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The Impact of Research and Development on Socio-Economic Development: Perspectives from Selected Developing Economies

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Abstract
Research and innovation have been acknowledged as critical factors for fuelling long-term sustainable economic growth and, concomitantly, employment creation and poverty alleviation in developed and developing economies. However, the overwhelming majority of studies conducted on these critical factors have tended to focus on developed economies. The purpose of this study, therefore, was to undertake an empirical investigation of the importance of research and innovation for industrial and economic growth in the developing economies of Sub-Saharan Africa (SSA). Specifically, the study investigated the practical utilisation of the end-product of research to fuel innovation and growth in developing economies. The significance of this study therefore derives from utilising empirical findings to influence policy on R&D in sub-Saharan developing countries. The study used the Cobb-Douglas production function and panel data from a selected number of countries in SSA to assess the impact and correlation between research and innovation and economic growth. From our regression results, the estimated parameters of all the independent variables, with the exception of labour, are statistically significant at the 5 percent (or better) level of significance. The coefficients (elasticities) of lagged GDP, gross fixed capital formation (investment) and R&D are all positive and statistically significant. The size of the coefficients implies that a 1% increase in investment, increases economic growth by about 0.236%. Similarly our results show that a 1% increase in gross domestic expenditure on R&D will lead to an increase of about 0.326% in economic growth. The insignificance of the labour variable may be attributed to how the variable was measured in this study. Our inability to obtain comparable measure of the quality of labour across all countries in the study meant that the only measure of labour we could use was the total number of economically active population (aged between 15-65 years). Given the paucity of studies on R&D impact that are devoted exclusively to sub-Saharan Africa, our study supports the general contention among development scholars that technological innovation and their adoption (through increased investment in R&D) remains ***the*** pathway to increased growth among emerging economies of the sub-Saharan African region. The study therefore adds to the debate among researchers on the impact of R&D in sub-Sahara African countries, therefore enriching the literature on the subject. In addition governments in these countries should increase support for R&D in the relevant institutions and industries.

Keywords: development, developing countries, research, innovation, socio-economic growth, sub-saharan africa.

INTRODUCTION

The importance of research and innovation (technological, product, process, organisational and marketing innovations) in achieving economic growth in developed countries has been firmly established by theoretical and empirical studies. The pioneering studies on this subject include Adam Smith (1776), Schumpeter (1934), and Solow (1957). Later studies firmly establishing a critical link between innovation and growth include Pelz and Andrews (1966); Allen (1970), Rothwell and Robertson (1973), Mansfield (1977), Ebadi and Utterback (1984), Fischer (1980) and Jaffe (1986). Sratmann (2005), one of the latest contributors in this area, has clearly demonstrated that there is a direct positive correlation between R&D investment and economic growth. To date, however, the link between research and innovation and economic growth has been left largely unexplored in the case of developing countries. The purpose of this study is to attempt to supply this necessary link by examining the effect of research and innovation on economic growth in sub-Saharan Africa (SSA).

As noted by Gaillard (2008) research and innovation comprises all fields of Science and Technology (i.e. natural sciences, social sciences, engineering and humanities). Link (1982) perceives research as primarily concerned with the search for technical or scientific advancement and development, and the translation of such advancement into product or process innovation. It is important to note that the first international attempt to arrive at a standard definition of research and development was made by the Organisation for Economic Cooperation and Development (OECD) at a conference in Frascati, Italy, in 1963. Following the approach advocated by the *Frascati Manual* research and development (R&D)1 is defined in this study as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".

It is clear that research (both academic and commercial) is a key and vital component of economic development. However, there is widespread recognition that although research *per se* is a necessary condition for economic growth, it is not sufficient. Other factors such as political will, the symbiosis between academia and industry, etc. play key roles. In other words, for research to yield practical fruits, the results must inform and shape socio-economic policies and be adaptable to the needs of the particular environment. This is where innovation comes in.

