Human Capital and Economic Growth in Morocco: Evidence from Bayesian Model Averaging

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Abstract

The paper investigates the relationship between human capital and economic growth in Morocco during the period from 1965 to 2015. In order to test this relationship we estimated a growth function using firstly the Johansen multivariate cointegration test and the Granger causality test. Secondly, we used the method of the Bayesian Model Averaging (BMA) that takes into consideration the uncertainty related to the specification of the model studied. In the theoretical literature, the difficulty of measuring human capital is often stressed. In order to overcome this problem, we use four proxies of human capital: first, we employ the average years of schooling. Second, we use the index of the gap in life expectancy between Morocco and developed countries. Third, we integrate the qualitative aspects of education and health by constructing two composite indicators of human capital using Principal Component Analysis (PCA) method.

The main results of regression analysis confirm that in the specification of determinants of GDP per worker the average years of total schooling, the life expectancy index and the indicator of quality of health affect positively and significantly level of GDP per worker. However, in the specification of determinants of the growth of the GDP per worker, we found there is no proxy of human capital that affects significantly the growth of the GDP per worker.

In addition, the results of Granger causality test show that only the indicator of quality of health cause the GDP per worker. As well, these results show that the average years of total schooling and the indicator of quality of education cause the growth of GDP per worker. We suggest that the Moroccan authorities should make additional efforts to raise the level of quality of human capital especially in the health sector and increase the productivity of both public and private investment.

Keywords: human capital, economic growth, Bayesian Model Averaging (BMA), Principal Component Analysis (PCA)

1. Introduction

The importance of human capital into economic growth goes back to the works of (Smith, 1795) who stated that “training in its all forms improve productivity which contributes to economic expansion”.

The debate on this relationship was developed, in the first place, thanks to the works of the designers of the theory of human capital (Mincer, 1958), (Schultz, 1961), (Becker, 1962) and (Denison, 1962), which they investigated the impact of human capital through its influence on the workers productivity. After that, the works of theorists of the models of endogenous growth enriched this debate (Romer, 1986), (Lucas, 1988), (Barro, 1991), (Mankiw et al., 1992), they integrate the human capital as determinant of economic growth.

The empirical studies related to models of endogenous growth confirm that differences in stock of human capital could explain differences of production growth between countries, see (Barro, 1991), (Mankiw et al., 1992), (Barro & others, 2003)).

In the empirical studies, we detect three mechanisms by which human capital may influence economic growth:

1. The increase in the stock of human capital by promoting education and health can increase the workers productivity, which in turn increases the productive capacity of the national economy (Schultz, 1961), (Mincer, 1974), (Mankiw et al., 1992)).
2. The increase in stock of human capital can influence the workers productivity by promoting innovation and using new technologies ((Nelson & Phelps, 1966), (Romer, 1990), (Aghion & Howitt, 1992), (Benhabib & Spiegel, 1994)).

3. The stock of human capital can be an important determinant for the attraction of foreign direct investment inflows ((Noorbakhsh et al., 2001), (Koukpo, 2005), (Bouoiyour et al., 2009)).

However, with the improvement of data quality and the application of more sophisticated econometric methods, some authors concluded that the effects of the human capital on economic growth are negatives and sometimes not significant ((Islam, 1995), (Caselli et al., 1996), (Dessus, 2000), (Pritchett, 2001)).

Pritchett (2001) provided three interpretations to explain the controversial results on the effects of human capital in economic growth: First, he supposes that the institutional framework does not encourage positive externalities of human capital on economic performance. Second, he believes that the quality of education may be low despite of the increase in the years of education. Finally, he considers that low demand of educated workers could characterize the labor market, which reduces the excepted human capital benefits.

In September 2000, as part of 189 countries that signed the United Nations Millennium Declaration, Morocco government has engaged to achieve eight development goals and developed countries are engaged to support poor countries to achieve these objectives. Among the eight objectives four are directly linked to human capital: to ensure primary education for all, to reduce child mortality, to improve maternal health, to defeat HIV/AIDS, malaria and other diseases, and the others objectives contribute to the improvement of human capital: reducing extreme poverty and hunger and promoting gender equality.

In order to achieve these objectives, Morocco has engaged in many reforms in the sectors of education and health. On the one hand, the reforms of the Moroccan educational system started by the adoption in 1999 of the National Charter for Education and training. After that, authorities take on the emergency program for the period from 2009 to 2012 and they launched in 2015 a new strategy teaching called "vision 2030". On the other hand, authorities in health sector applied the basic medical coverage through the generalization of the medical assistance schema in 2012 and launching health strategy for next four years.

The main objective of this paper is to test first the long-run dynamic relationship between Moroccan economic growth and human capital by using Johansen multivariate cointegration test and the Granger causality test. Secondly, we use the method of (BMA) which takes into account the uncertainty related to the specification of the model studied.

We will organize the paper as the following: we will start by presenting a review of the empirical studies. Then we present the macroeconomic conditions and indicators of in Moroccan human capital after that we present the empirical approach, data sources and variables used. Afterward we discuss the results obtained finally we come up with conclusion.

2. Review of the Empirical Studies

Human capital is at the heart of empirical works that explain the determinants of economic growth. Aghion & Howitt (1998) point out that the authors follow two main approaches to quantify human capital and its impact on economic growth. Some authors consider human capital as flow variable in the process of accumulation is just as physical capital (((Lucas, 1988), (Romer, 1989),(Barro, 1991),(Mankiw et al., 1992))). Other authors consider it a variable stock and when it is high, the country's production processes could benefit from the positive externalities related using innovation and new technologies ((Barro & Lee, 1994),(Benhabib & Spiegel, 1994),(Bloom & Mahal, 1995)).

Recent works has followed three main research directions. In the first direction, authors have enriched the endogenous growth model by introducing in addition to the basic model variables other variables related to health conditions, institutions and free trade policy ((Berthély et al., 1997), (Abdouni & Hanchane, 2008), (Mansour, 2009) and (Bouoiyour et al., 2009)). On the second research direction, some authors have used more sophisticated econometric methods because studies that rely on cross section data has been criticized (GMM panel data, Bayesian approach ...) ( (Fall & Thiaw, 2012), (Leon-Gonzalez & Vinayagathasan, 2015), (Fetahi-Vehapi et al., 2015) and (Mbulawa, 2015)). The authors of the third research direction have introduced the role of quality education in explaining growth ((Hanushek & Kimko, 2000), (Barro & Lee, 2001), (Altinok & Murseli, 2007), (Hanushek & Woessmann, 2012), (Altinok et al., 2014)).

