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Research Article

INVESTIGATING THE IMPACT OF HUMAN CAPITAL DEVELOPMENT ON BRAZIL'S ECONOMIC GROWTH

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ABSTRACT

This study contributes to the existing literature by exploring the relationship between human capital development and economic growth in Brazil. The study employs the Johansen Cointegration approach, the Grangercausality test according to Toda and Yamamoto (1995), and the Fully Modified Ordinary Least Square (FMOLS) method. The analysis is based on time series data extracted from the World Development Indicator (WDI) and the Pen World Table 9.1 database, covering the period from 1980 to 2017. The findings suggest that, in the long term, economic growth in Brazil is primarily influenced by human and physical capital as well as trade openness. Furthermore, both human and physical capital exhibit a positive and significant impact on short-term growth.

Keywords: Human Capital, Economic Growth, Toda-Yamamoto, FMOLS.

INTRODUCTION

Human capital, which refers to the knowledge, skills, and experience of a country's workforce, is a critical driver of sustainable economic development. The concept of human capital was introduced by Becker (1962) and Rosen (1976). It is defined as the collection of knowledge, skills, and competencies individuals acquire over time through education, training, work experience, medical care, and migration (Becker, 1964). In the long run, a healthy, educated, and productive workforce will contribute to economic well-being. In this sense, the rapid development of human capital is essential for nations. The advancement of human capital helps a country establish a competitive structure to meet the demands of global competition and elevate the society's welfare to higher living standards.

Human capital is recognized as a fundamental factor affecting a nation's sustainable economic development[1]. The concept of human capital was introduced by Becker (1962) and Rosen (1976). Human capital is defined as the accumulation of knowledge, skills, and competencies that individuals acquire over time through education, training, work experience, healthcare, and migration (Becker, 1964). In the long term, a healthy, educated, and productive workforce will lead to economic prosperity. In this regard, the rapid development of human capital is crucial for countries. The advancement of human capital assists a nation in establishing a competitive framework to meet the demands of today's global competition and elevate society's well-being to higher living standards.

Since the 1990s, Brazil's increasing openness to international trade and the resulting growth in trade flows have captured the attention of researchers attempting to identify the determinants of international competitiveness in both developing and developed countries. In this context, researchers have focused on specific factors related to competitiveness, such as the importance of human capital. This study investigates the relationship between human capital and economic growth in Brazil, utilizing the Human Capital Index as the metric for human capital. The subsequent sections of the paper are structured as follows: an exploration of theoretical and empirical studies existing in the literature regarding this topic, the introduction of the data utilized in the study, and subsequently, an analysis of the associations between human capital and economic growth in Brazil employing data for the Human Capital Index spanning from 1980 to 2017. Finally, the findings will be presented along with recommendations.

LITERATURE REVIEW

In the literature, the relationship between human capital and economic growth has been explored both theoretically and empirically. Dissatisfied with the traditional growth models that assumed exogenous technological progress, Romer (1986) and Lucas (1988) introduced an internal growth model by incorporating human capital as an additional variable. Consequently, technology became internalized. Empirical studies have been conducted to validate the connection between human capital and economic growth, with notable contributions from early works such as those by Barro (1991) and Mankiw, Romer, and Weil (1992). However, the evidence regarding the human capital variable has sometimes been inconclusive, with occasional negative or frequently statistically insignificant parameter estimates. In recent years, the literature has made significant efforts to shed light on the outcomes of human capital's impact on growth. Empirically, there has been a consensus on the poor quality of existing human capital data for international comparisons, suggesting the inadequacy or weakening explanatory power of this variable in explaining growth. Consequently, some studies have emerged to produce improved measures related to the quantity and quality of human capital. In this context, Benhabib and Spiegel (1994) found a weak relationship between educational attainments and economic growth in cross-country studies.

Kim and Hong (2010) conducted a comparative study between Korea and Mexico, demonstrating that high education spending may not have a positive impact on growth if not allocated according to each country's respective industrial policies. They identified that a fundamental difference between the two countries in terms of education policy lies in the allocation of public expenditures for education. Additionally, they found disparities in the distribution of

[1] In the development economics literature, human capital is recognized as a significant element of economic growth. See Romer, 1986; Qadri and Waheed, 2014; Barro and Sala-i-Martin, 2004; Gyimah-Brempong and Wilson, 2004.

spending across different educational levels, with Korea allocating a higher amount to primary and secondary education, while Mexico allocated more to preparatory levels. Similarly, Hanushek and Woessmann (2020) explore the role of education in promoting economic growth, with a focus on the role of knowledge or a country's overall skills.

