THE ROLE OF HUMAN CAPITAL IN GUINEA'S ECONOMIC GROWTH: AN EMPIRICAL ANALYSIS OF THE EDUCATION EFFECT ON TECHNOLOGICAL PROGRESS OVER THE PERIOD, 1980-2010

SALIOU DIALLO
University of Tsukuba
Tsukuba, Japan

ABSTRACT

This study examines the education effect on Guinea's economic growth and empirically estimates the contribution of human capital accumulation on technological progress in Guinea's economy from 1980 to 2010. During this period, Guinea experienced a profound mutation in its political, economic and educational system which led to the implementation of various reforms, especially targeting the economy and the education sector. The educational system as a whole went through three sets of reform programs, occasioning however a significant increase in primary school gross enrolment rate. Following a time-series approach, the study applies the Mankiw, Romer and Weil model and the Solow's growth accounting framework by using the flow measure of education as proxy. The empirical findings reveal that education had an insignificant effect on Guinea's economic growth. However, the growth accounting estimations show that education effect on technological progress measured by total factor productivity is proven to be significant and positive.

Keywords: human capital; education; economic growth; technological progress; Guinea

INTRODUCTION

The role of human capital in the process of developing all countries' economies is overwhelmingly recognized to be preponderant and education, in turn, considered being a conducive way in increasing the level of

human capital in the workforce. Education is therefore widely accepted as a leading instrument for promoting economic growth as many experiences proved that, a country cannot achieve a lasting and sustainable economic development without building a skilled labor force. "The contribution of education to national development has long been examined and recognized not only by educationalists but also by modernization theorists" (Inkeles and Smith, 1974; Almond and Verba, 1965) and "economists of the human capital approach" (Schultz, 1961; Kuznets, 1966; Young, 1990).

"The correlation between human resource development and economic growth therefore appears to run both ways. It is necessary for human resources to grow if development is to proceed in the productive sectors". "The productive sectors in turn have to grow and diversify in order to permit more opportunities for human resources to develop and to employ the enhanced flow of skills and talents that are produced" (Barro, 2000; Lall, 1990; Wolf, 2002; Oketch, 2005). A positive correlation between education and economic growth in Guinea is observed in the primary and secondary level. In the tertiary level such observation exists but it is relatively weak. However, the causality behind this phenomenon is unknown and has to be determined. The contribution of primary education to Guinea's economic growth seems to be positive, however, the impact of secondary and tertiary education remains questionable (See Appendix A).

The purpose of this study is first, to investigate the impact of (primary) education on the growth of Guinea economy over the period 1980-2010; second to examine the effect of education on technological progress in Guinea's economy and third try to identify the contributing factors in relationship with Guinea's education and economic outcomes and policy initiatives and educational outcomes. However, the motivation behind the focus on the period

1980-2010 is of a particular interest. During this period, Guinea experienced a profound mutation in its political, economic and educational system which occasioned the implementation of various reforms, especially targeting the economy and the educational sector. In reference to these reforms, three major events remarkably influenced Guinea's socio-economic and political sphere: (a) the change of the one single state party into a multiparty system (ushering a first wave of democracy), (b) the shift of the economy from centrally planned model into liberal market, and (c) the implementation of three stages of educational reforms. Along this period, policies enforced in both sectors though yielded some results but full expectations were not met. However, this study's findings would help orienting the decisions of policymakers on education dedicated to the cause of promoting economic growth in the country.

The rest of the paper is organized as follows: Section 2 presents a brief review of empirical literature. Section 3 explains the methodology and discusses the model. Section 4 provides a brief description of Guinea economy and education and presents the sources and data. Section 5 delineates the empirical analysis and portrays the results. Lastly, section 6 summarises the main findings and conclusions of the paper.

LITERATURE REVIEW

A plethora of empirical papers investigates the growth effects of human capital, especially emphasising on the role of education. Thus, most studies assessing the role of education on economic growth usually employ standard sources-of-growth equations based on a dynamic Cobb–Douglas aggregate production function which can easily be extended to include human capital as a determinant of the

economy's growth rate[1].

The proxy of human capital is a key issue in the empirical growth models. There have been many studies on the impact of education on economic growth using different proxies of human capital. However, the most common used proxies are school enrolment rates and the average number of years of schooling. Although, in a general perspective, most of studies investigating the impact of education on economic growth have used different proxies for human capital, and concluded that education has a positive impact on growth rate of income. As for the level of education that is positively related to the growth rate of income, however, remains still a controversy.

Agiomirgianaskis, Asteriou and Monasitiriotis (2002) and Voon (2001) assert that the higher the level of education (primary, secondary and tertiary), the stronger the growth impact of education, all things equal. Petrakis and Stamatakis (2002) find that the growth effects of education depend on the level of development; low-income countries benefit from primary and secondary education while high income developed countries benefit from tertiary education. Benhabib and Spiegel (1994) estimation of human capital into a growth-rate production function indicates that human capital enters insignificantly in explaining capita growth rates. Using an alternative model in which the growth rate of total factor productivity (TFP) depends on nation's human capital, the tests indicate a positive role for human capital.

Gemmell (1996) for OECD (Organization for the Economic Cooperation and Development) countries concluded that primary education most affects the less developed countries, while secondary and higher education the developed ones. Villa (2005) investigated the effect of

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1 For more details refer to Constantinos and Panagiotis (2012)

the three levels of education on economic growth for Italy and found that the higher and secondary education have a positive effect on economic growth, while the primary has no significant effect. Pereira and Aubyn (2009) showed that in Portugal, primary and secondary education have a positive impact on GDP (Gross Domestic Product), while higher has a small negative effect. In Greece, Asteriou and Agiomirgianakis (2001) showed that the growth of enrolment rates in primary, secondary and higher education positively affected the GDP in Greece for the period 1960–1994. Tsamadias and Prontzas (2012) used the secondary school enrolment rate as a proxy and found that education had a positive and statistically significant effect on economic growth in Greece over the period 1960–2000. Pegkas (2014) estimated the potential impact of the different educational levels on economic growth over the period 1960–2009, and showed that secondary and higher education have had a statistically significant positive impact on growth, while primary had not.

Mc Mahon (1998) examined the effect of the three levels of education on economic growth for a sample of Asian countries and concluded that primary and secondary levels have a significantly positive effect on economic growth, while higher is negative. Chi (2008) showed that in China, higher education has a positive and larger impact on GDP growth than primary and secondary education. Self and Grabowski (2004) for the case of India showed that except higher education the primary and secondary education had a strong causal impact on economic growth.

Lin (2006) for the case of Taiwan found that primary, secondary and tertiary, have a positive impact on economic growth. Shaihani, Haris, Ismail, and Said (2011) for the case of Malaysia concluded that in the short run only secondary education has a positive and statistically significant coefficient, while the primary and tertiary exhibit negative and statistically significant results.

In Latin America, Loening, Bhaskara, and Singh (2010) examine the case of Guatemala and found that primary education is more important than secondary and tertiary education.