The existing theoretical literature argues that human capital may interact positively and significantly to economic growth. However, several empirical studies obtained controversial results. Many authors like (Dessus, 2000), (Kruger & Lindahl, 2001), (De la Fuente & Doménech, 2002), (Altinok & Murseli, 2007), (Sunde & Vischer,
confirmed that many studies fail to measure the impact of human capital on the economic growth because they use weak proxies of different dimensions of human capital.

In the other hand, two categories of empirical studies characterized the Moroccan context: studies based on time series data and the studies based on the panel data as part of the countries of the region of MENA or countries of South Mediterranean.

Bouayad (1994) to investigate the relationship between the growth rate of GDP and social expenditures related to the education and health sectors using the tests of causality and cointegration. He shows that GDP reacted positively to changes in social spending for a period from 1950 to 1985.

Bouoiyour (2000) in a study that takes into account the data covering the period from 1958 to 1994 and approximating human capital by the rate of primary and secondary schooling, has concluded that there is bidirectional causality between education and growth in the short term but not confirmed in the long term.

Besides, Bouoiyour & Bennaghmouch (2002) in a study that considers the period from 1975 to 1995 and measuring human capital by the years of education at primary, secondary and higher level. They conclude the presence of a significant positive effect of education on economic growth. But, this effect reduces when the level of education increases.

Ibourk & Amaghouss (2013) in a study that covers the period from 1975 to 2010 and takes into account data from 15 countries in the MENA region fragmented into two categories: countries with high-income level and countries with an average income level estimated a growth function. They approximate human capital through several proxies including the literacy rate, primary, secondary and higher school enrollment, the average years of school at primary education and secondary, the number of students per teacher and life expectancy. They show that the impact of education on growth is positive but it depends on the level of group of countries studied income.

In addition, Sbaouelgi(2015) in a comparative analysis of three different countries including Morocco, Tunisia and Korea, she investigates the relationship between human capital and economic growth approximating human capital through three proxies: expenditure per student as a percentage of GDP per capita, the number of graduates in science and engineering and the gross rate of higher education enrollment. In addition, she applied the causality tests and co-integration between these indicators and economic growth. She concluded the absence of a long-term relationship for the cases of Tunisia and Morocco. Nevertheless, the case of South Korea is characterized by a long-term relationship, which justifies the development gap between these countries.

In sum, despite the variety of measures used to approximate the human capital in the Moroccan context, realized empirical work offers an assessment concluding that there is positive impact of human capital on economic growth.

3. Macroeconomic Conditions and Indicators of Human Capital in Morocco

Since independence, Morocco has implemented several social and economic policies to ensure the integration of the Moroccan economy in the way of development. We distinguish three periods of reforms: the period between 1965 and 1983, authorities made strong intervention in the economy to restructure the industrial sector and substitute products importation by local production. During the period between 1985 and 1999, the Moroccan economy has seen the introduction of the structural adjustment plan under the advices of international financial institutions, which made significant impact concerning the increase of the rate of growth, the control of inflation and the improving of trade terms. However, the expected results are insufficient in particular with respect to the reduction of poverty and inequality.

The period between 2000 and 2015 was marked by social and economic reforms focused on several levers: Improving working conditions with the new labor code established in 2003. Modernization of industrial, agricultural fabric and promotion of exportations because authorities implemented emergence plan in 2005 and applied the green plan since 2007. Improving well-being and social stability with the measures of the National Human Development Initiative1 (NHDI) in 2005. Introduction of program of Assistance medical Obligatory (AMO) in (2005) and generalization of medical assistance scheme since 2011.

Besides, despite the vulnerability of agricultural production to climatic conditions ( (Mansouri, 2009)). The Moroccan economy has grown steadily in the past two decades with an average growth rate, which reached 4.65% in the period 1996-2005 and 4.38% in the period 2006-2015. The inflation rate is at an average rate of 1.6 during

1NHDI, which mean by French INDH: “Initiative National de Développement Humain”.

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the period between 2006 and 2015. The investments rate increased from 29.4% to 34.2 also the rate of unemployment decreased from 12% to 9.8% during the same period. Many economists agree that these performances are due to the emergence of new motor trades of growth including automotive, electrical and electronic, aeronautics industries and offshoring.

However, the Moroccan economy faces four constraints: first, the total external debt to GDP is high; it has decrease less from 41.82 to 32.98 on average during the last 10 years. Secondly, the trade deficit continued to extend going from -3.66% of GDP on average for 1996-2005 to -11, 34% of GDP on average for the period 2006-2015. Thirdly, despite increase of investment rate, this capital has less productivity and it is concentrated in just two sector industry and building sectors. In the end, Morocco suffers from a problem of unemployment, which is high.

As to conditions of human capital indicators, the proportion of the illiterate population in the population aged more than 15 years has decreased significantly. However, Morocco is characterized by the highest rate in the region of MENA with a percentage of 42.1% in 2015.

By examining the database of (Barro & Lee, 2016) from 1965 to 2015, we identify that the evolution of the average years of schooling in Morocco is characterized by a steady growth. It varied from 0.28 in 1965 to 3.41 in 2015 at the level of primary education, from 0.19 to 1.6 at the secondary education and 0.01 to 0.37 at the level of higher education.

Also, the resources that have been allocated to the sector of education which were 4.51 percent of GDP during the period 1986-1990 they rose to 6.72 during the period 2011-2015; this increase is faster at the heading of personnel and material expenses.

Despite the progress made over the past two decades, the public offering of education in Morocco has many problems: first, the rate of alphabetization is the highest in the North Africa region with a percentage of 42.1%. Second, according to (UNESCO, 2016), the rate of drop out and repetition rate in primary and secondary education is very high. Third, according to results of Mathematics and Science related to achievement tests the quality of education is very low comparing to other countries in MENA region.