Schumpeter (1934) is credited with being the first economist to draw attention to the significance of innovation in the context of economic development. Schumpeter cited in de Haan and de Groot (2009), defined innovation as "the introduction of new or improved products, production techniques and organisation structures as well as the discovery of new markets and the use of new input factors". Schumpeter argued that competition through innovation is the driving force of economic development. Indeed, prior to this period the term innovation was not extensively referred to, instead the processes that are associated with innovation and economic and technological change were emphasised as being important (Lorenzi et al., 1912; Veblen, 1899).

Building on these various definitions, the *Oslo Manual* (2005) authoritatively defines innovation as "the implementation of a new or significantly improved product (goods or services), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations". The definition indicates that innovation is not limited to technological innovation but also to product, process, organisation and marketing innovations. Clearly, the minimum requirement for a phenomenon to qualify as innovation is that the product, process, marketing method or organizational method must be new, or involve a new application of the old. Innovation activities therefore encompass all scientific, technological, organizational, financial and commercial steps which lead to positive novelty and change. Examples of innovation, according to the European Commission's ***"Green Paper on Innovation"*** (1995), include development of vaccines and medicines, improved safety in transport, (ABS, airbags), easier communications (mobile phones, video-conferencing), more open access to know-how (CD-ROM, multimedia), new marketing methods (home banking), better working conditions, more environment-friendly techniques, more efficient public services, etc.

The importance of research and innovation in enhancing economic growth and development has long been recognised and emphasized in the developed economies. Goldin (2000), in an article published in the *Fast Company* magazine, noted that "the first 100 years of the United States of America's history were about who could build the biggest, most efficient farm. The second 100 years were about the race to build efficient factories. The third 100 years are about ideas." This clearly and unambiguously emphasises the critical and vital nexus between research-generated knowledge and innovation.

Until now, very little attention has, however, been paid to the link between research and innovation in developing economies. The purpose of this study, therefore, is to undertake an empirical investigation of the practical application and utilisation of research-fuelled innovation for industrial and economic growth in the developing economies of Sub-Saharan Africa (SSA). In other words, the study specifically investigates the practical utilisation of innovation as a positive catalyst for economic growth in developing economies.

THEORETICAL FRAMEWORK

Adam Smith (1776) is thought of as the first economist to have pioneered a theoretical link between innovation and economic growth (Agrawal, 2002). Following Smith's work, numerous theoretical studies have examined the link between innovation and economic growth, and have developed a number of innovation models. Tidd (2006), cited in Gerryts and Buy (2008), classified these models into the following generational categories:

[1] It is important to note that the term "research and experimental development" is used as synonymous to the term "research and development" and are both abbreviated as "R&D"

- First and second generation models, also called linear models, emphasise need or market pull or technological push.
- Third generation models or coupling models. Here the emphasis is placed on the interaction between different elements and feedback loops between them.
- Fourth generation models (or parallel lines model). This model emphasises linkages and alliances.
- Fifth generation models, also known as systems integration and extensive networking. The emphasis here is on flexible and customised response, continuous innovation.

The present study focuses on the linear model which is based on the assumption that there is a strong causal relationship between research/innovation and economic growth. In the analytic scheme of Gerryts and Buys (2008), the discreet stages in the linear innovation model are research (or science) which comes first, followed by development and finally production and marketing. These two authors went on to argue that research is the critical component because it is the starting point in the model, and it constitutes the essential building block to innovation which, in their scheme, is applied science.

Global Research and Innovation Activities

According to UNESCO 2007, the share of GDP devoted to R&D investment in "developing" and "less developed" countries has been insignificant compared to developed countries. Gross domestic expenditure on R&D (GERD), expressed in purchasing power parity (PPP$) and R&D intensity (i.e. percentage of GDP devoted to R&D activities) are the most commonly used indicators to monitor the resources devoted to R&D world-wide. The following tables indicate the global level of research and development expenditure in developed and "developing countries" as well as "less developed countries" over the period 2002 and 2007.