In the context of Africa, few empirical studies examined this. Artadi and Sala-i-Martin (2003) found a positive relationship between primary school enrolment rates and growth rate of GDP per capita in African countries. Gyimah-Brempong, Paddison, and Mitiku (2006) found that all levels of education have a positive and statistically significant impact on the growth of per-capita income in African countries. Gyimah-Brempong (2010) found that different levels of education affect development outcomes differently; for some development outcomes, primary and secondary education may be more important than tertiary education while for some development outcomes, such as income growth rate, tertiary education may be more important. In the case of Guinea, besides annual reports (Poverty Reduction Strategy Papers) of the World Bank, International Monetary Fund (IMF) and African Development Bank (AfDB), briefly reviewing Guinea's education and economy, and the IMF Country Staff Report (2006), empirically examining Guinea's growth from 1970 to 2004. An empirical study investigating the growth effects of human capital per se to my knowledge is merely absent. This study however stands to fill up this gap.

METHODOLOGY AND MODEL

To conduct the empirical investigation of this study, two levels of empirical analysis are envisaged and each level employed the Cobb-Douglas production function.

Mankiw-Romer-Weil Model

The first level is a sensitive analysis that uses the methodology of neoclassical theory implemented by Mankiw, Romer, and Weil (1992). The MRW's augmented Solow model is being expanded to include physical and human capital as separate inputs and basic determinants of growth. The model also used the variable 'school enrolments' as a proxy for human capital (the most common representing variable for human capital according to Schütt (2003)) with the country-specific constant rates assumptions of investment in human capital and physical capital. The Cobb-Douglas production function of MRW model takes the following form:

$$Y_t=K_t^{\alpha}+H_t^{\beta}(A_tL_t)^{1-\alpha-\beta} \quad (1)$$

where Y represents output, K is the physical capital, H is human capital and A is the level of technical knowledge and L is labor. L and A are assumed to grow exogenously at constant rates n and g, respectively. Considering decreasing returns to scale, that is $\alpha + \beta < 1$, transforms equation (1) and ends up with an equation on income per worker of the following form:

$$\ln\frac{Y}{L} = \ln A + \mathrm{g}t - \frac{a+\beta}{1-a-\beta}\ln(n+\mathrm{g}+\delta) + \frac{a}{1-a-\beta}\ln(s_k) + \frac{\beta}{1-a-\beta}ln(s_h) \quad (2)$$

where s_k: investment in physical capital, s_h: human capital investment, n, g and δ: the growth rates of labor, technology and depreciation rate of capital respectively and t: time.

In accordance with the MRW (1992) study, whereby they considered the investment in percentage of GDP as the index of physical capital, the percentage of the working population that is enrolled in a specific level of education

(secondary school in their case) as a proxy for the rate of human capital accumulation. The use of these variables fall under the quantity approach of human capital, which is versed into the "stock approach" and the "flow approach" (for more details refer to Schütt, 2003)**,** and this study considered the flow approach. With this approach, contribution of these variables to the production is assumed to be easy to control and assess. For an ease of exposition, carrying on with framework (2) by taking the first differences to overcome the lack of time-series stationary, the following function is obtained:

$$\Delta \ln q_t = C_o + \alpha \Delta \ln k_t + \beta \Delta \ln (n + g + \delta)_t + \gamma \Delta \ln h_t + \varepsilon_t \quad (3)$$

where q = output per worker, k = investment as percentage of GDP, h = gross percentage of the enrolled in (primary education), and ε = the error term.

Even though education is the most often used representative dimension of human capital but still measurement of human capital presents great practical challenges. As the model specifies, the gross enrolment rates in flow is used in this estimation as proxy which represents a quantitative measurement of human capital. The quality of education is not taken into account. The estimation of this variable is therefore achieved by using the following function (World Bank, 2012):

$$GHER^t = \frac{E^t}{P^t} * 100 \quad (4)$$

where $GHER^t$ = Gross enrolment ratio in school year t for the level of education, E^t=Enrolment in the level of education in school year t, P^t= Population in age-group which officially corresponds to the level of education in school year t.

Growth Accounting Model a-TFP as residuals from a production function

The second level of analysis applies the growth accounting model whereby two aggregate production functions are estimated. One excluding and one including human capital as follows:

Y= $A_{1t}^{a} K_t^{\beta k} L_t^{\beta l}$, $0 < \beta_k < 1$ and $0 < \beta_l < 1$ (1)

and Y $= A_{2t}^{a} K_t^{\beta k} L_t^{\beta l} H_t^{\beta h}$ $0 < \beta_k < 1,\ 0 < \beta l < 1\ and\ 0 < \beta_h < 1$ (2)

where *Y* is real GDP, *K* is total physical capital, *L* is the labor force, *H* is the measure of human capital, and *A* equals the level of total factor productivity. The possibility of non-constant returns to scale by not restricting (β_k+β_l) or (β_k+β_l+β_h) to equal one is been allowed.

Dividing Eqs. (1) and (2) by the labor force (*L*) reads output, the physical capital stock, and the human capital index on a per worker basis. That specifies,

y= $A_1^{a} K^{\beta k} L^{\beta k+\beta l-1}$ (3)

and y $= A_2^{a} K^{\beta k} L^{\beta l} H^{\beta k+\beta l+\beta h-1}$ (4)

where *Y* is real GDP per worker, *K* is total physical capital per worker, *H* is the measure of human capital per worker. These production functions display increasing, constant, or decreasing returns to scale as (β_k+β_l) or (β_k+β_l+β_h) are greater than, equal to, or less than one, respectively.

Rewriting Eqs. (3) and (4) in natural logarithms yields the following:

$ln = ln A_1 + \beta_k lnK + (\beta_k + \beta_l - 1) lnL,$ (5)

and $ln\ y = lnA_2 + \beta_k lnK + \beta_h lnH + (\beta_k + \beta_l + \beta_h - 1) lnL$ (6)

Thus, constant return to scale implies that the coefficient of *lnL* equals zero.

b-TFP from growth accounting

Let us consider the following Cobb-Douglas production functions with and without human capital:

$$Y_t = A_{1t}^{b} K_t^{Bk} L_t^{Bl} \quad (1)$$

and

$$Y_t = A_{2t}^{b} K_t^{Bk} L_t^{Bl} H_t^{Bh} \quad (2)$$

where Y_t is GDP in real terms, A_t is TFP, K_t is the stock of capital, L_t is total employment (or the labor force), and H_t is an index of human capital.

In addition, an adoption of the simplified form of Eqs. (1) and (2), by taking their total derivative forms with respect to time (t) and dividing all terms by Y_t yields the following:

$$GY_t = A_1^{b} + BkGK_t + (Bl)GL_t \quad (3)$$

and

$$GY_t = A_2^{b} + BkGK_t + BlGL_t + BhGH_t \quad (4)$$

where GY_t denotes the growth rate GDP, GA_t denotes the growth rate of TFP, GK_t denotes the growth rate of the capital stock, GL_t denotes the growth rate of labor, and GH_t represents the growth rate of human capital, Bk, Bl and Bh represent the parameters to be estimated.