In the health sector, comparing Morocco to Tunisia, Algeria, Jordan and Egypt in terms of indicators related to expenditure on health per capita and the infant mortality rate per 1000 live births, we realize that Morocco needs much efforts to invest in this respect.

Moreover, according to (BAD, 2013), only 50% of Moroccans have the basic medical coverage. Besides, in the report of (CESE, 2013) showed that the share of health expenditures directly supported by Moroccan households is 53.6%, which mean that an average amount of 802 dirham per capita annually. This amount does not include additional fees related to transportation and accommodation. Furthermore, the rate of infant mortality remains high, particularly in rural areas, (Rural 35.3 and Urban 25.3 per thousand born) and the maternal mortality rate in rural areas is two times higher than urban areas. This calls into question the quality of care offered by this sector.

By and large, we can conclude that despite the progress made over the past two decades, the public offering of health and education doesn’t respond to the huge needs of people therefore, the stakeholders are called invest more so as to live up to citizens’ expectations.

4. The Empirical Approach

To investigate the relationship between human capital and economic growth in Morocco we estimated a growth function relying in (Mankiw et al., 1992) specification. We propose to extend this equation in two steps: first, we take into account the effects of the health dimension, based on the works of (Knowles & Owen, 1995) and (Ram, 2007). Secondly, we take into account the effects of the qualitative dimension of human capital, based on the work of (Boccanfuso et al., 2009).

To measure impact of human capital in the economic growth, we propose to use the method of the Bayesian Model Averaging, which takes into account the uncertainty related to the specification of the model studied.

4.1 Specification of the Empirical Model

Mankiw et al. (1992) propose the Cobb Douglas production function developed by human capital following the form:

2Consul Economic, Social and Environment, which means by French CESE: “Conseil économique, social et environnemental (CESE)”.
\[ Y_t = K_t^\alpha H_t^\beta (A_tL_t)^{1-\alpha-\beta} \]  

(1)

Where \( Y_t \) is gross domestic product at time \( t \), \( \alpha \) and \( \beta \) denotes the elasticity of production in relation to changes in the physical capital stock \( K_t \) and the stock of human capital \( H_t \), \( A_t \) represents technological progress and \( L_t \) denotes the quantity of labor, considering:

\[ Y_t = \frac{Y_t}{A_tL_t}, \quad k_t = \frac{K_t}{A_tL_t} \quad \text{And} \quad h_t = \frac{H_t}{A_tL_t} \]

We write the previous equation as follows:

\[ y_t = k_t^\alpha h_t^\beta \]  

(2)

With \( y_t \) corresponds to the quantity of output per effective unit of labor at period \( t \). As in the Solow model, Mankiw et al. (1992) suppose that \( L_t \) and \( A_t \) progress to an exogenous growth rate \( n \) and \( g \) and the dynamics of factor accumulation are determined by:

\[
\begin{cases}
    \dot{k}_t = s_k Y_t - (n + g + \delta)k_t \\
    \dot{h}_t = s_h Y_t - (n + g + \delta)h_t
\end{cases}
\]

(3)

\( k_t \) is the rate of the physical capital stock growth while \( s_k \) is the share of income invested in physical capital, \( h_t \) is the rate of human capital stock growth whereas \( s_h \) is the share invested in human capital, \( n \) is the rate of the active population growth, which \( g \) is the rate of technological progress growth and \( \delta \) is the rate of human capital depreciation identical to that of physical capital.

Considering that yields of production factors are decreasing \((\alpha + \beta < 1)\), the level of human capital and physical capital in the steady state is:

\[
\begin{align*}
    k^* &= \left( \frac{1}{1-\alpha-\beta} \right) \frac{1 + \beta}{n + g + \delta} \\
    h^* &= \left( \frac{1}{1-\alpha-\beta} \right) \frac{1}{n + g + \delta} 
\end{align*}
\]

(4)

We substitute these two values into the production function and we introduce this latter to logarithm. Then, we obtain the following specification:

\[
\ln \left( \frac{Y_t}{L_t} \right) = \ln A_0 + gt - \frac{\alpha + \beta}{1-\alpha-\beta} \ln(n + g + \delta) + \frac{\alpha}{1-\alpha-\beta} \ln(s_k) + \frac{\beta}{1-\alpha-\beta} \ln(s_h)
\]

(5)

Mankiw et al. (1992) state that if we suppose that \((\alpha + \beta = 1)\) the equation mentioned above is transformed to an endogenous growth function.

The rate of convergence towards the level of income per capita of steady equilibrium is given by:

\[
\frac{d\ln(y_t)}{dt} = \frac{\dot{y}}{y} = \lambda [\ln(y^*) - \ln(y_t)]
\]

With

\[ \lambda = (n + g + \delta)(1 - \alpha - \beta). \]

This implies that:

\[
\ln(y_t) = (1 - e^{-\lambda t}) \ln(y^*) + e^{-\lambda t} \ln(y_0)
\]

Consider subtracting \( \ln(y_0) \) from each member of the above equation we find:

\[
\ln(y_t) - \ln(y_0) = (1 - e^{-\lambda t}) \ln(y^*) - (1 - e^{-\lambda t}) \ln(y_0)
\]
By substituting \( y^* \), we deduce:

\[
\ln(y_1) - \ln(y_0) = - \left(1 - e^{-\lambda t}\right) \ln(y_0) - \left(1 - e^{-\lambda t}\right) \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) + \left(1 - e^{-\lambda t}\right) \frac{\alpha}{1 - \alpha - \beta} \ln(s_k) + \\
\left(1 - e^{-\lambda t}\right) \frac{\beta}{1 - \alpha - \beta} \ln(s_h)
\]  

(6)

By considering that:

\[
\alpha_1 = -(1 - e^{-\lambda t}), \quad \alpha_2 = -(1 - e^{-\lambda t}) \frac{\alpha + \beta}{1 - \alpha - \beta}, \quad \alpha_3 = (1 - e^{-\lambda t}) \frac{\alpha}{1 - \alpha - \beta} \quad \text{and} \quad \alpha_4 = (1 - e^{-\lambda t}) \frac{\beta}{1 - \alpha - \beta}
\]

The following test specification is obtained:

\[
\ln(y_1) - \ln(y_0) = \alpha_0 + \alpha_1 \ln(y_{t-5}) + \alpha_2 \ln(n + g + \delta) + \alpha_3 \ln(s_k) + \alpha_4 \ln(s_h) + \epsilon_t
\]  

(7)

This specification only takes into account the determinants of economic growth within the steady state. We tried to extend this specification by considering, first, the nature of the time-series data and in addition to the basic model variables we take other variables which may influence the Moroccan aggregate production relying on the empirical studies conducted by (Barro & others, 2003), (Bassanini & Scarpetta, 2002), (Boccanfuso et al., 2009), (Khan, 2015).