Table 1: R&D expenditure (GERD) by principal regions and countries, 2002 and 2007

Country	GERD (billion PPP $)		
	2002	2007	% change
World	**788.5**	**1 137.9**	**44.3**
Developed countries (DC)	653.3	864.2	32.3
Developing countries (DPC	134.0	272.0	103
Less developed countries (LDC)	1.2	1.7	41.7

Source: UNESCO Institute of Statistics, 2009

Key: GERD – Gross Domestic Expenditure on Research & Development; GDP – Gross Domestic Product; PPP – Purchasing Power Parity.

Table 1 shows that over the period from 2002 to 2007, world expenditure on R&D increased to just under 45% in absolute terms, from US$788.5 billion to US$ 1137.9 in current purchasing power parities (PPP$). Expenditure by "developed" countries increased over the same period by 32.3%. The corresponding figures for "developing" and "less developed" countries are 103% and 41.7% respectively.

Table 2: Gross Domestic Expenditure (GERD) as a percentage of GDP

	GERD as % of GDP	
	2002	2007
World	**1.7%**	**1.7%**
Developed countries	2.2%	2.3%
Developing countries	0.8%	1.0%
Less developed countries	0.2%	0.2%

Source: UNESCO Institute of Statistics, 2009

The following characteristics are discernible from the table 2. In relative terms, 1.7% of the world's GDP was devoted to R&D in 2007. R&D investment remains stable in developed countries increased to 2.3% of GDP in 2007, compared to 2.2% in 2002. Developing countries reported a substantial increase in R&D investment from 0.8% in 2002 to the benchmark target for developing countries of 1.0% in 2007.

STATEMENT OF THE PROBLEM

As indicated in our introduction there is a dearth of research on the link between research/innovation and economic growth in developing countries. Yet the importance of research and development (R&D), and innovation in achieving economic growth in developed countries has been firmly established and confirmed by several studies. This leads inevitably to the question: ***is there a link between research/innovation and economic growth in developing countries?*** Of particular interest is the correlation between research and innovation and economic growth in Sub-Saharan Africa.

Cognate question is: ***What is the relationship between the composition of R&D expenditure to innovation rate and growth in developing countries?***

HYPOTHESIS

It is hypothesised that countries with higher R&D quantity (intensity) have higher economic growth rate (higher GDP) than those with lower R&D activities.

OBJECTIVES

The main objective of this study is to analyse the impact of research and innovation on socio-economic development in developing countries in general, and in the selected countries in sub-Saharan African countries, in particular.

The specific objectives are:

- To assess the link between research intensity and economic growth in Sub-Saharan Africa.
- To draw policy conclusions from the findings.

Constraints of the Study

This investigation suffered from a number of constraints, chief amongst which was data availability in many SSA countries. This factor constitutes a formidable disincentive to research in the field of science, technology and innovation in Africa.

LITERATURE REVIEW

Solow (1957) was the first to have conducted an empirical study between technical progress (innovation) and economic growth. This is why Cameron (1996) in *Innovation and Economic Growth* argued that "any serious study of the literature on technical progress and growth must start with the work of Solow (1957)". Solow analysed data on total factor productivity in the United States between 1909 and 1949 and concluded that technical change was responsible for about 87.5 per cent of economic growth.

A number of other empirical studies have estimated the impact of research and development and innovation on productivity in advanced economies such as the USA, Japan, France and Germany (Griliches, 1994; Nadiri, 1993; Fagerberg, 1994; Bassanini and Scarpetta, 2001; de la Fuente and Ciccone, 2002). Most of these studies again confirm the following:

- There is a positive correlation between R&D intensity and productivity growth.
- Productivity growth is fuelled by R&D investment
- R&D has a positive impact on total factor productivity
- Social rates of return on R&D investment 'remain significantly above private rates' of return.
- There is a positive correlation between investment in R&D and the quality of the human capital
- There is a positive correlation between R&D intensity and the inflow of foreign direct investment (FDI).