The growth rate of output equals the growth rate of the technology term plus a weighted average of capital growth, labor growth and human capital growth, where the weight is determined by the parameters Bk, Bl and Bh.

From Eqs (3) and (4), two different measures of TFP growth rate have been estimated and decomposed based on the following equations:

$$Gtfp1_t = a_0 + a_1 Gpser_t + a_2 Gfdi_t + a_3 Gexp_t + a_4 Gimp_t + a_5 D_{E1} + a_6 D_{E2} + a_7 D_{E3} + a_8 D_R + e_{1t} \quad (5a)$$

$$\text{and } Gtfp2_t = b_0 + b_1 Gfdi_t + b_2 Gexp_t + b_3 Gimp_t + b_4 D_{E1} + b_5 D_{E2} + b_6 D_{E3} + b_7 D_R + e_{2t} \qquad (5a_1)$$

where tfp is growth rate of the total factor productivity derived from the estimated production functions, fdi is growth rate of the foreign direct investment, exp is the growth rate of export, imp is the growth of import, $pser$ is the growth rate of human capital, $D_{E1} \ldots D_{E3}$ education dummy variables, D_R economic dummy variable, a and b are parameters to be estimated, and, e_t is the error term.

A BRIEF DESCRIPTION OF GUINEA ECONOMY AND EDUCATION DURING THE PERIOD 1980-2010

Since independence in 1958, most of the policies implemented in Guinea, from its economy to its revolutionary educational system, were closely watched as a new African experiment in the making[2]. From 1958 to 1984, the Sékou Touré government pursued a centrally planned model of economic development. The country's development since independence can be broken into two major periods. Prior to 1985, the socioeconomic policy framework aimed at modernizing and industrializing the country. Its implementation was based on a command and control approach and led to a very poor economic performance and a dismal social situation.

It is estimated that real per capita GDP declined by 11% between 1960 and 1965, and then by about 1% between 1965 and 1970.From 1960 to 1974, GDP per capita declined 4%. Growth was estimated at 3.5% between 1975 and 1980. Private sector activities were limited and

[2]See http://education.stateuniversity.com/pages/577/Guinea-EDUCATIONAL-SYSTEM-OVERVIEW.html

largely underground. GDP declined by 1.4% between 1980 and 1985 (Gellar, Groelsema, Kanté, & Reintsma, 1994).

The economic mismanagement, internal repression and the isolation of the country became intense by the end of 1970s. These factors coupled with economic stagnation, inflation, general rationing and acute shortages of basic commodities, huge foreign debts led to a general mass frustration and plots. This signalled the failure of the socialist option adopted by the country which ended up in an extremely difficult situation by the time of Touré's death in 1984.

In 1985, the new government launched the Economic and Financial Reform Program (PREF)–reform intended to significantly reduce the role of the state in the productive sphere and promote the private sector to lead Guinea's future socioeconomic development.

As a result, export value increased about 16% between 1986 and 1989, thanks to the non-mining sector–trade activities, mainly the informal sector–agricultural production. Despite positive overall results in 1984-96 (including economic growth of 4% and single digit inflation), performance was uneven, successes alternating with policy reversals, especially in 1995 (Seldon, 2005). During the period 1990-2000, Guinea faces serious constraints to development stemming from domestic political instability and conflicts in the neighboring countries. Nonetheless, between 1990-2000 Guinea's GDP grew at an average annual rate of 3.4% in real terms (Economic Report on Africa, 2002). However, this macroeconomic stability did not keep the same pace for the following decade to ensure a continuous sustainable growth. Guinea's economic situation worsened in 2003 as GDP growth slowed down at 1.2%, reflecting exogenous shocks, inconsistent macroeconomic policies, and a significant decline in investment. 2004-2005 marked a transition period, and GDP growth remained stable, at an average

annual rate which was around 2.5% with a drastic drop in the year 2007, compare to an annual growth track of 5% from 2006 onward, which was in line with the projections of the poverty reduction strategy (IMF, 2004). Economic growth averaged 2.1% between 2007 and 2009, with annual rates of 1.8% in 2007, 4.9% in 2008, -0.3% in 2009, and 1.9% in 2010 according to the most recent macroeconomic framing (IMF, 2012). In fact, year-on-year inflation leveled off at 19% in 2011, after standing at 12.8% in 2007, 13.5% in 2008, 7.9% in 2009, and 20.8% in 2010 (IMF, 2013). Guinea's main obstacles to a balanced and sustainable growth are considered to be: (i) weakness of human capital—conducive to low productivity, high unemployment and income inequality; (ii) lack of infrastructure for economic development, with, as a corollary, the high transaction and production costs—limiting the emergence of a modern sector of the economy; (iii) weakness of national capacities—governance problems, civic behavior and effective development policies' implementation (IMF, 2013).

Guinea's educational system after the independence, suffered from different abnormalities. The objective sought by Touré's regime in its educational innovation during the 1960s and1970s was simply to rid Guinea of colonial influences and promote education for self-sufficiency (Walmond, 2002). To achieve this ambitious educational policy, "a mass education ("education de masse") was set allowing a wide access to education for all children in the country regardless their social or regional origin, age or gender. [Therefore], primary education becomes compulsory and lower achievement requirement for access to secondary school was set for female and a quota was reserved for them to the higher education institutions" (Barry, 2010). The effect of these policies mixed with the lack of standardized syntax,

appropriate textbooks, poorly trained teachers and rapid enrolment growth resulted in a low quality of education, inadequate external efficiency, and inefficiency in the allocation of scarce resources.

With the change of regime in 1984, the new authority decidedly committed to depart itself from the ancient regime, launched an ambitious and wide reform programs in the education sector. Among these reform efforts, one of the ultimate goals was "to substantially increase primary school enrolment and public expenditure for primary education" (Walmond, 2002). According to the World Bank (1990), total public expenditure on education relative to GNP (Gross National Product) is only 1.7% in 1989, and the proportion of the government recurrent budget allocated to education was 12.9 % in the same year (as compared to a sub-Saharan Africa average of over 20 %). Literally, education in Guinea is free in theory from the lower level throughout the university. Also, the structural adjustment reform program in the education sector favored the emergence of an evolving private sector. Overall, Guinea education sector went through three sets of reform, the two Educational Sector Adjustment Programs (PASE1:1990-1995; PASE2:1995-2000) and the Education for All program (EFA: 2001-2015). With these reforms, the higher education including vocational training expanded, occasioning a drastic increase in school enrolment rate with little progress made in terms of education quality. The literacy rate in Guinea is estimated around 50% of its population. As a consequence, there are few employment opportunities due to the lower level of skills resulting in a poor contribution to the country's economic growth.