In fact, in order to test the relationship between human capital and economic growth of Morocco we use the two specifications as follows:

\[
\ln(y_1) = \alpha_0 + \alpha_1 \ln(y_{t-5}) + \alpha_2 \ln(n + g + \delta) + \alpha_3 \ln(s_k) + \alpha_4 \ln(s_h) + \alpha_5 \ln(Open) + \alpha_6 \ln(R_{agr}) + \\
\alpha_7 \ln(Inf) + \epsilon_t
\]

\[
\ln(y_1) - \ln(y_{t-1}) = \alpha_0 + \alpha_1 \Delta \ln(y_{t-5}) + \alpha_2 \Delta \ln(n + g + \delta) + \alpha_3 \Delta \ln(s_k) + \alpha_4 \Delta \ln(s_h) + \alpha_5 \Delta \ln(Open) + \\
\alpha_6 \Delta \ln(R_{agr}) + \alpha_7 \Delta \ln(Inf) + \epsilon_t
\]

(8)

(9)

Where \( y_1 \) refers to the Gross Domestic Product by worker, \( y_{t-5} \) represents the Gross Domestic Product by worker in date \( t - 5 \), \( n_t \) is the growth rate of the active population, \( g \) means the growth rate of technological progress and \( \delta \) is the depreciation rate of human capital, \( s_k \) represents the stock of physical capital, \( s_h \) refers to the stock of human capital, \( OPEN \) is the trade openness index, \( R_{agr} \) is the agriculture production index, \( Inf \) is the price increases index and \( \epsilon_t \) is the error term.

4.2 Bayesian Model Averaging Method

The empirical studies that examine determinants of economic growth suggest many potential explanatory variables, for example, (Durlauf et al., 2005) distinguish 43 models and 145 variables that determine economic growth. This context related to the lack of consensual theory that guides the choice of determinants of economic growth raise uncertainty about the true set of explanatory variables to use in model studied.

The BMA method overcome this problem in terms of uncertainty about the true set of explanatory variables by joining prior probabilities to alternative sets of explanatory variables and then update these probabilities using data collected. (Ciccone & Jarocinski, 2008).

Like (Zeugner, 2011), if we suggest this equation of determinants of economic growth:

\[ y = \alpha_y + X_y \beta_y + \epsilon \]

\[ \epsilon \rightarrow N(0,\sigma^2.I) \]

Where \( y \) referring to the dependent variable \( \beta_y \) is the vector of coefficients of explanatory variables \( X_y \) and \( \epsilon \) is the error term with variance \( \sigma^2 \).

If \{\( X \)\} has \( K \) potentials variables that means there are \( 2^K \) potentials models. These models are depended to \( \beta_y \) where \( M_y \); \( y = 1,2,\ldots,2^K \).

as well, “the Bayesian approaches use Bayes theorem to convert the density of the data conditional on the model...

\(^3\)The introduction of parameter Gross Domestic Product by worker in date \( t - 5 \) in specification is debatable. Some authors made estimations without introducing this variable. (Boccanfuso et al., 2009), (Ibourk & Amaghouss, 2013), (Khan, 2015)...). However, many authors introduced in their estimations (Mankiw et al., 1992), (Islam, 1995), (Berthélémy et al., 1997), (Ram, 2007)...). Following the previous authors, we decided to use this parameter in our estimation. In addition, we suppose that it reflect beginning of the government mandate in Morocco.
(the marginal likelihood) into a posterior probability of the model conditional on the observed data” (Ciccone & Jarocinski, 2008) as follows:

\[
\rho(M_y/y, X) = \frac{\rho(y/M_y, X)\rho(M_y)}{\rho(y/X)} = \frac{\rho(y/M_y, X)\rho(M_y)}{\sum_{\gamma=1}^{2^k}\rho(y/M_\gamma, X)\rho(M_\gamma)}
\]

Where \( \rho(M_y/y, X) \) refers to posterior model probability which is proportional to marginal likelihood of the model \( \rho(y/M_y, X) \) and a prior model probability \( \rho(M_y) \), \( \rho(y/X) \) correspond to the integrated likelihood which is steady over all models. (Zeugner, 2011)

Knowing that \( \int \rho(M_y/y, X) dM_y = 1 \), we get the function marginal likelihood of models:

\[
\rho(y/X) = \int \rho(y/X, X)\rho(M_y/X) dM_y
\]

Therefore, the model weighted posterior distribution of the coefficients of explanatory variable is as follows:

\[
\rho(\theta/y, X) = \sum_{\gamma=1}^{2^k} \rho(\theta/M_y, y, X)\rho(y/M_y, X)
\]

For our model the formula is:

\[
\rho(\beta_y \neq 0/y, X) = \sum_{\beta_y} \rho(M_y/y, X)
\]

This posterior probability measure the intensity of relation between the dependent variable and explanatory variables. However, in order to determine the posterior distribution of model coefficients we need to specify the prior on model parameters, which refer to weight of potential explanatory variable.

In order to determine the posterior distribution of model, we suppose like (Fernandez et al., 2001) and (Bodman et al., 2009)), the equal prior probabilities for all models or « unit information prior ».

Most authors used a common prior \( g \) specified by (Zellner, 1986) where:

\[
\beta_y/g \sim N(0, \sigma^2 (\Sigma_{M_y} X'_y X_y)^{-1})
\]

4.3 The Unit Root Testing

The unit root testing allows both to detect the existence of trend and to determine the order of integration of series studied. These tests are important since they preclude the risk of spurious regression.