Ram (2007) introduced the intelligence variable into the model of Mankiw *et al.,* (1992) and found that the inclusion of this variable reduced the dimension and significance of the education and health variables. Therefore, according to the findings obtained by this author, IQ is a superior human capital variable compared to both education and health. Tsamadias and Prontzas (2012) examined the impact of education on economic growth in Greece for the period 1960-2000 using the Mankiw, Romer, and Weil model, and they found that physical and human capital are key factors in promoting economic growth. Similarly, Pegkas and Tsamadias (2014) applied the same growth model and conducted stationarity, cointegration, and causality tests for Greece for the period 1960-2009, using higher education as a variable for human capital. The results demonstrated the existence of a one-way causal relationship from higher education to economic growth.

Siddiqui and Rehman (2017) investigated the relationship between human capital and economic growth in ten Asian countries. The study revealed variations among the countries in terms of economic well-being, and it also highlighted disparities in the level of educational attainment. Barcenilla and Pueyo (2018) conducted research on the impact of human capital on the process of innovation and technology adoption in European Union countries. The study utilized the methodology proposed by Benhabib and Spiegel (2005). In the study, a panel data model was estimated for the period from 1950 to 2011 using human capital variables found in PWT 8.0 and advanced total factor productivity. The results suggest that, regardless of academic levels, an increase in the quantity of unskilled human capital restricts European Union countries growth, while high-quality human capital is essential for growth through innovation.

Sehrawat and Singh (2019) investigated the impact of human capital on income in Indian states. The study revealed that human capital is positively associated with income inequalities.

Akinlo and Oyeleke (2020) employed the Generalized Method of Moments (GMM) and static predictions to identify the relationship between human capital and economic growth for 36 sub-Saharan African countries during the period from 1986 to 2018. The study revealed that human capital makes a positive contribution to economic growth. Additionally, it found that the connection between human capital and economic growth is dependent on the level of economic development. Rodriguez *et al.,*(2020) estimated the relationship between human capital and economic growth for Mexico during the period from 1971 to 2010. The study used both the least squares model and the structural change least squares model. The results indicate that in Mexico, the impact of human capital on economic growth is greater than that of physical capital. Furthermore, the results of the Granger causality test demonstrate the presence of a two-way causality between human capital and economic growth in Mexico.

DATA

The study utilizes annual time series data from the period of 1980 to 2017. In the study, real GDP is used as an indicator of economic performance, the Human Capital Index (HCI) represents human capital, gross fixed capital formation serves as an indicator of physical capital (PC), total trade as a share of GDP represents trade openness (TO), and the GDP deflator is used as an indicator of inflation (INF). Real GDP, trade openness, and GDP deflator data were sourced from the World Development Indicators (WDI) database, while the Human Capital Index (HCI) data were obtained from the Pen World Table 9.1.

Tablo 1: Descriptive statistics.

DescriptiveStatistics	lnGDP	lnPC	lnHCI	lnINF	lnTO
Mean	28.741	27.043	0.791	3.001	3.106
Median	28.710	26.957	0.784	4.132	3.183
Maximum	29.081	27.535	1.081	5.095	3.390
Minimum	28.369	26.595	0.540	-7.502	2.718
Std. deviation	0.240	0.280	0.164	3.262	0.203
Observations	28	28	28	28	28
Correlation Matrix					
lnGDP	1.000				
lnPC	0.958	1.000			
lnHCI	0.978	0.892	1.000		
lnINF	0.709	0.685	0.685	1.000	
lnTO	0.672	0.526	0.688	0.604	1.000

source: Constructed by the author using data from WDI and Pen World Table 9.1.

Descriptive statistics and the correlation matrix of the variables used in the study are presented in Table 1. The average values for lnGDP, lnPC, lnHCI, lnINF, and lnTO are 28.741, 27.043, 0.791, 3.001, and 3.106, respectively. LnGDP has a significant positive linear relationship with lnPC, lnHC, and lnTO. This is consistent with endogenous growth theory and previous empirical literature regarding the determinants of economic growth.

METHOD

The literature on the relationship between human capital development and economic growth is primarily based on a traditional growth model known as the K-L model. In the K-L model, income (GDP), represented as Y, is a function of two factors: capital (K) and labor (L). The relationship between human capital and economic growth can be measured with a standard production model. This model can be represented by the following equations:

$Y = f(K, L)$(1)

Y, L, and K represent output, capital, and labor measures, respectively

Equation (1) can be modified using the specification proposed by Barro and Lee (2000). These growth models utilize production factors as independent variables in a multivariate regression[2].