It should be pointed out that several research findings suggest that certain specific socioeconomic conditions must be met for R&D investment to actually lead to innovation. For example, there is some evidence from empirical regional studies that 'innovation averse' and 'innovation prone' regions have different capacities to ensure high R&D productivity (Bilbao-Osorio and Rodríguez-Pose, 2004; Rodríguez-Pose, 1999). There is also some evidence that social capital – defined by Putnam (1993) as features of social organisation, such as civic participation, norms of reciprocity and trust in others – facilitates cooperation for mutual benefit and that firms and regions with higher levels of social capital are characterised by higher levels of innovation (Ruuskanen, 2004).

Lichtenberg (1992) examined the macroeconomic effect of R&D using national level data. Using cross-sectional data from 98 countries Lichtenberg estimated directly a non-linear production function that included the rates of investment in labour, physical capital and research as regressors. The results show that privately-funded R&D investment has positive significant effects on the level and growth rate of productivity. Additionally, it was found that the rate of return to private R&D investment is seven times larger than the return to investment in equipment and structures.

In another econometric study, Coe, Helpman, and Hoffmaister (2008) concluded that "there is robust evidence that total factor productivity, domestic R&D capital and foreign R&D capital are cointegrated (i.e. share a common trend) and that both measures of R&D capital are significant determinants of TFP." From R&D perspective, four factors were found to make a difference among nations: 1) the ease of doing business, 2) the quality of the tertiary education system, 3) intellectual property protection, and 4) the historical origins of the legal system.

The US Bureau of Economic Analysis (BEA), and the National Science Foundation, published preliminary calculations showing that the treatment of R&D as investment would have raised the level of GDP by 2.6% and real GDP growth by an average 0.1 percentage points per year in the period since 1959. In their calculations this increased to an average 0.8 percentage points per year in 1995-2002, adding up to a contribution of about 6.5% to real GDP growth in this period (Okubo et al, 2006).

The positive relationship between a country's R&D and productivity growth has been confirmed by studies using international panel data, such as Frantzen (2000) and Griffith, Redding and Reenen (2002). These studies provide strong evidence that R&D spillovers from industrialized countries to developing countries have positive effects on the TFP growth of the latter (Coe, Helpman and Hoffmaister, 1995; Griffith, Redding and Reenen, 2002). In another study Savvides and Zachariadis (2003) found that both domestic R&D and foreign direct investment increase the domestic productivity and value added growth.

Birdsall and Rhee (1993) used UNESCO data for research and development (R&D) expenditures and personnel to analyse the differences in R&D activities and assess the determinants of these differences and the link between R&D and economic growth. They found that R&D activity (expenditure) and economic growth are positively correlated only

in countries in the OECD while there was no significant relationship in the case of developing countries. Even for OECD countries, the study found no evidence that R&D activity fuels growth. These findings suggest that R&D activities contribute to productivity only when a country attains a threshold level of economic prosperity.

Ulku (2004) investigated the link between innovation, R&D and economic growth. The writer employed various panel data techniques and relied on patent and R&D data for 20 OECD and 10 Non-OECD countries for the period 1981-97. The results suggest a positive relationship between per capita GDP and innovation in both OECD and non-OECD countries, while the effect of R&D stock on innovation is significant only in the OECD countries with large markets.

Goel and Ram (1994) used data from a cross-section of 52 countries in the late 1970s and early 1980s to assess the effect of research and development (R&D) outlays on economic growth. The variables in the growth model include labour, capital and R&D expenditure. The estimated impact of R&D outlays on economic growth is positive and large, but its statistical significance is low.

Yang (2006) investigated the importance of innovation efforts and the discovery of new ideas worldwide in promoting Taiwan's economic growth. Using patents application as proxy of innovation, the empirical estimates show that increase in patenting leads to increase in economic growth for both the long-run and short-run. The findings suggest further that part of the post-war economic growth of Taiwan might plausibly be attributed to innovation, even though factor accumulations have indeed helped the rapid growth of Taiwan.