The literature review distinguishes several tests; the most widely used tests are the Dickey-Fuller augmented (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). We use the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to detect the presence of unit roots.

The tests of ADF establish the alternative hypothesis \( |\theta_1| < 1 \), which ascertain the estimation by the Method of Ordinary Least Square of the three equations:

\[
\Delta x_t = \rho x_{t-1} - \sum_{j=2}^{\rho} \theta_j \Delta x_{t-j+1} + \epsilon_t
\]

\[
\Delta x_t = \rho x_{t-1} - \sum_{j=2}^{\rho} \theta_j \Delta x_{t-j+1} + c + \epsilon_t
\]

\[
\Delta x_t = \rho x_{t-1} - \sum_{j=2}^{\rho} \theta_j \Delta x_{t-j+1} + c + b_t + \epsilon_t
\]

The estimation of the standard deviation coefficients of the models by the OLS provides \( t_{\theta_1} \), which is analogous to the student statistic (coefficient on standard deviation) if \( t_{\theta_1} \geq t_{tabulated} \), then we accept the hypothesis \( H_0 \);
which implies the variable has unit root, so the process is not stationary. Besides, Phillips & Perron unit root tests conducted from a regression similar to that of the Dickey and Fuller test. (Bourbonnais, 2005)

4.4 Tests of Cointegration

The theory of cointegration was initiated by (Granger, 1981), then later developed and popularized by (Engle & Granger, 1987). (Johansen, 1988). The two-step (Engle & Granger, 1987; Barro & Lee, 2016) test only allows the identification of the number of cointegration relationships in the case of two variables. Johansen & Juselius (1990) modified this test to study multiple variables.

They proposed two tests: the maximum eigenvalue test and the trace test.

\[ \lambda_{\text{trace}}(r) = -T \sum_{i=1}^{r} \ln(1 - \hat{\lambda}_i) \]

\[ \lambda_{\text{trace}}(r, r + 1) = -T \ln(1 - \hat{\lambda}_{r+1}) \]

Where \( r \) is the number of cointegration vectors under the null hypothesis and \( \lambda_i \) is the estimated value of the ith eigenvalue of the matrix. In the statistic \( \lambda_{\text{trace}} \) we suppose the null hypothesis where the number of cointegration vectors is less than or equal to \( r \) against the alternative hypothesis in which the number is greater than \( r \) (for the test of the maximum eigenvalue, \( H_0: R = r \) against \( H_1 : R = r + 1 \) (Vangu & Boboy, 2013).

4.5 Test of Causality

The causality, in the sense of Granger (1969) between \( X_t \) and \( Y_t \) means that the prediction of \( Y_t \) based on both the perception of the joint past of \( X_t \) and \( Y_t \) is better than the prediction based only on the past knowledge of \( Y_t \).

The Granger causality test for the case of the two variables \( Y_t \) and \( X_t \) implies the estimation of the following autoregressive vector model (VAR):

\[ Y_t = \alpha_1 + \sum_{j=1}^{n} \beta_j X_{t-j} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + \varepsilon_{1t} \]

\[ X_t = \alpha_2 + \sum_{j=1}^{n} \theta_j X_{t-j} + \sum_{j=1}^{n} \delta_j Y_{t-j} + \varepsilon_{2t} \]

The test can lead to three results: bidirectional causality, unidirectional causality or no variable (X or Y) causes the other.

5. Data, Empirical Results and Interpretations

5.1 Presentation of Data and Variables Selections

In the context of the above empirical studies, the GDP per worker in constant 2005 US$ is used as dependent variable. We have measured human capital by four proxies, of which two are quantitative and two qualitative, firstly the average years of schooling at the level of primary, secondary and higher education calculated by the methodology of the permanent inventory developed by (Nehru et al., 1995).

Secondly, the index of Morocco’s life expectancy gap compared to developed countries, as measured by (Knowles & Owen, 1995). We integrate the qualitative aspects of education and health by constructing two composite indicators of human capital using method of Principal Component Analysis (PCA). The choice of the methodology of Nehru et al., 1995 was because it takes into account the effects of repeating and dropping out of school.

The authors presume that children enter in school at the age of 6, then, they get into the labor market at the age of 15 and leave it at the age of 64, also in Moroccan primary education there is six grades. Therefore, the equation for primary level is writing as follows:

\[ S_{PA} = \sum_{T=5}^{T-9} \sum_{g=1}^{6} E_{g,T-g-1} \]

Where:

\[ E_{gT}^* = E_{gT} (1 - r_{gT} - d_{gT}) \]

\( E_{gT} \) is the gross enrollment level of education adjusted by repetition rates \( r_{gT} \) and drop-out rate \( d_{gT} \). The same approach is used to calculate secondary and tertiary education.

To measure the health dimension, Authors used several indicators: Food intake, life expectancy, infant mortality rate and public health expenditure. Nevertheless, in most empirical studies, life expectancy is used as a health proxy, see (Nadiri, 1972); (Hicks, 1980); (Anand & Ravallion, 1993); (Knowles & Owen, 1995); (Bloom et al., 2004)).

We suggest approximating the health dimension by the following index:
Health case indicator = \(- \ln (80 - \text{lifeExp}_t)\)

This indicator takes into account the "shortfall" in terms of years of life to reach the level of the most developed countries that corresponds to 80 years.

Finally, to capture the qualitative aspects of human capital, we have extended the methodology developed by (Boccanfuso et al., 2009) who used the techniques of multivariate analysis to construct synthetic indicators of the quality of the education system\(^4\).

According to Berthélemy et al. (1997) and Abdouni & Hanchane (2008), the effects of human capital in economic growth depend on the social policy of the country, particularly the policy of openness and economic stability. We consider a composite index of openness policy\(^5\) and we use cereal yield (kg per hectare) and the rate of inflation as proxies of economic stability in Morocco\(^6\).