$Y_t = \beta_0 + \beta_1 PC_t + \beta_2 HCI_t + U_t$(2)

In Equation 2, the dependent variable Y_t represents output or the level of real GDP, while the independent variables are physical capital PC and human capital HCI. '$_t$' denotes the time period.
Equation 2 can be modified by adding control variables.

$Y_t = \beta_0 + \beta_1 PC_t + \beta_2 HCI_t + \beta_3 TO_t + \beta_4 INF_t + U_t$(3)

In Equation (3), the openness of the economy, represented as TO_t, is used as an indicator for control variables. INF_t is used as a measure of inflation, reflecting the price level in the economy.

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[2]Mankiw *et al.,* 1992; Barro, 1991; Barro and Lee 2000.

Stationarity Analysis

Before testing whether there is a long-term relationship between variables, determining the presence or absence of unit roots is an important prerequisite. This is a crucial step because using non-stationary variables in a regression can lead to inefficient coefficients, suboptimal predictions, and unreliable tests. A time series is considered stationary if its mean and variance remain constant over time; otherwise, it is termed non-stationary. The analysis of stationary time series has become an indispensable exercise and is essential in current econometric practice. It also helps prevent issues that may arise from using non-stationary variables. In this study, the Augmented Dickey-Fuller Test (ADF), the Phillips and Perron (PP) stationarity test, and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test were used to examine the stationarity of the variables.

Cointegration Analysis

Once the integration order of the series is determined, the next step is to identify the presence of cointegration relationships. Cointegration is defined as a systematic and long-term movement among two or more economic variables. This concept was first introduced by Engle & Granger in 1987 and later formalized by Johansen in 1991 and 1995. Engle and Granger (1987) demonstrated that it is possible for all integrated series of the same order to remain stationary with cointegration. The Granger test is structured around two stages, involving statistical regression between cointegrated variables at the same level and verification of the stationarity of residuals. Johansen's method introduces constraints through cointegration and tests them. The Johansen Juselius test is widely used to test cointegration and determine the number of cointegration relationships. In this study, the Johansen Julelius test was employed to determine the integration order of variables for each country.

Toda Yamamoto Granger Causality Test

Toda and Yamamoto (1995) developed a VAR model with (k + d_{max}) forecasts to investigate Granger causality. 'K' is the optimal time lag in the initial VAR model, and 'dmax' is the maximum integration order. The Toda and Yamamoto approach follows the following steps:

- If the integration order varies from series to series, the maximum (d_{max}) is used.
- A VAR model is constructed while ignoring the integration order found for the series.
- The order of the VAR model is determined from the lag length obtained from LR, final prediction error (FPE), AIC, SC, and HQ criteria.
- The adjusted VAR model VAR (k + d_{max}) is tested for correctness.
- If the series has the same integration order, the cointegration test is continued using the Johansen methodology. Otherwise, the approach of Pesaran *et al.,* (2001) is used.
- Regardless of the results obtained from the cointegration test, the causality test is continued.
- For each equation, a VAR (k + $d_{max)}$ model is obtained using appropriate lags.
- Causality is tested using Granger causality test and modified Wald test for the significance of parameters based on pairwise equations.
- The modified Wald test asymptotically follows a chi-square (χ^2) distribution with degrees of freedom equal to the number of time lags (k + d_{max}).
- Rejecting the null hypothesis implies rejecting Granger causality.
- Finally, it is checked whether there is cointegration in the VAR model.
- If two or more series are cointegrated, there is a causal relationship (unidirectional or bidirectional), but not vice versa.

Fully Modified Ordinary Least Square (FMOLS)

The FMOL Sestimator, proposed by Pedroni (2001, 2004), aims to address potential endogeneity issues among regressors while accounting for heterogeneity in cointegrated vectors. The FMOLS method not only handles heterogeneity but also takes into consideration issues of endogeneity and autocorrelation. One of the advantages of this method is its performance in finite samples, as compared by Banerjee (1999).

TEST RESULTS

In this section, the outcomes of different tests are presented.

