advantage in the Knowledge Economy, 1–10

doi:10.1108/978-1-80071-040-520210001

Keywords: Economic development; educational system; human capital; information and communications technology; knowledge-based economy; Ghana

JEL Classification: J24

1. Introduction

In today's world, the economies are rapidly transiting toward being more knowledge-based, and supporting knowledge is a vital factor of the processes of economic growth and development. The trend of globalization has led all continents, regions, or countries to be actively involved in the global economy so that the competition is the main factor in progress. Knowledge-based economies (KBEs) provide an environment where competition is vital. The KBEs are an economic development model which emerged in the late 1990s in the Organization for Economic Co-operation and Development (OECD) (World Bank, 2007). This chapter discusses the extent to which Information and Communications Technology (ICT) has been incorporated into the educational system to transform it from traditional education in order to reskill human capital in postprimary schools to support the creation and growth of KBE in Ghana. To achieve the goal of the chapter, the study is divided into five sections. Section one is the introductory aspect; section two presents the literature review and theoretical and empirical evidence; section three dwells on the methodology model and data requirements; section four brings to the fore the results and interpretation of the extracted data; and the conclusion is to be found in section five.

2. Literature Review and Theoretical and Empirical Evidence

There appears to be no coherent definition of what constitutes KBE, although the concept itself is embedded in an extensive tradition of economic and social theories. It is believed the concept of knowledge economy has its roots in theories spanning information theory to that of theories relative to postindustrialism (Bell & Pavitt, 1993). Broadly, the concept of KBE is defined as an economy that is directly based on the production, distribution, and use of knowledge and information (OECD, 1996).

The primary goal of modern nation building has been the advancement of science, economic growth, and development. However, differences in the levels of economic development within and between developing countries persist despite efforts made in support of less spatial regions. These noted resultant differences have emerged when comparing countries and comparing regions within a country relative to Gross Domestic Product (GDP) and other indices. There are many reasons for such differences: historic, environmental, economic, and cultural. But the question is not only about the causes of this economic diversification but about the mechanisms of the most effective convergence tools as well. Technology change and innovation based on knowledge and scientific research are claimed to

be the most important causes of diversification and at the same time one of the best ways for further development (Svare & Dabie, 2005).

The integration of science, technology, and the economy within a body of theories that promote KBE has emerged due to changes in material production after the end of World War II. They include the theories of economic growth, theories of evolutionary economic change, new growth, technology, and that of knowledge gap. This stems from the fact that neoclassical growth theories, to an extent, failed to offer any practical solutions for capitalizing on knowledge or turning knowledge into innovation, hence the need for a more policy-oriented approach emerged. The exogenous growth model perceived nonmaterial production factors, in particular, research and development (R&D) and education, as being the catalyst for economic growth (Solow, 1957).

However, unlike the Solow (1957) model that treated technology as given from the heavens that enhances human work and thus, leading to higher productivity, the new growth model brought to the fore a deliberate investment in endogenous variables, including human capital and scientific research based on knowledge that finally translate into goods leading to higher rate of economic growth (Romer, 1989, pp. 323–348). These theories not only influenced but more, importantly, impacted governments between the 1960s and 1990s, by prompting them to invest heavily in scientific research as the prime mover of new technological breakthroughs.

Due to the economic recession of the 1970s, evolutionary theory of technological change spurred certain best practices that policy-makers could apply to foster innovation and thus, economic growth and development. The foci of evolutionary theory were radical technological innovations such as the application of microelectronic revolution as the missing link and critical not in solving economic crisis but relevant to enhancing the processes of change, growth, and economic development (Nelson & Winter, 1982). Therefore, the coevolution of technologies, firms, and industry structures and their supporting governing institutions were perceived as critical for generating innovation (Svare & Dabie, 2005).

Over the past few decades, it is difficult to deny that important changes have been occurring in the means and ways that economies operate, and these changes revolve in part around the creation, transfer, and use of knowledge. Knowledge indeed has become by far the most important factor determining standard of living and/or well-being more so than land, capital, or labor (Leydesdorff, Cooke, & Olazaran, 2002). A research study involving the estimating and analysis of the processes of economic growth in Saudi Arabia, GDP is applied as a proxy for KBE as part of the country's vision 2030 (Amirat & Zaidi, 2020). The knowledge gap theory emphasizes that wealthier and more educated people acquire information from mass media faster than lower socioeconomic classes. Therefore, as mass media grows, so too does the gap in knowledge between the higher and lower social class (Tichenor, Donohue, & Olien, 1970).