5.2 Results of Unit Root Tests and Johansen Co-integration Test

As can be seen from the Table 1, the results of unit root tests lead to the conclusion that only the variables \(\Delta \text{GDP}, \text{LnGDP}, \text{L(n+g+§)}, \text{LGDP}(t-5), \text{Lmyscho}, \text{LifeExpInd}, \text{inf} \) and \( \text{Lagrucul} \) are stationary and that the variables \( \text{eduqualInd}, \text{healqualInd} \) and \( \text{openness} \) are non-stationary in level but stationary in first difference.

The results show the possibility of a cointegration relationship between the variables: the growth rate of GDP per worker, the rate of investment, the growth of active population, the GDP in date \( (t-5) \), the average years of education of the labor force, life expectancy, the indicator of agriculture and the rate of inflation.

Before starting the cointegration test, we determine the number of delays of our VAR model based on the information criteria of (Akaike, 1974), (Schwarz & others, 1978) and (Hannan & Quinn, 1979). As result, we identify one number of retard in the first specification and Zero retard in the second specification. (See Table 2 and Table 3)

As in the Table 4, the results show that there are four linear co-integration relationships in the (Mankiw et al., 1992) specification, which shows the existence of a long-run relationship between GDP per worker and human capital approximated by the average years of study. However, we found that there is no linear co-integration relationship when we integrate the health dimension, (Ram, 2007) specification and the results show three linear co-integration relationships when we has introduced the qualitative dimension of human capital resulting from (PCA), ((Boccanfuso et al., 2009) specification).

As in the Table 5, the results show that there are more than five linear co-integration relationships, which shows the existence of a long-run relationship between the growth of the GDP per worker and human capital.

\(^4\)Boccanfuso et al., (2009) consider only the qualitative aspects of education; we propose to introduce the qualitative aspects of health. We take into account the following variables: life expectancy, birth rate, gross (per 1,000 persons), infant mortality rate (per 1,000 live births), maternal mortality rate (per 1,000 live births), the number of physicians per capita, total health expenditure (% of GDP) and student-teacher ratio in primary, secondary and tertiary education.

\(^5\)The composite index of openness results in applying PCA to these variables: Exports and imports of goods and services, personal remittances received, international tourism receipts, total foreign direct investment (FDI) inflows, net official development assistance received, investment in telecoms with private participation and external debt. All these variables reported as percentage of GDP and we added insurance and financial services as a percentage of commercial service exports.

\(^6\)The choice of cereal yield (kg per hectare) as indicator of economic stability due to vulnerability of agricultural production to climatic conditions (Mansouri, 2009).
Table 1. Results of Augmented Dickey Fuller (ADF) and Phillips and Perron tests for unit root

<table>
<thead>
<tr>
<th>Variables</th>
<th>Augmented Dickey Fuller (ADF) test</th>
<th>Phillips and Perron test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test with constant trend</td>
<td>Test without constant trend</td>
</tr>
<tr>
<td></td>
<td>T-stat</td>
<td>Pval</td>
</tr>
<tr>
<td>ΔLGDP</td>
<td>-7.53</td>
<td>0.00</td>
</tr>
<tr>
<td>LinGDP</td>
<td>-1.89</td>
<td>0.06</td>
</tr>
<tr>
<td>L (n+g+$)</td>
<td>-0.26</td>
<td>0.78</td>
</tr>
<tr>
<td>LGDP (t-5)</td>
<td>3.35</td>
<td>0.01</td>
</tr>
<tr>
<td>Lmyenso</td>
<td>-2.36</td>
<td>0.02</td>
</tr>
<tr>
<td>Lifexpind</td>
<td>-11.98</td>
<td>0.00</td>
</tr>
<tr>
<td>Healqualind</td>
<td>-0.79</td>
<td>0.43</td>
</tr>
<tr>
<td>Δeduqualind</td>
<td>-6.64</td>
<td>0.00</td>
</tr>
<tr>
<td>heaqualind</td>
<td>1.17</td>
<td>0.25</td>
</tr>
<tr>
<td>Δhealqualind</td>
<td>9.00</td>
<td>0.00</td>
</tr>
<tr>
<td>openness</td>
<td>-1.77</td>
<td>0.08</td>
</tr>
<tr>
<td>Δopenness</td>
<td>-8.53</td>
<td>0.00</td>
</tr>
<tr>
<td>Inf</td>
<td>-2.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Lr-agricul</td>
<td>-0.17</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Table 2. VAR lag order selection criteria (Dependent variable LGDP)

<table>
<thead>
<tr>
<th>Specifications</th>
<th>(Mankiw et al., 1992)</th>
<th>(Ram, 2007)</th>
<th>(Boccanfuso et al., 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIC</td>
<td>HQIC</td>
<td>SBIC</td>
</tr>
<tr>
<td>Number de retard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>-4.95</td>
<td>-4.84</td>
<td>-4.67</td>
</tr>
<tr>
<td>1</td>
<td>-6.31</td>
<td>-6.19</td>
<td>-5.98*</td>
</tr>
<tr>
<td>2</td>
<td>-6.29</td>
<td>-6.15</td>
<td>-5.92</td>
</tr>
<tr>
<td>3</td>
<td>-6.26</td>
<td>-6.11</td>
<td>-5.86</td>
</tr>
</tbody>
</table>

Table 3. VAR lag order selection criteria (Dependent variable DIGDP)

<table>
<thead>
<tr>
<th>Specifications</th>
<th>(Mankiw et al., 1992)</th>
<th>(Ram, 2007)</th>
<th>(Boccanfuso et al., 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIC</td>
<td>HQIC</td>
<td>SBIC</td>
</tr>
<tr>
<td>Number de retard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>-5.17*</td>
<td>-5.07*</td>
<td>-4.89*</td>
</tr>
<tr>
<td>1</td>
<td>-5.14</td>
<td>-5.03</td>
<td>-4.82</td>
</tr>
<tr>
<td>2</td>
<td>-5.10</td>
<td>-4.97</td>
<td>-4.74</td>
</tr>
<tr>
<td>3</td>
<td>-5.09</td>
<td>-4.96</td>
<td>-4.71</td>
</tr>
</tbody>
</table>

Table 4. Results of Unrestricted co-integration rank test (Dependent variable LGDP)