Table 2: Results of Unit Root Tests

Series	ADF(C) t-value	ADF(C+T) t-value	P-P (C) t-value	P(C+T) t-value	KPSS(C) t-value	KPSS(C+T) t-value
lnGDP	-1.251	-2.224	-1.149	-1.049	0.650	0.084
lnPC	-1.393	-4.398	-1.556	-1.273	0.578	0.069
lnHCI	4.524	-0.378	4.524	-0.378	0.674	0.173
lnINF	-7.482	-4.941	-7.482	-4.941	4.868	-0.975
lnTO	-2.019	-1.676	-2.067	-1.928	0.450	0.132
ΔlnGDP	-3.569**	-3.731**	-3.569**	-3.731**	4.805*	3.396*
ΔlnPC	-2.772***	-2.664**	-3.643*	-3.714**	1.461***	1.919***
ΔlnHC	-3.010*	-4.616*	-2.908***	-4.616*	13.410*	26.929*
ΔlnINF	-1.772*	-3.056*	1.832***	1.855***	2.614**	4.991*
ΔlnTO	-4.544*	-4.978*	-4.562*	-4.606*	0.959***	1.433***

Note: *, **, *** denote the significance levels of 1, 5, and 10% respectively. C= constant and C+T= constant and trend. Δ represents the first difference. ADF: Augmented Dickey-Fuller, PP: Phillips-Perron, KPSS (1992): Kwiatkowski, Phillips, Schmidt, and Shin.

The results of the unit root tests indicate that the time series are not stationary at their own levels, implying that the null hypothesis of the time series having a unit root cannot be rejected. The results indicate that all the series are first-order integrated and stationary in their first differences.

Table 3 : The results of the cointegration test

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
None *	99.273	69.818	0.000
At most 1 *	61.256	47.856	0.001
At most 2 *	30.410	29.797	0.042
At most 3	10.147	15.494	0.269

Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	38.017	33.876	0.015
At most 1*	30.845	27.584	0.018
At most 2	20.262	21.131	0.065
At most 3	10.121	14.264	0.204

The results of the Johansen cointegration test indicate that the null hypothesis of no cointegration equations in the vector autoregressive model can be rejected at a 0.05 significance level. The trace test results for Brazil indicate the presence of 3 cointegration equations, while the Max-Eigen test results suggest the presence of at least 2 cointegration equations in the model.

Table 4: Results of the Toda-Yamamoto granger causality test

Variables	Chi-Square	p-value
Physical Capital does not Granger Cause GDP	25.592	0.000
GDP does not Granger Cause Physical Capital	11.777	0.008
Human Capital does not Granger Cause GDP	21.471	0.000
GDP does not Granger Cause Human Capital	3.520	0.318
Trade Openness does not Granger Cause GDP	2.676	0.444
GDP does not Granger Cause Trade Openness	1.272	0.735
Inflation does not Granger Cause GDP	10.575	0.014
GDP does not Granger Cause Inflation	5.018	0.170

The results of the Toda-Yamamoto test are presented in Table 4. The findings indicate a significant short-term impact of physical and human capital on economic growth. However, trade openness does not have a significant effect on GDP. On the other hand, it indicates that increased economic production (Real GDP) could be beneficial in acquiring greater physical capital.

Table 5: FMOLS test results (Dependent variable: InGDP)

	FMOLS	
	Coefficient	Prob.
lnHCI	0.787	0.000
lnPC	0.374	0.000
lnINF	-0.001	0.475
lnTO	0.100	0.000
R^2	0.995	
Adj. R^2	0.994	

After controlling for the long-term dynamics between the variables, the long-term coefficients were obtained using the FMOLS technique. The results indicate that in the long run, human capital development in Brazil has a positive impact on economic growth. There is a positive connection between economic growth and both physical capital and trade openness. Inflation and growth exhibit a negative relationship, although it is not statistically significant.

An increase in physical capital stock helps expand Brazil's production capacity. According to neoclassical endogenous growth theories, in the long run, human capital is a fundamental determinant of economic development. In the case of Brazil, the FMOLS estimates confirm the validity of human capital theory. Based on the results obtained from this study, it can be concluded that in the long run, both physical and human capital are important for economic development in the Brazilian context.

CONCLUSION AND RECOMMENDATIONS

In this study, the role of human capital in determining economic growth in the Brazilian economy has been investigated. Annual data related to real GDP, the human capital index, physical capital, trade openness, and GDP deflator (INF) were obtained from the World Bank (WDI) and Penn World Table 9.1 databases. The study covers the period from 1980 to 2017. Long-term equilibrium relationships and dynamics were examined using FMOLS techniques. The Toda and Yamamoto (1995) Granger causality test was used as a short-term diagnostic test for the long-term equilibrium relationship.

The study shows that in the short run, both human and physical capital have a positive and significant impact on economic growth in Brazil. On the other hand, in the short run, the level of economic growth determines the level of physical capital. Furthermore, in the long run, physical capital, human capital and trade openness have a significant impact on economic growth.In light of these findings, actions should be implemented to maximize the positive and substantial impacts of critical drivers of growth, such as physical and human capital in Brazil. Additionally, for Brazil to become more competitive, it is crucial for decision-makers to be aware of the determinants of the country's exports or imports.

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