Noted observers suggest that a KBE is built upon four pillars: First, it requires an economic and institutional framework that provides incentives for the efficient creation, the dissemination, and the use of knowledge to promote growth and

increase welfare. Second, it needs an educated and skilled population that can create knowledge and use it. Third, innovation systems that can tap into the growing stock of global knowledge, adapt it to local needs, and transform it into products valued by markets are necessary. Finally, a dynamic information infrastructure is required that can facilitate effective communication and processing of information (Chen & Dahlman, 2005, pp. 1–24).

Although, interrelated, dynamically, it is the second pillar that stands out as the main pillar behind the processes of economic growth and development. Human capital and research are included in growth as knowledge, skills, competencies, and other attributes embodied in individuals (Health, 2001). There is a strong positive correlation between human capital and economic growth in 100 countries (Sab & Smith, 2001, pp. 2001–2032). A recent study showed that there is a positive and significant relationship between human capital and growth in 15 countries within the European Union (Cardoso & Pentecost, 2011, pp. 1193–1229).

More importantly, they found that both secondary and higher levels of education as proxies for human capital had a significant positive effect on regional growth in Portuguese regions. Similarly, other results indicated that human capital either resists income divergence across middle- and high-income nations or supports conditional convergence (Qadri & Waheed, 2013). The empirical studies in this group at both micro and macro levels suggest that education and skills development provide new opportunities to developing and adopting new technology (Barkhordari, Fattahi, & Azimi, 2018). Although Ghana, a developing nation like Malaysia and South Africa, has emphasized innovation and ICT relative to KBE, it is not able to get on par with these countries. Unlike Ghana, Malaysia in 2006 alone spent 9.32 billion US$ on ICT as part of meeting her knowledge societal goals (Kefela, 2010).

3. Methodology and Data Requirement

In order to investigate, assess, and analyze the relationship between post-secondary education and the processes of enhancing GDP as a proxy for KBE that thrives on innovation and creativity, which in turn drive economic growth and development, data are obtained from the World Bank world development data series (indicators). The extracted data: Primary Education-Pupils (% gross), Expenditure on Primary Education (% of Government expenditure on education), Secondary Education (% gross), Expenditure on Secondary Education (% of Government expenditure on education), School enrollment-Tertiary (% gross) and, Technicians in R&D (per million people) for the period of 1983–2018.

We apply the empirical methodology framework of the Cobb–Douglas Production Function:

$$Y = (A, K, L) \tag{1.1}$$

When human capital is introduced in Equation (1.1) above it becomes:

$$Y = (A, K, L, H) \tag{1.2}$$

Where: Y indicates GDP growth, A is a technological parameter, L shows labor, K is physical capital, and H represents human capital (Cobb & Douglas, 1928). The variable H is usually represented by education. The Mankiw, Romer, and Weil (MRW) model relative to the Solow (1956) growth model resolves the steady-state per capita income level results in an equation that includes physical and human capital as the basic determinants of growth (Mankiw, Romer, & Weil, 1992). The MRW model employs the Cobb–Douglas production function in which human capital is therefore considered as an independent factor of production:

$$Y = K^{\alpha} H^{\beta} (AL)^{1-\alpha-\beta} \tag{1.3}$$

The empirical form of the model can be written as:

$$\log Y = a_0 + a_1 \log L + a_3 \log H + \varepsilon \tag{1.4}$$

Linear models, LOG-LIN, LIN-LOG, and LOG-LOG, are used to describe the relationship between economic growth and education quantity and quality as the bases and/or driver of KBE. First, in the LOG-LIN model (the dependent variable will be the logarithm of GDP growth as a proxy for KBE), absolute change in the dependent variable will cause relative (percentage) change in the dependent variables. Similarly, in the LIN-LOG model, absolute change in the regressands is caused by relative (percentage) change in the dependent variable. Furthermore, in the LOG-LOG model, relative change in the dependent variables will entail relative change in regressands (Ciucu & Dragoescu, 2014).