Data and Sources

To conduct this analysis, a secondary data was collected from different sources. Due to the constraint and unavailability of complete datasets, a data compilation from

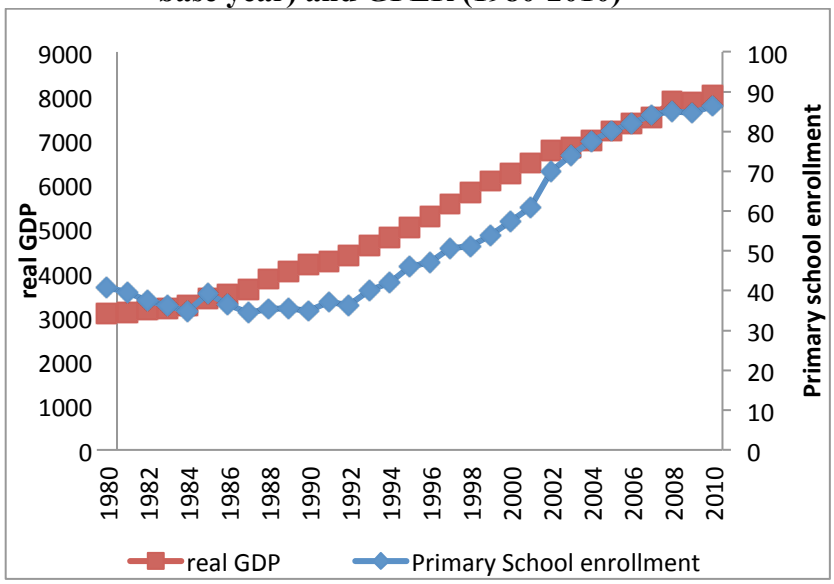
different databases helped obtaining a time series of 30 years, from 1980 to 2010 (See Table 1).

Data on GDP, physical capital investments and GDP deflator series, import and export were taken from the World Economic Outlook (WEO) database. GDP (real growth rate) measured at constant prices, national currency, investments is the gross capital formation as percentage of GDP at constant prices, national currency for the total economy. The growth accounting estimation used the series of the physical capital stock estimated from investment data flow using the perpetual inventory method. For the input variable L, the series of total labor force absolute value in thousands and FDI measure from the United Nations Conference on Trade and Development (UNCTAD). From the World Development Indicators (WDI), the series of gross primary enrolment ratio (GPER) were extracted. The exchange rate was retrieved from the Federal Reserve Bank of St Louis. Looking at the education and the economic performance during the period 1980-2010, it appears that increase in real GDP followed a continuous and stable trend while the GPER had known a periodic decrease which later on increased significantly (see Figure 1).

Table 1: Guinea: Data Sources

Series	Range	Data Set	Code
GDP at current prices, national currency	1980-2010	WEO	W 656 NGDP
GDP deflator, index	1980-2010	WEO	W 656 NGDP_D
Total Investment, percentage of GDP	1980-2010	WEO	W 656 NID_NGDP
Labor force, thousands	1980-2010	UNCTADSTAT	N/A
Prim. Sch. Enrolment Rate, percentage gross	1980-2010	WDI	SE.PRM.ENRR
FDI at US dollars, Current prices	1980-2010	UNCTADSTAT	N/A
Export, volume of goods % change	1980-2010	WEO	656
Import, volume of goods % change	1980-2010	WEO	656
Exchange Rate National Currency/US Dollar	1980-2010	FRED	N/A

Figure 1: Real GDP (bill.national currency, 2003 as base year) and GPER (1980-2010)



Source: Data derived from World Economic Outlook and World Bank Development Indicators databases

The primary education performance over this period which allowed doubling the number of enrolled pupils with an annual average of 2% (Table 2), is considered to be largely due to the increased supply of educational infrastructure–major gains of the PASE, part of the EFA program initiative (IMF, 2012). Despite the noticeable increase in the primary school enrolment rate, still some inequalities and disparities remained in terms of access between male and female, urban and rural areas. A partition of the 30-year period into three 10-year periods reveals the imbalance. The first 10-year period–1980s demonstrates the lowest growth rate of enrolled students, while the 2000s registered the highest number of enrolment. The national rate in primary education participation rose from 57 % in 2000 to reach a maximum level of 86 % in 2010.

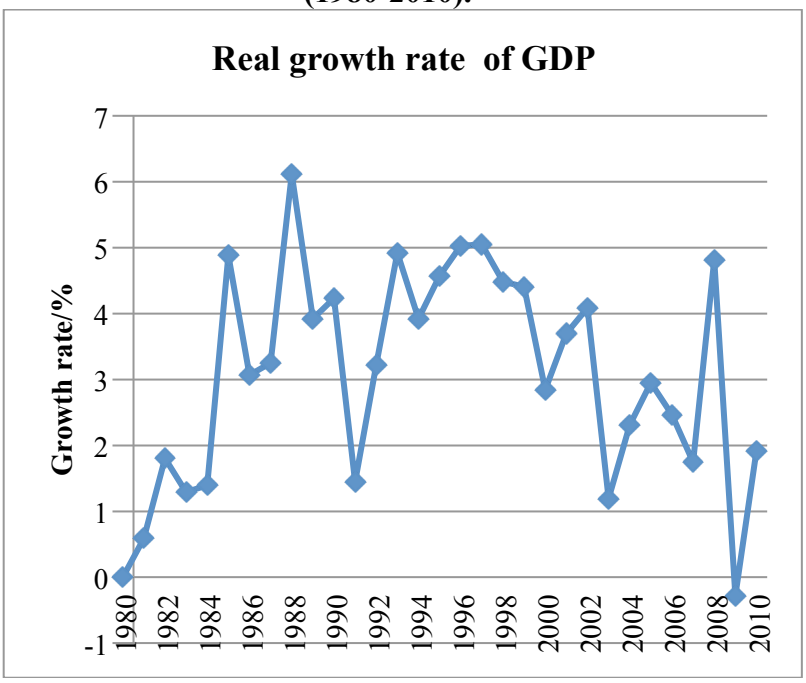
Table 2: GDP, Capital investments, and Primary education

	real GDP (bill.national currency,2003 as base year)	Capital investments as percentage of GDP (%)	GPER (%)	Real GDP-average growth rate (%)	Capital investments as percentage of GDP-average growth rate (%)	GPER average growth rate (%)
1980	3091.880	14.44	40.83	___	___	___
2010	8022.395	9.42	86.36	___	___	___
1980-2010	5276.978	17.62	53.28	3.17	1.75	2.49
1980-1990	3499.016	16.48	36.80	3.05	9.03	-1.57
1990-2000	5117.707	21.31	45.16	3.99	1.11	4.98
2000-2010	7204.729	16.04	76.59	2.49	-4.88	4.07

Source: Data on real GDP, capital investment and primary education derived from World Economic Outlook database; GPER from World Bank Development Indicators database.

In 2009, Guinea experienced its first economic recession since 1987, with a growth rate of -0.3% compared to an estimated 4.9%; this weak economic performance took place in the wake of 2009/2010 political crisis (AfDB, 2011) (Figure 2).