<table>
<thead>
<tr>
<th>Specifications</th>
<th>(Mankiw et al., 1992)</th>
<th>(Ram, 2007)</th>
<th>(Boccanfuso et al., 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rank test</td>
<td>5% crit. val.</td>
<td>Rank test</td>
</tr>
<tr>
<td>H0</td>
<td>H1</td>
<td></td>
<td>H0</td>
</tr>
<tr>
<td>r = 0</td>
<td>r ≥ 1</td>
<td></td>
<td>r=0</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>r ≥ 2</td>
<td></td>
<td>r ≤ 1</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>r ≥ 3</td>
<td></td>
<td>r ≤ 2</td>
</tr>
<tr>
<td>r ≤ 3</td>
<td>r ≥ 4</td>
<td></td>
<td>r ≤ 3</td>
</tr>
<tr>
<td>r ≤ 4</td>
<td>r ≥ 5</td>
<td></td>
<td>r ≤ 4</td>
</tr>
<tr>
<td>r ≤ 5</td>
<td>r ≥ 6</td>
<td></td>
<td>r ≤ 5</td>
</tr>
<tr>
<td>r ≤ 6</td>
<td>r ≥ 7</td>
<td></td>
<td>r ≤ 6</td>
</tr>
<tr>
<td>r ≤ 7</td>
<td>r ≥ 8</td>
<td></td>
<td>r ≤ 7</td>
</tr>
</tbody>
</table>
Table 5. Results of Unrestricted co-integration rank test: (Dependent variable DlGDP)

<table>
<thead>
<tr>
<th>Specifications</th>
<th>(Mankiw et al., 1992)</th>
<th>(Ram, 2007)</th>
<th>(Boccanguso et al., 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H_0$</td>
<td>$H_1$</td>
<td>Rank test</td>
</tr>
<tr>
<td>$r = 0$</td>
<td>$r \geq 1$</td>
<td>323.65</td>
<td>156.00</td>
</tr>
<tr>
<td>$r \leq 1$</td>
<td>$r \geq 2$</td>
<td>208.13</td>
<td>124.24</td>
</tr>
<tr>
<td>$r \leq 2$</td>
<td>$r \geq 3$</td>
<td>136.20</td>
<td>94.15</td>
</tr>
<tr>
<td>$r \leq 3$</td>
<td>$r \geq 4$</td>
<td>88.15</td>
<td>68.52</td>
</tr>
<tr>
<td>$r \leq 4$</td>
<td>$r \geq 5$</td>
<td>4.520*</td>
<td>47.21</td>
</tr>
<tr>
<td>$r \leq 5$</td>
<td>$r \geq 6$</td>
<td>21.51</td>
<td>29.68</td>
</tr>
<tr>
<td>$r \leq 6$</td>
<td>$r \geq 7$</td>
<td>7.54</td>
<td>15.41</td>
</tr>
<tr>
<td>$r \leq 7$</td>
<td>$r \geq 8$</td>
<td>2.15</td>
<td>3.76</td>
</tr>
</tbody>
</table>

5.3 Regression Analysis

As seen in Table 6, we investigate the determinants of LGDP. If we refer to the criteria of (Raftery, 1995) which suggests that the posterior probabilities should be higher than 0.5. We distinguish five variables that affect significantly GDP per worker where three are proxies of human capital: The average years of total schooling that affects positively and significantly GDP per worker with the probability of 0.9976. Also, these results show that the life expectancy index affects positively and significantly GDP per worker with the probability of 0.6312 and the quality index of health resulting from the PCA method affects positively and significantly the growth of GDP per worker with the probability of 0.8496. However, the quality index of education resulting from the PCA method affects negatively and not significantly GDP per worker.

These results confirm that the economic growth is affected by degree of growth of human capital measured by growth of average years of total schooling and health indicator used.

These results could be explained in two ways: either the Moroccan economy is characterized by the low level of quality of education, as shown by (Pritchett, 2001) or the stock of human capital is allocated in low productivity sectors (Murphy et al., 1991).

In addition, we found that the indicator of openness resulting from the PCA method and the agricultural production index has positive and significant impact on GDP per worker respectively with the probability of 0.8338 and 0.9864.

These results could be explained by the fact that the policy of openness made by Morocco promoted the economic growth by insuring transfer of qualifications and new technologies. However, the Moroccan authorities need to make additional efforts to obtain much opportunities related to this policy. In addition, the agricultural production index affects positively and significantly the GDP per worker that confirms the dependence of Moroccan economic growth on agricultural production. The agriculture sector contributes to more than 14% of GDP and creates employment of more than 75% of population in rural areas.

As seen in Table 7, we investigate the determinants of the growth of GDP per worker, we found that only the growth of physical capital and growth of active that affects significantly the growth of GDP per worker, As for the four proxies of human capital, they affect positively but not significantly the economic growth of Morocco.

As in the Table 8 and the Table 9, the results of Granger causality test show first that only the indicator of quality of health that cause the GDP per worker. Secondly, these results show that the average years of total schooling and the indicator of quality of education cause the growth of GDP per worker and the growth of GDP cause the growth of the quality index of health.
Table 6. Results of Bayesian Model Averaging method data from 1965 to 2015: (Dependent variable LGDP)

<table>
<thead>
<tr>
<th>Description</th>
<th>Name</th>
<th>Posterior Inclusion Probability</th>
<th>Posterior Mean</th>
<th>Conditional Posterior Standard Deviation</th>
<th>Sign Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average years of schooling</td>
<td>lmyscho</td>
<td>0.9976</td>
<td>0.8607</td>
<td>0.1666</td>
<td>1.0000</td>
</tr>
<tr>
<td>life expectancy index</td>
<td>Llifeexpind</td>
<td>0.6312</td>
<td>0.2183</td>
<td>0.2042</td>
<td>1.0000</td>
</tr>
<tr>
<td>Quality index of education</td>
<td>eduqualind</td>
<td>0.2664</td>
<td>-0.0331</td>
<td>0.0687</td>
<td>0.0000</td>
</tr>
<tr>
<td>Quality index of health</td>
<td>healqualind</td>
<td>0.8496</td>
<td>0.2506</td>
<td>0.1448</td>
<td>0.9999</td>
</tr>
<tr>
<td>Physical capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth of active population</td>
<td>L(n+g+$\gamma$)</td>
<td>0.1359</td>
<td>-0.0035</td>
<td>0.0154</td>
<td>0.0978</td>
</tr>
<tr>
<td>Convergence affect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index of openness policy</td>
<td>openness</td>
<td>0.8338</td>
<td>0.0957</td>
<td>0.0583</td>
<td>1.0000</td>
</tr>
<tr>
<td>Inflation</td>
<td>Inf</td>
<td>0.1279</td>
<td>-0.0022</td>
<td>0.0002</td>
<td>0.2121</td>
</tr>
<tr>
<td>agricultural production index</td>
<td>Lr-agricul</td>
<td>0.9864</td>
<td>0.0962</td>
<td>0.0282</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Observations: 51
Number of potential variables: 1024
The mean of variables to include: 5.0578