Using country-level data Coe and Helpman (1995) and Engelbrecht (1997) established a relationship between R&D expenditures and TFP in OECD countries plus Israel, focusing on international R&D spillovers from foreign R&D capital. Coe et al. (1997) extended this analysis to developing countries by estimating the elasticities of TFP in 77 developing countries with respect to R&D capital stock in 22 industrialized economies. The results suggest that R&D spillovers from the twenty-two industrial countries over the study period, 1971-1990, are substantial.

Samini and Alerrasoul (2009) used panel data to estimate the impact of R&D on economic growth in 30 developing countries over the period 2000-2006, the period for which data was available. They used three proxies for R&D: number of researchers in one million population, the share of government expenditure on research in GDP, and the scientific output of each country. Their findings, based on panel data regressions indicate that in general, no significant positive relationship exists between R&D and economic growth in the countries studied.

Gerryts and Buy (2008) studied the link between R&D and innovation in South Africa based on data from the South African Innovation Survey of 2001. The findings suggest that South African enterprises had a relatively high level of innovation with very low innovation costs. In addition, a cross tabulation analysis of the data revealed a significant positive link between innovation and R&D.

Cameron (1996) presents an overview of the empirical literature that investigates the link between innovation and economic growth. The author relied on a number of different measures of innovation, such as R&D spending, patenting, and innovation counts, as well as the pervasive effect of technological spillovers between firms, industries, and countries. Three conclusions were drawn from the study: i) innovation makes a significant contribution to growth; ii) there are significant spillovers between countries, firms and industries, and to a lesser extent from government funded research; and iii) the spillovers tend to be localized, with foreign economies gaining significantly less from domestic innovation than other domestic firms.

METHODOLOGY

The Model

We conducted this study on a number of Sub-Saharan African countries and used annual data for the ten year period, 1997 – 2007. This time period and frequency was largely dictated by the availability of data on R&D.

The basic model estimated on panel data for selected developing countries is a simple Cobb-Douglas production function and the sample period is 2000-2007.

$$GDP_{it} = e^{\alpha i} GDP_{it-1}^{\beta_1} L_{it}^{\beta_1} K_{it}^{\beta_3} RD_{it}^{\beta_4} U_{it}. \quad (1)$$

Where

GDP_{it} = the gross domestic product for country *i* in time *t*.

L_{it} = Labour force for country *i* in time *t*.

K_{it} = Investment measured by gross fixed capital formation.

RD_{it} = R&D expenditure for country *i* in time *t*.

U_{it} = error term.

Equation (1) can be rewritten in logarithmic (linear) form as follows:

$$Ln(GDP_{it}) = \alpha_i + \beta_1 Ln(GDP_{it-1}) + \beta_2 Ln(L_{it}) + \beta_3 Ln(K_{it}) + \beta_4 Ln(RD_{it}) + u_{it} \quad (2)$$

(2)

Where

$\beta_{i's}$ = Social output elasticities with respect to lagged GDP, Labour, Investment and Research and Innovation, respectively.

$\alpha_{i'}$ = an index of efficiency or total factor productivity

U_{it} = error term

Data

The model was estimated using the Cobb-Douglas production function and panel data for a selected number of Sub-Saharan African countries for the ten year period, 1997 - 2007. The main sources of data are the World Development Indicators (WDI) of the World Bank, UNESCO Institute of Statistics, and IMF's International Financial Statistics (IFS).

ANALYSIS AND INTERPRETATION

The study utilised panel data regression to estimate the parameters (output elasticities) of the model. Panel data regression technique is the most appropriate technique for an investigation of this nature as it enables researchers to use data with cross-section and time series dimensions to conduct a study that cannot be carried out with cross-section or time series data separately.

Generally, a regression model for panel data analysis is stated as follows:

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + ... + U_{it},$$

$$U_{it} + \mu + v_{it}$$

Where $E(U_i) = 0$ and has a constant variance.