Figure 2: Real growth rate of GDP (bill.national currency, 2003 as base year) in Guinea (1980-2010).



Source: Data derived from World Economic Outlook database.

Overall, "FDI flows to Guinea remained very low until the 1990s; an average of $2.2 million for the period 1980-1990. Since 1990, they began to increase as agreed with the reform program and privatizations have continued to improve good records for the past few years, an average of $101,350,000 million in 1999-2010" (Diallo & Xu, 2013). Along the examined period, capital investments in Guinea range at an average 16 % of GDP. The highest capital investments are registered during the period 1990-2000 and the lowest in late 2000s particularly in 2010 at a rate of 9%.

Empirical Results

Estimating equation (3) of the MRW model helped assessing the effect of education on Guinea's economic growth. On the basis of this model, it is considered that g + n=0.05 and remains constant while carrying this analysis which includes two specifications (estimation with and without lags). The basic assumption of MRW (1992), positing that g and δ are constant for all countries considering that technology is a public good available to all countries. Hence, assuming g+δ are constant; their influence on the estimated results from equation (3) is therefore unobserved. Thus, similar assumptions can be also applied in the case of Guinea.

Moreover, one cannot ignore the fact that the transfer of technology towards the developing world is most often subject to various difficulties. This fact therefore renders the adoption/adaptation of technologies quite problematic in some developing countries. The case of Guinea, in this respect, is not an exception. Also, the availability of updated statistics in most of developing countries is usually lacking. Such an apparent situation, further complicate the depreciation rate measurement for a specific country. Thus, this observation may also account for Guinea as it holds for many other countries. However, from the standpoint of these aforementioned factors, the hypothesis that g and δ assumed to be constant is taken into account in order to apply the MRW model to estimate the growth effect of human capital on Guinea economy. The estimation results of the model are based on two specifications (See Table 3).

Table 3: Estimated parameters and *t*-value of Primary education effect on ΔGDP growth

	Specification 1	Specification 2
Constant	0.009	0.014
	(1.356)	(1.582)
$\Delta \ln k_t$	0.068*	0.068
	(1.789)	(1.656)
$\Delta \ln l\ (n+g+\delta)_t$	-0.164***	-0.141***
	(-3.923)	(-2.824)
$\Delta \ln H_t$	0.0511	0.099
	(0.405)	(0.769)
$\Delta \ln H_t(-1)$		-0.097
		(-0.753)
$\Delta \ln H_t(-2)$		0.015
		(0.117)
$\Delta \ln H_t(-3)$		-0.121
		(-0.909)
$\Delta \ln H_t(-4)$		-0.228*
		(-1.795)
$\Delta \ln H_t(-5)$		0.19
		(1.338)
R^2	0.52	0.64
Adjusted R^2	0.46	0.50
Observations	29	29

Note: The dependent variable is $\Delta \ln q_t$ (1980-2010), *t*-statistics in parentheses
*** Means significant at the 1% level; ** Means significant at the 5% level; * Means significant at the 10% level

In the first specification, the human capital coefficient is estimated at 0.05 which shows that it is positive but statistically not significant. The insignificance of human capital in the first place of the estimation leads to consider another specification. Since the time effect is determinant in the process of acquiring knowledge or skill and translating it into productivity. The second model is therefore considered, which consists of estimating equation (3) of the MRW model by taking time lags. Introducing time lags is necessary since a certain time intervenes

between the enrolment of students and their actual entry as workers in the productive sectors (Prontzas, 2004; Tsamadias and Prontzas, 2010). In the context of this analysis, the primary schooling is the targeted level of education. Thus, five years span is considered as a minimum length of time that could enable some of those students enrolled in the primary education to eventually become active in the labor market. In addition, the choice of five years time lag covers the first five years of the period observed in this study. Basically, these five years depict Guinea's education situation before the first reforms in the sector.

Under this second specification, the coefficient (γ) of *H* (primary school enrolment rate) slightly increases from 0.05 without lags to 0.09 with lags and reaches its highest point (0.19) in the case of five years time lags. Despite the introduction of time lags, actually no major changes intervened that helped translating significantly the education effect variable in the production function. These results show that the role of human capital in growth process remains insignificant under these two specifications of the MRW model.

On the basis of these initial results, the second analysis level is applying the growth accounting framework to estimate two production functions that exclude and include human capital as an input. The results of estimation from Eqs. (5) and Eq. (6) are reported on Table 4. Column 1 gives the estimates of Eq. (5). The coefficient of ln*L* ($\beta = 0.742$), significant at the 1% level tends to exhibit either increasing or constant returns to scale. The coefficient of the ln*K* assigns a value of 0.377 to the elasticity of output with respect to the physical capital stock, which is also significant at the 1% confidence level. The estimate of Eq. (6) is shown in column 2 of Table 4, where the variable of human capital per worker enters the production function. Here, the output elasticity with respect

to human capital equals 0.273, which is significantly different from zero at the 1% level. The output elasticity with respect to physical capital remains essentially unchanged from the model without human capital at 0.397. The combined elasticity of output with respect to physical capital and human capital totals 0.67, which is consistent with the findings of Mankiw et al. (1992), who estimated γ=0.66 (to be positive and significant) in a sample of 98 countries. Moreover, the output elasticity with respect to the labor force fall to 0.228, indicating that the coefficient of labor in the model without human capital captures much of the influence of human capital. In short, the results of human capital from the production function regression applying the growth accounting framework, corroborate with the findings of Mankiw et al. (1992) and differ from those of Islam (1995) and Benhabib and Spiegel (1994).

The assumption of constant returns to scale was tested. According to the results, the F-statistics is not rejected at the 1% level in the production function model without human capital. While in the model with human capital, the F-statistics indicates that the null hypothesis is rejected. This leads to consider a third production function model by restricting $(\alpha + \beta)$ to equal one, implicit parameter of β_L is given by 1-β_K (See column 3 in Table 4). Since the type of the model to be estimated might depend on the independent variables. The serial correlation was also tested. The Durbin-Watson (DW) statistic is 0.7, which is between 0 and the lower bound at the 1% significance level. Thus, the DW test reveals to be positive in the production function model including human capital. In such a situation, the possible alternative to refer to is the Lagrange Multiplier (LM) test. According to the LM test, autocorrelation does not exist. However, to see if there is greater error variability in the early or late portion of the sample, the LM test for heteroskedasticity is used. The result shows no evidence supporting a conjecture of

heteroskedasticity in the model. Furthermore, the estimation results of Eqs. (5) and (6) in column 1 and 2 in Table 4, have been used to obtain two TFP estimates for the next step of the analysis. Thus, the correlation between these two TFP equal 0.9161, indicating a consistent pattern across the two different estimates of TFP. In addition, the correlation between the TFP measures and real GDP per worker equal 0.68 and 0.89, excluding and including human capital in the production function. However, in order to examine the effect of human capital on technological progress, these two different measures of TFP have been employed. As a preference, the growth rate of TFP from the growth accounting model is being used for its decomposition in the second level of analysis.