Table 7. Results of Bayesian Model Averaging method data from 1965 to 2015: (Dependent variable DigDP)

<table>
<thead>
<tr>
<th>Description</th>
<th>Name</th>
<th>Posterior Inclusion Probability</th>
<th>Posterior Mean</th>
<th>Conditional Posterior Standard Deviation</th>
<th>Sign Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The growth of the average years of schooling</td>
<td>Dimyscho</td>
<td>0.3681</td>
<td>0.0866</td>
<td>0.1369</td>
<td>1.0000</td>
</tr>
<tr>
<td>life expectancy index</td>
<td>Dllifeexpind</td>
<td>0.0933</td>
<td>-0.0001</td>
<td>0.0414</td>
<td>0.4345</td>
</tr>
<tr>
<td>Quality index of education</td>
<td>Deduqualind</td>
<td>0.2548</td>
<td>-0.0495</td>
<td>0.1057</td>
<td>0.0000</td>
</tr>
<tr>
<td>Quality index of health</td>
<td>Dhealqualind</td>
<td>0.1448</td>
<td>-0.0184</td>
<td>0.0693</td>
<td>1.0000</td>
</tr>
<tr>
<td>Physical capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth of active population</td>
<td>Dl(n+g+$\gamma$)</td>
<td>0.5461</td>
<td>-0.1617</td>
<td>0.1780</td>
<td>0.0000</td>
</tr>
<tr>
<td>Convergence affect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index of openness policy</td>
<td>Dopenness</td>
<td>0.09537</td>
<td>0.0021</td>
<td>0.0421</td>
<td>0.6842</td>
</tr>
<tr>
<td>Inflation</td>
<td>Din</td>
<td>0.1815</td>
<td>0.0292</td>
<td>0.0833</td>
<td>1.0000</td>
</tr>
<tr>
<td>agricultural production index</td>
<td>Dil-agricul</td>
<td>0.1004</td>
<td>0.0051</td>
<td>0.0461</td>
<td>0.8557</td>
</tr>
</tbody>
</table>

Observations: 51
Number of potential variables: 1024
The mean of variables to include: 2.7288

Table 8. Results of Granger causality test (Dependent variable LGDP)

<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>F-test</th>
<th>Prob</th>
<th>F-test</th>
<th>Prob</th>
<th>F-test</th>
<th>Prob</th>
<th>F-test</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital does not cause LGDP</td>
<td>1.07</td>
<td>0.43</td>
<td>1.56</td>
<td>0.21</td>
<td>0.63</td>
<td>0.43</td>
<td>4.12</td>
<td>0.04</td>
</tr>
<tr>
<td>LGDP does not cause Human capital</td>
<td>0.04</td>
<td>0.95</td>
<td>0.56</td>
<td>0.45</td>
<td>1.17</td>
<td>0.28</td>
<td>19.01</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Table 6. Results of Granger causality test (Dependent variable DlGDP)

<table>
<thead>
<tr>
<th>Indicators of human capital</th>
<th>the average years of total schooling</th>
<th>the index of the gap in life expectancy</th>
<th>the quality index of education</th>
<th>the quality index of health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis</td>
<td>F-test 11.15 Prob 0.001</td>
<td>F-test 1.55 Prob 0.69</td>
<td>F-test 6.23 Prob 0.01</td>
<td>F-test 1.59 Prob 0.21</td>
</tr>
<tr>
<td>Human capital does not cause DlGDP.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DlGDP does not cause Human capital.</td>
<td>0.73 F-test 0.79 Prob 0.79</td>
<td>0.16 F-test 0.69 Prob 0.24</td>
<td>0.24 F-test 0.62 Prob 0.24</td>
<td>6.1 F-test 0.08 Prob</td>
</tr>
</tbody>
</table>

6. Conclusion

Human capital is at the heart of empirical works that explain the determinants of economic growth. Although, many authors argue that human capital may affect positively and significantly the economic growth several empirical studies obtained controversial results.

This paper investigates the relationship between human capital and economic growth in Morocco during the period from 1965 to 2015. In order to test this relationship, we firstly use the Johansen multivariate cointegration test and the Granger causality test. Secondly, we use the method of the Bayesian Model Averaging which takes into consideration the uncertainty related to the specification of the model studied. In order to measure human capital, we have used four proxies of human capital: first, the average years of total schooling, second the index of the gap in life expectancy between Morocco and developed countries and third we integrate the qualitative aspects of education and health by constructing two composite indicator of human capital using method of Principal Component Analysis (PCA).

The main results confirm that in the specification of determinants of GDP per worker the average years of total schooling, the life expectancy index and the indicator of quality of health affect positively and significantly level of GDP per worker. However, in the specification of determinants of the growth of the GDP per worker, we found there is no proxy of human capital that affects significantly the growth of the GDP per worker.

In addition, the results of Granger causality test show that only the indicator of quality of health that cause the GDP per worker. As well, these results show that the average years of total schooling and the indicator of quality of education cause the growth of GDP per worker. We suggest that the Moroccan authorities should make additional efforts to raise the level of quality of human capital especially in the health sector and increase the productivity of both public and private investment.

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Economic papers, 53, 541-563. https://doi.org/10.1093/oep/53.3.541


66, 281-302. https://doi.org/10.1086/258055

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