Henceforth, for this chapter, the multiple regression model applied is:

$$y = \beta_0 + \beta_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon \tag{1.5}$$

Thus, the estimated multiple regression equation is:

$$y = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_k x_k \tag{1.6}$$

Where:

b_0 = estimate of β_0
b_1 = estimate of β_1
b_k = estimate of β_k
y = GDP growth (%)
X_1 = Gross enrollment ratio (primary: total)
X_2 = Gross enrollment ratio (secondary: total)
X_3 = Gross enrollment ratio (tertiary: total)
4_3 = Expenditure on Secondary Education (% of Government expenditure on education)
5_3 = Technicians in R&D (per million people)
$\mathcal{E}$ = Random variable

Henceforth, to obtain good estimates the least squares criterion will be applied; b_0,b_1, …, b_k in order to minimize the sum of square errors ($mim\sum_i (y_i - y_i)^2$). On the other hand, b_1 represents the relationship between y and x_1; if it is positive, then it means that y and x_1 are positively related and, if it is negative that means that they are negatively related. Thus, the multiple coefficients of determination:

$R^2 = \frac{SSR}{SST} = 1 - (\frac{SSE}{SST})$,where SST = SSR + SSE. The adjusted R^2, noted $R\frac{2}{\alpha} = 1 - (1 - R^2)(\frac{n-1}{n-k-1})$. The linear models: LIN-LIN, LOG-LIN, LIN-LOG, and LOG-LOG for the multiple regression model is be tested, to ascertain the best model.

4. Results and Interpretation

This section of the chapter presents an analysis and interpretation of the extracted data variables relative to the interrelation between the content of postsecondary education and GDP as a proxy for KBE. A good regression model should meet Gauss–Markov assumptions relative to full ideal conditions of Ordinary Lest Squares (OLS) with the following characteristics: a high *R* square value with a high adjusted *R* square value; using a *t*-test, the independent variables should be individually significant to impact the dependent variable; when an *F*– test is used, the independent variables should be jointly significant to influence the dependent variable within a model; there shouldn't be a serial correlation in the residuals; the resultant model should not have heteroskedasticity; and, the residuals should be normally distributed. All these ideal conditions have to be met in order for the OLS to be the best linear estimator (BLUE) (Henri, 1971). Based on Excel version 2019 16.0.6742.2048, Table 1.1 presents a summary statistic of the multiple regression model.

Table 1.1 Multiple Regression Summary Output.

Variable (Statistical Technique)	Statistical Result
Multiple R	0.758,090,754
R square	0.744,701,591
Adjusted R square	0.736,708,816
Standard error	0.641,024,221
Sum squared residuals	1.567,000,999
Log likelihood	−6.465,645,112
F – statistic	6.011,544,806
Prob(F-statistic)	0.020,191,881
Mean dependent variable	1.560,094,821
Standard deviation	8789,975,446
Akaike information criterion	1.2382,245,434
Schwarz criterion	2.028,987,271
Hannan–Quinn criterion	1.877,933,458
Durbin–Watson statistics	1.872,797,327
Observations	36

Source: Authors' Compilation, (2020).

The coefficient of determination is R^2 = 0.744,701,591, meaning that approximately 75.05% of the variability of the GDP growth as proxy for KBE is explained by the education related variables. The Prob(F-statistic) is actually the *p*-value, the least significant variable is the gross percentage of enrollment in secondary education variable, and the most significant variable the gross percentage of enrollment in tertiary education.