μ includes fixed effects that show differences among countries' characteristics

$$v_{it} = IND(0, \sigma^2)$$

To obtain the estimates of the effects of the independent variables R&D, Labour, Investment and lagged GDP, Fixed effect (fe) model was first estimated. The random effect (re) model was also estimated. In panel data regression, a choice is usually made between fixed effect and random effect models. Statistically, fixed effect regression always gives consistent results but they may not be the most efficient or accurate (results).On the other hand, random effect regression yields more efficient estimators. Therefore, it is advisable to use random effect model if it is statistically justifiable to do so.

The Hausman test is the usual test employed to make a choice between a more efficient (random effect) model and a less efficient but consistent (fixed effect) model. The Hausman test, tests the hypothesis that the coefficients estimated by the efficient random effect estimators are the same as the ones estimated by the consistent fixed effect estimators.

If the estimators of the two models are (statistically) the same, then it is safe to use the random effect results. Otherwise if the estimators are (statistically) different, one uses the fixed effect results. When applied to the analysis of the panel data for this study, the Hausman test showed a statistically significant difference between fixed effect and random effect models. Accordingly, we report in Table 1 below, the regression results using the fixed effect model.

Table 1: Fixed Effect Regression Results

Dependent variable: Ln (GDP)			
Observations (countries): 5			
Period: 1997-2007			
Total panel observations: 55			
Variable	Coefficient	Std error	t-statistic
Prob.			
C	0.022	0.0103	2.14
0.0385			
Ln(GDPt-1)	0.148	0.0382	3.87
0.0004			
Ln(Labour)	0.126	0.3818	0.33
0.5789			
Ln(K)	0.236	0.0918	2.57
0.0295			
Ln(R&D)	0.326	0.0600	5.43
0.0000			
R- Squared: 0.904			
Adjusted R- Squared: 0.901			
Durbin Watson Statistic: 2,128			

Source: Model estimates obtained from panel data compiled by authors and derived using the STATA statistical software.

DISCUSSION

The results of our regression analysis reveal an important dimension in the empirical literature on the role of research and innovation in economic growth. On the one hand, our results are consistent with many previous studies on the impact of R&D on developed countries which have indicated strong positive association between R&D and growth rates (Barro, 1991; Birdsall and Rhee, 1993; Coe and Helpman, 1995; Ulku, 2004).

On the other hand, the results are inconsistent with many a number of studies on developing countries which have shown generally insignificant and, in some cases, negative impact of R&D on economic growth in developing economies (Samini & Alerasoul, 2009, Birdsall &Rhee, 1993, Goel & Ram, 1994).

From our regression results, the estimated parameters of all the independent variables, with the exception of labour, are statistically significant at the 5 percent (or better) level of significance. The coefficients (elasticities) of lagged GDP, gross fixed capital formation (investment) and R&D are all positive and significant. The size of the coefficients implies that a 1% increase in investment, increases economic growth by about 0.236%. Similarly our results show that a 1% increase in gross domestic expenditure on

R&D leads to an increase of about 0.326% in economic growth.

The insignificance of the labour variable may be attributed to how the variable was measured in this study. Our inability to obtain comparable measure of the quality of labour across all countries in the study meant that the only measure of labour we could use was the total number of economically active population (aged between 15-65 years)

CONCLUSION

Using World Bank (World Development Indicators), UNESCO, and International Financial Statistics (IFS) data, this paper has assessed empirically, the link between R&D (and other variables) and economic growth for 5 Sub-Saharan African countries for the period 1997 to 2007. Within the group of Sub-Saharan African countries, R&D expenditure and economic growth are found to be significantly correlated. Given the paucity of studies on R&D impact that are devoted exclusively to sub-Saharan Africa, our study supports the general contention among development scholars that technological innovation and adoption (through increased investment in R&D) remains ***the*** pathway to increased growth among the emerging economies of the sub-Saharan African region. We therefore advocate that governments in these countries should increase support for R&D in the relevant institutions and industries

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