Table 4: Estimated parameters and *t*-value of Production function

	Model 1	**Model 2**	**Model 3**
Constant	-0.699	2.153*	0.885*
	(-1.370)	(4.795)	(22.052)
ln*K*	0.377*	0.397*	0.380*
	(10.357)	(19.751)	(21.558)
ln*L*	0.742*	0.228*	0.620
ln*H*		0.273*	
		(8.133)	
R^2	0.9846	0.9958	0.9204
Adjusted R^2	0.9846	0.9954	0.9176
Observations	31	31	31
Durbin-Watson (Autocorrelation)			(Positive)
Autocorrelation(LM Test)			No
Heteroskedasticity (LM Test)			No
Test of constant returns to scale			Accept C.R.T.S

Note: The variables are defined as follows: y equals *real GDP* per worker; *k* equals the capital stock per worker; *L* equals the stock of workers; *h* equals the human capital per worker. The t-statistics is in parentheses. C.R.T.S=Constant Returns to Scale; *Means significant at the 1% level

To estimate Eqs (5a), trade-related variables (i.e., openness) and human capital variable are considered as influencing factors of TFP. In addition, some time-specific dummy variables are included to capture the three educational reforms and the economic reform program as well. From this equation, TFP can be decomposed to find out the level of contribution of each possible determinant factor. It should be noted that the estimations of Eq. (5a) where TFP and the independent variables measured in growth rate have shown no multicollinearity problem. It is also worth recalling that measurement of human capital variable in Eqs. (5a) has been estimated in one specification only. More specifically, based on the dependent variables where TFP is derived from the production function that excludes human capital as an input. By doing so, it helps better capturing the effect of human capital in influencing TFP. Since the inclusion of human capital variable in the underlying production function may possibly overestimate the final estimates of TFP. Table 5 reports the estimate results of Eq. (5a).

Table 5: Estimated parameters and *t*-value of growth of TFP regressions

	Gtfp1	Gtfp1	Gtfp2	Gtfp2
Constant	-1.384***	-2.603***	-0.359	-0.958
	(-3.08)	(-3.04)	(-1.00)	(-1.09)
g*pser*	0.169**	0.151**		
	(2.15)	(2.27)		
g*fdi*	1.19	2.65	-4.95	-4.63
	(0.09)	(0.26)	(-0.43)	(-0.43)
g*exp*	0.079	0.050	0.081*	0.066
	(1.55)	(1.32)	(1.92)	(1.59)
g*imp*	-0.009	-0.010	0.002	0.002
	(-0.43)	(-0.64)	(0.15)	(0.18)
D_{E1}		-3.309***		-2.03 **
		(-4.19)		(-2.39)
D_{E2}		1.105		0.673
		(1.45)		(0.81)
D_{E3}		0.087		0.081
		(0.11)		(0.10)
D_R		1.868		0.964
		(1.62)		(0.85)
R^2	0.26	0.71	0.16	0.42
Adjusted R^2	0.14	0.59	0.06	0.22
Observations	29	29	29	29

Note: The variables are defined as follows: tfp represents the dependent variables (growth rate) derived from production functions that exclude (tfp1) and include (tfp2) human capital; *fdi* equals growth rates of foreign direct investment; *exp* equals growth rate of exports; *imp* equals growth rate of imports; $D_{E1}..D_{E3}$ and D_R are dummy variables of education and economic reforms, respectively. The *t*-statistics is in parentheses. * **Means significant at the 1% level; ** Means significant at the 5% level; * Means significant at the 10% level

Column 1 and 2 give the estimates of the specification without human capital. And column 3 and 4 provide the estimates of the specification with human capital. Taken together, the openness variables offer particular interpretations. The growth rate of *fdi* is positive but insignificant in both cases in the specification without human capital. Reversely, it turns out to be insignificantly negative in both cases under the specification with human capital.

The growth rate of export also displays an insignificant positive effect in all cases, except under the

specification with human capital without dummy, where it turns out to be significantly positive at the 10% level. Expectedly, the growth rate of import is negative and insignificant in the specification without human capital. This trend changed in both cases under the specification with human capital but remains insignificantly positive.

As mentioned earlier, the human capital variable is only measured under the specification where TFP is the dependent variable that excludes human capital in the first-stage of the production function regression. With this same dynamic, the estimate results of human capital, reported in column 1 and 2, show that all coefficients are positive and significant at the 1% level without dummy introduction and 5% level with dummy.

The dummy variables of education and economic reform programs have been also introduced in the estimation of Eq. (5a) to see how responsive would be their effects. Thus, column 2 and 4 provide the result of these estimates. Among the three dummy variables of education reforms, only PASE1 is negative and significant at the 1% and 5% levels in both specifications. While PASE2 and EFA, remain positive but insignificant in both specifications. The economic reform dummy variable also exhibits the same trend in both specifications.

Discussion of the Results

The positive but insignificant coefficients of primary education under the two specifications of the MRW model indicate that, the role of human capital in Guinea economic growth process was insignificant during the observed period. This observation is in line with the findings of Islam (1995), contending that human capital does not contribute significantly to explaining output. Instead, human capital should significantly affect TFP. And to some extent with the findings of Benhabib and Spiegel (1994), concluding that "human capital does not enter the

production function as an input, but rather influences growth through its effect on TFP". Considering the immense efforts directed towards expanding and improving the quality of basic education since the reforms inception in this sector, a long run effect is likely to be expected. As Romer (2001) noted, "primary education might not show short run results in the economy, but has indirectly long term effects on it".

The second level of analysis that estimated two production functions, one excluding and one including human capital, applying the growth accounting framework offers wider interpretation on human capital effect when it is used as an input in the production function. First, it shows that the human capital variable, when included in the production function enters with a positive sign, significantly different from zero. Second, the physical capital output elasticity remains essentially unchanged from the specification without human capital. However, when this output elasticity of physical capital is combined with human capital output elasticity; this gives a coefficient output elasticity which somehow confirms the findings of Mankiw et al. (1992), advocating physical and human capital to be the basic determinants of growth. Third, the output elasticity of labor force reduces significantly in the specification without human capital, suggesting that the labor force coefficient captures much of the human capital influence. These results corroborate with the findings of Miller and Upadhyay (2000), in their study of the openness effect, trade orientation and human capital on TFP.

Now moving on to the most specific part of this second level of analysis, it is worth stressing on the motivation behind examining the effect of human capital on technological progress under different specifications. In doing so, it may help defining the responsivity of each variable in influencing TFP. The Eqs. (5a) estimation offers an objective interpretation of the results in relation to

Guinea's situation. So said, the result estimates of growth of *fdi* almost in all specifications appear to be negative and insignificant. This indicates that the contribution of FDI to technological progress in Guinea is limited if not non-existent due to its effects driven by capital intensive sectors rather than labor intensive. In this postulate, Keita and Yang (2010), conducted an empirical study on FDI effect on economic growth with evidence from Guinea. Their findings show that the level of FDI is still low in promoting economic growth in Guinea.