From the *p*-value of the *F*-statistics it can be noticed that *F*-statistics is significant. This means that the three main independent variables – (i) Expenditure on Secondary Education (% of Government expenditure on education), (ii) School enrollment-Tertiary (% gross), and (iii) Technicians in R&D (per million people) for the period of 1983–2018 – jointly influence the GDP growth (KBE) in Ghana. The product (students) coming out of the tertiary educational system become the labor force which drives the needed innovation and technical know-how within the economy. The Durbin–Watson statistic of 1.872,797,327 is significant, hence there is negative autocorrelation as the residuals are not related. We fail to accept the alternate hypothesis of the presence of positive autocorrelation. Autocorrelation is a correlation of the errors (residuals) over time. It violates the regression assumption that residuals are random and independent (Durbin, 1970). The Akaike Information Criterion (AIC) of 1.2382,245,434 depicts that the model fits the extracted data. Generally, the smaller the AIC, the "better" is the predictive performance of the model (Burnham & Anderson, 2003). Although the Hannan–Quinn criterion (1.87,793,458) from Table 1.1 is an alternative to the AIC and Bayesian criteria, it equally is well behaved as it follows from the law of the iterated logarithm which describes fluctuations of random walk (Hannan & Quinn, 1979). To check for residuals distribution in Table 1.1, the Breusch–Godfrey serial correlation LM test is presented in Table 1.2.

From Table 1.2, the *p*-value of the noted residuals in the model are not serial correlated. Thus, the null hypothesis that there is no serial correlation. Its inclusion is to enhance the Durbin–Watson statistical technique as its application such as education as a variable has a lagged value period relative to the dependent variable of GDP as proxy for KBE (Breusch, 1978). Table 1.3 brings to the fore the heteroskedasticity test of variance of the residuals.

The Breusch–Pagan–Godfrey test is used to test for heteroskedasticity in a linear regression model. It tests if the variance of the errors from a regression model is dependent on the values of the independent variables; heteroskedasticity is present if that is the case. It is seen from Table 1.3 that the *p*-value of the test relative to the residuals is homoscedastic (Breusch & Pagan, 1979).

Although, there is a gap in the human skill and capital in Ghana, the Government's attempt to make human capital development as the main factor and/or

Table 1.2. Breusch–Godfrey Serial Correlation LM Test.

F-Statistic 0.762,414	Prob. F (2,4) 05,165
Obs*R-squared 2.436,513	Prob. Chi-square (2) 02,687

Source: Authors' Compilation, (2020).

Table 1.3. Heteroskedasticity Test: Breusch–Pagan–Godfrey test.

F-Statistic 3.815,571	Prob. F (2,4) 0.0521
Obs*R-squared 6.798,875	Prob. Chi-square (3) 0.0651
Scaled explained SS 3.220,014	Prob. Chi-square (3) 0.3566

Source: Authors' Compilation, (2020).

bedrock for development through the expansion of education within the last few years is beginning to pay off. Thus, as seen from the literature review, unlike the Solow (1957) model that treated technology as given from the heavens that enhances human work and thus, leading to higher productivity, the new growth model brought to the fore, a deliberate investment in endogenous variables including human capital and scientific research based on knowledge that finally translate into goods leading to higher rate of economic growth (Romer, 1989, pp. 323–348). These theories not only influenced but more importantly, impacted governments' efforts starting from the 1980s till the present in the expansion of tertiary education by promoting investment in ICT infrastructure and the incorporation of scientific knowledge and technology into the educational system to transform it from traditional education in order to reskill human capital in postprimary schools to support the creation and growth as the basis of KBE. Apart from government infrastructure development in postprimary education, the private sector has taken advantage of a more liberal open economy to expand in its educational facilities nation-wide.

As part of sweeping education reforms that began in 1987, higher education provision was opened up to the private sector, while public higher education was gradually deregulated. A legally mandated quality assurance body, the National Accreditation Board (NAB), was established in 1993 to regulate and guide the deregulation process. Before 2000, there were less than 15 private Higher Education Institutions (HEIs), but by 2015 their number had grown to 106, compared to 83 public HEIs. There are also numerous unaccredited institutions, 55 of which have been identified and published in the media by the NAB for the information of the general public (Akpalu, 2016). The liberalization policies of past and present governments have made higher education provision in Ghana, more stable, vibrant, and responsive to market conditions over the past two decades. The expansion in higher education is based on innovative financing mechanisms whereby the state has left the payment of fees to the private individual or through impact investing instruments like private equity, private debt, and real asset applied specifically to the education sector (iD4D, 2020).

5. Conclusion

The purpose of the chapter is to investigate, estimate, and analyze the extent to which ICT has been incorporated into the educational system to transform it from traditional education in order to reskill human capital in postprimary schools