Looking at the trade-related variables, a completely contrasting responsive effect emerges between export and import. The estimation results of export measured in growth rates, overall exhibit positive signs in all specifications. Indeed, it remains significantly positive under the specification where growth rate of TFP derived from the production function that includes human capital as an input. These findings somehow illustrate the effect of the economic reform program. These effects were identified to have set the stage for a boom in trade, the expansion of the informal sector in Conakry (Guinea's capital city), and a revival of the agricultural production (Waldstein, Gellar, Roberts, and Keita, 1991). As a result of this improved incentive structure, export value increased about 16% between 1986 and 1989 during the first reform phase. Under the second phase, despite difficulties, non-mining revenues increased from 4.6% of GDP in 1988 to about 7.4% in 1994 (World Bank, 1997). However, this performance could not hold longer, due to political instability and unfavorable world price trends for the country's two main exports, bauxite and alumina, in 2000. In this respect, the most common argument in support to the hypothesis that openness affects economic growth rests on the notion that "openness/trade leads to improvements in TFP, as a result of either static or dynamic gain from trade. Larger trade implies greater openness that facilitates the

economy's adoption of more efficient production techniques, leading to faster growth of TFP and, hence, real per capita income" (Romer, 1990; Barro and Sala-i-Martin, 1995). Subsequently, a contrasted observation emerges from the estimates of import variable.

The import coefficients measured also in growth rates have shown to be insignificantly negative in almost all specifications, except under the specification of growth of TFP including human capital, where it is positive but insignificant. Roughly taken, the import estimation in influencing TFP is literally negative. Apparently, this fact echoes with the country's poor import regulations. Among other things, one can point the excessive taxation "which makes charges higher for companies and increases costs for consumers, which lower competitiveness of imports for Guinea's economy" (World Trade Organisation, 2011).

The most important point that emerges from examining TFP influencing factors in Eqs. (5a) is the overall responsiveness of human capital variable. The human capital coefficients, estimated under TFP measured in growth rates, proved to be higher and significantly different from zero. This observation indicates that TFP growth in Guinea is highly influenced by human capital. More specifically, these empirical results suggest that the primary schooling enrolment rate as a proxy for human capital is a determinant factor, which positively and significantly affects TFP. This estimation result is consistent with Lin's (2003) argument that "the use of gross investment in human capital or gross enrolment rates helps to assess the way the new knowledge and technologies bear on production when introduced in the process". Benavot (1989), also argued that "the main contribution of human capital, which is generally and often crudely measured in terms of school enrolment ratios, to the growth process, is to increase the level of cognitive skills possessed by the labor force, and as a consequence, to

improve productivity in general; and therefore should be attributed to TFP". Campos and Root (1996) further posit that "all of the High-Performing Asian Economies invested heavily in education and, unlike many other developing countries, have concentrated on primary and secondary schooling…The benefits of focusing on primary and secondary education are substantial. The higher the (sic) enrolment rates in primary and secondary, the higher the growth in a country's per capita GDP".

The last and paramount emphasis to make in interpreting factors that influence TFP is to identify the responsive effect of education and economic reforms dummy variables. Altogether, the coefficients of education dummy variables D_{E1} and D_{E2} basically reveal to be significantly negative. These results indicate that education reform PASE1 and PASE2 have not contributed to TFP growth. The systematic non-contribution of these first two sets of education reform has been largely notified in many reports pertaining to Guinea education sector. In general, these reports unanimously acknowledge some quantitative gains in terms of school enrolment, but little progress made in terms of education quality (USAID, World Bank and IMF: PRSP). Nonetheless, the estimated coefficient of education dummy variableD_{E3}, proves to be positive and insignificant. This observation suggest that, even though the third education reform has not entirely affect TFP, it somehow exhibits a sign of slight revival which could turn to be significant if more appropriate measures are taken. Presumably, the EFA program's tenets and goals to achieve a quality universal primary education by 2015 in Guinea, may have contributed to this perceived revival.

Lastly, the economic dummy variable assessment appears distinctly from the two TFP specification measurements. The economic dummy variable estimation reveals to be positive but insignificant in both cases of TFP growth rates. The estimate results suggest that the

economic reform has not fully and significantly affected TFP. A claim supporting this, points out the weak development of the private sector, most of which is informal, and is constrained by a business environment considered to be one of the world's least conducive–179th position out of 183 and 47th position in Africa (Doing Business, 2009/2010).

An additional step in the second level of analysis, which primarily aimed at examining the contribution of human capital accumulation on technological progress, would consist of recapitulating the TFP average contribution level to growth during this observed period. Thus, based on the estimation coefficients of Eq. (5) and Eq. (6), Guinea's growth during the period 1980-2010 is decomposed into its approximate sources, and the average percentage of distribution for TFP, capital, labor and human capital obtained. The decomposition results are reported in Table 6 and 7.

Table 6: Growth of TFP and its relative contribution to growth in Guinea (1980-2010)

	β=0.377	Growth G(Y)	Average growth rate Capital β_KG(K)	Labor β_LG(L)	TFP G(A)	Percentage Contribution of TFP %
	(1)	(2)	(3)	(4)	(5)	(6)=(5)/(2)
1980-1985		1.98	2.47	1.75	-2.24	-113.1
		(100)	(124.7)	(88.3)	(-113.1)	(-57.1)
1985-1990		4.11	3.42	-	0.69	16.7
		(100)	(83.2)	-	(16.7)	(4.0)
1990-1995		3.61	2.51	3.95	-2.85	-78.9
		(100)	(69.5)	(109.4)	(-78.9)	(-21.8)
1995-2000		4.36	1.77	1.49	1.1	25.2
		(100)	(40.6)	(34.1)	(25.2)	(5.7)
2000-2005		2.84	1.19	1.39	0.26	9.1
		(100)	(41.9)	(48.9)	(9.1)	(3.2)
2005-2010		2.13	-	1.82	0.31	14.5
		(100)	(-7.9)	(85.4)	(14.5)	(6.8)

Notes: Estimates using the Cobb-Douglas production function. Relative contributions to growth rate in percentages of inputs are shown in parentheses.

In general, TFP intends to capture how institutional and exogenous variables, as well as macroeconomic and structural policies, affect overall productivity. Findings from the decomposition in Table 6 show that, the increase in technological progress contribution to growth without human capital is observed during the period 1985-1990 and 1995-2000. Thus, exhibiting an average contribution level of 0.6% and a high contribution level of 1.1% during the whole period observed in this analysis. On the one hand, this observation tends to support the massive absorption of FDI by the capital intensive sector (mining), during the first sets of economic reform. As Campbell and Clapp (1995) contend that "the first SAP came to effect in January 1986, and the second came later in mid-1988". In addition, the IMF (2006) supports that during the 1995-1999; Guinea

managed to reduce annual inflation from two digits to below 5%. In the same period, the fiscal deficit was reduced from above 5% of GDP, on average, to about 3% of GDP, and the terms of trade were improving. In contrast, between 2000 and 2004, inflation increased, the fiscal position deteriorated, and the country was exposed to numerous exogenous shocks…this has weakened growth since 2000.

Whereas, on the other hand, when looking at the decomposition in Table 7, rather, it appears that, the increase in technological progress contribution to growth with human capital is observed during the period 1995-2000 and 2005-2010. Therefore, it displays an average contribution level of 0.8% and a high contribution level of 1.18% during the entire observed period. These findings suggest that, irrespective of numerous exogenous shocks: (i) insecurity in the region;(ii) a fall in the bauxite prices–Guinea's main export commodity; (iii) a sharp increase in the price of imported goods; and a significant change in the stance of macroeconomic policy, identified to be major factors in weakening growth in Guinea since 2000 (IMF, 2006). Basically, the growth registered in Guinea from the mid-2000, which is largely contributed by the technological progress can be attributed to human capital accumulation. Hence, on the basis of this observation, it can be noted that, despite little progress made in terms of education quality in Guinea, human capital proves to be a determinant growth enhancing factor in the country.

Table 7: Growth of TFP and its relative contribution to growth in Guinea (1980-2010)

	β=0.397	Average growth rate				Percentage Contribution
	Growth G(Y)	Capital β_KG(K)	Labor β_LG(L)	Human.C β_HG(H)	TFP G(A)	of TFP %
	(1) (2)	(3)	(4)	(5)	(6)	(7)=(6)/(2)
1980-1985	1.98	2.60	0.53	-	-1.15	-58.0
	(100)	(131.3)	(26.7)	-	(-58.0)	(-29.2)
1985-1990	4.11	3.61	-	-	0.5	12.1
	(100)	(87.8)	-	-	(12.1)	(2.9)
1990-1995	3.61	2.64	1.21	1.50	-1.74	-48.1
	(100)	(73.1)	(33.5)	(41.5)	(-48.1)	(-13.3)
1995-2000	4.36	1.86	0.45	1.21	0.84	19.2
	(100)	(42.7)	(10.3)	(27.7)	(19.2)	(4.4)
2000-2005	2.84	1.25	0.42	1.81	-0.64	-22.5
	(100)	(44.0)	(14.7)	(63.7)	(-22.5)	(-7.9)
2005-2010	2.13	-	0.55	0.40	1.18	55.3
	(100)	-	(25.8)	(18.7)	(55.3)	(29.9)

Notes: Estimates using the Cobb-Douglas production function. Relative contributions to growth rate in percentages of inputs are shown in parentheses.

CONCLUSION AND IMPLICATIONS

Following a time-series approach, the study conducts two levels of analysis based on Cobb-Douglas production function and applies the empirical model developed by MRW (1992) and the Solow's growth accounting framework by using the flow measure of education as proxy. In respect with these two levels of analysis, the findings of the empirical analysis reveal that the role of human capital through direct education effect to Guinea's growth is insignificant, pertaining to the estimation based on the model developed by MRW (1992). Moreover, the second level of analysis, employing the growth accounting framework by estimating two different production functions, one excluding and one including human capital, indicates that human capital has a significant effect on growth when included as a factor of production. More importantly, TFP decomposition shows

that human capital examined among openness variables as influencing factors, reveals to be a potential determinant factor of technological progress in Guinea over this observed period. Hence, the effect of human capital accumulation through education on technological progress is proven to be positive and significant. From this study, flows therefore both research and policy implications. Since this study aims to be a pioneer in this particular area intended to Guinea, suggests that other studies will hopefully examine the other educational levels' effect on Guinea's economic growth. Or attempt to examine it through the qualitative approach instead.

On the policy implications side, these results also suggest that complementary efforts are needed to reverse the inefficiency and structural imbalance within Guinea education system. An imbalance characterized by the fact that too much attention is paid to the upper part of the system–higher education–and insufficient attention to its lower part, especially in primary education recently. As a result, this imbalance shows to be harmful to the external efficiency of the education. Thus, it can be concluded that in general and for countries such as Guinea with no universal basic education, a good quality of education is an excellent investment. Hence the need to advocate for policies geared toward education investment to promote economic growth to consider the bottom-up approach for a better allocation of resources and qualification of the education system. Since the rates of return to investment in education are considered to be greater for primary education, followed by secondary and then higher education. Each education stage differently raises labor productivity.

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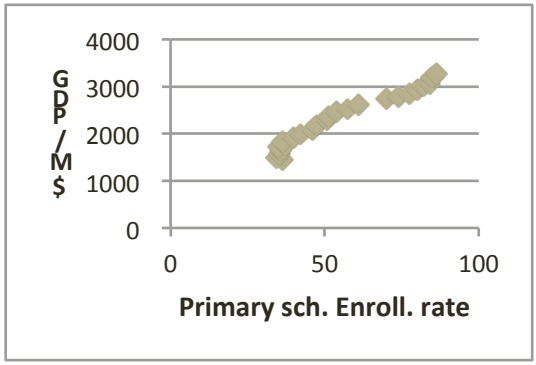
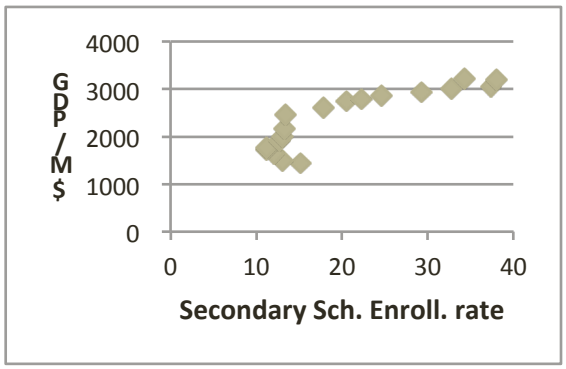
Appendix A

EDUCATION & ECONOMIC GROWTH CORRELATION IN GUINEA: 1980-2010

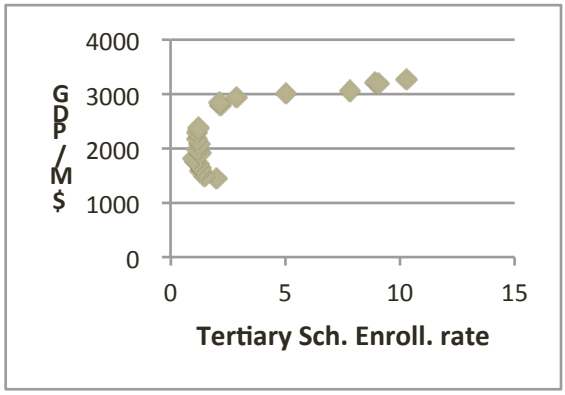
Primary Sch. Enrolment rate-GDP

Secondary Sch. Enrolment Rate-GDP





Tertiary School Enrolment Rate-GDP



- **Correlation coefficient of GDP and Education**

-Primary School: 0.98 (positive & strong)

-Secondary School: 0.92 (positive but weak)

-Tertiary school: 0.77 (positive but weak)