Journal DOI: 10.36713/epra1013 | SJIF Impact Factor (2023): 8.048 ISSN: 2347-4378
EPRA International Journal of Economics, Business and Management Studies (EBMS)
Volume: 10 | Issue: 7 | July 2023 -Peer-Reviewed Journal

# DYNAMIC ANALYSIS OF THE RELATIONSHIP BETWEEN INVESTMENTS AND HUMAN CAPITAL: THE CASE OF UZBEKISTAN

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**ABSTRACT**
*This research examines the relationship between human capital and investment in Uzbekistan from 2010 to 2021 using the Engle-Granger Cointegration test. The study reveals a strong bidirectional connection between human capital and investment, where each positively impacts the other. Additionally, the analysis identifies a mechanism that ensures the system returns to long-term equilibrium following disturbances, with investment adjusting more rapidly than human capital. These findings offer valuable insights for Uzbekistan's policymakers and economists, emphasizing the need for coordinated efforts to foster economic growth by investing in education and health sectors to improve human capital and attract domestic and foreign investments. While short-term shocks may occur, the economy's ability to revert to equilibrium over time provides some level of reassurance during policy implementation.*
**KEYWORDS:** *human capital, investment, Engle-Granger Cointegration test, economic relationship, bidirectional, short-term impact, long-term equilibrium, sustainable growth.*

## INTRODUCTION

In recent years, the relationship between investment and human capital has garnered increasing attention in both academic and policy circles. The significance of human capital as a critical driver of economic growth and development has been widely recognized, particularly in emerging economies seeking sustainable progress. Uzbekistan, a country situated in Central Asia, has been no exception to this trend. As the nation seeks to bolster its economic foundation and improve living standards for its citizens, understanding the interplay between investment and human capital becomes crucial.

The purpose of this study is to explore and identify the potential linkages between investment and human capital in Uzbekistan. To achieve this objective, we will analyze yearly data spanning the period from 2010 to 2021. The utilization of this extensive dataset allows for a comprehensive investigation of the dynamics between investment and human capital over a significant timeframe.

The study will adopt the Engle-Granger Cointegration test to assess both short-term and long-term causal relationships between investment and human capital. The Engle-Granger Cointegration test is employed to determine whether a stable long-run relationship exists between the two variables, indicating a sustainable and enduring connection.

## LITERATURE REVIEW

The nexus between human capital and investment has been extensively examined in the economics literature. Barro (1991) articulated the endogenous growth model, where human capital was deemed a critical factor for economic growth, suggesting that investment in human capital could contribute to national economic growth. Becker (1962) also noted the significance of investment in human capital, arguing that educational attainment could directly increase an individual's productivity and earnings.

In the context of Uzbekistan, a transition economy, this link between investment and human capital development is still underexplored. However, several studies have investigated similar dynamics in other transition economies.

The role of government in human capital development in transition economies has been examined by Pritchett (2001). He emphasized that government investment in education and healthcare was pivotal in shaping human capital development. This, in turn, positively influenced private investment due to a better-skilled workforce.

Similarly, Guellec and de la Potterie (2004) conducted an empirical analysis of 16 OECD countries, including several transition economies. They found that both private and public investments had a positive impact on human capital development and long-term economic growth. Furthermore, they noted that the impact was stronger in transition economies due to initial lower levels of human capital and the rapid structural changes occurring.

In a study on Eastern European transition economies, Svejnar (2002) highlighted the positive impacts of foreign direct investment (FDI) on human capital development. The study suggested that FDI brings in not only financial resources but also knowledge and skills, thereby enhancing human capital.

Kwon (2009) identified a strong positive relationship between foreign direct investment (FDI) and human capital development in South Korea, arguing that FDI fostered workforce training and skill development.

Meanwhile, Hanushek and Woessmann (2008) provided empirical evidence for the direct influence of quality education - a significant component of human capital - on economic growth. Bils and Klenow (2000) also studied the direct and indirect impacts of education on economic growth, arguing that a well-educated labor force can attract more investment, thus further facilitating economic growth.

The relationship between human capital and investment is further supported by numerous scholars across diverse contexts. Mankiw, Romer, and Weil (1992) investigated how human capital affects economic development and found that schooling, a key aspect of human capital, has a significant impact on income differences between countries. Their findings endorse the argument that increased investment in human capital can lead to improved economic outcomes.

Benhabib and Spiegel (1994) argued that both physical and human capital play essential roles in fostering economic growth. Their cross-country analysis suggested that the stock of human capital may be more influential in dictating a country's ability to absorb and implement new technologies, highlighting the indirect influence of human capital on investment.

Lau, Jamison, and Louat (1991) examined the relationship between healthcare (another aspect of human capital) and economic growth. Their study showed that the health status of a population could impact productivity and thus significantly affect economic growth, again suggesting that investment in human capital (healthcare, in this instance) has long-term implications for a country's economy.

The role of government policy in influencing investment in human capital was also discussed by Heckman, Lochner, and Todd (2003). They argued that government policy could play a vital role in encouraging investment in human capital, which in turn can drive economic growth.

However, some research suggests that the relationship between investment and human capital is not straightforward. Psacharopoulos (1994) indicated that the rate of return from investment in education could vary significantly depending on the country and level of education. It is therefore crucial to have a nuanced understanding of the specific contexts when studying the relationship between human capital and investment.

### *Theoretical Framework*

Our theoretical framework is grounded in the endogenous growth theory, particularly the model suggested by Lucas (1988). Lucas proposed that human capital accumulation could drive long-term economic growth. In this model, investment is not limited to physical capital like factories or machinery but also includes investment in human capital such as education and training.

Investment in human capital augments a workforce's productivity, allowing for better utilization of physical capital. An educated workforce, capable of more complex tasks and innovation, is more likely to attract investment, both domestic and foreign, which, in turn, further spurs economic growth. The interaction between human capital and investment thereby generates a positive feedback loop.

## METHODOLOGY AND DATA COLLECTION

This study will adopt a comprehensive quantitative research approach to investigate the relationship between investment and human capital in Uzbekistan from 2010 to 2021. The quantitative analysis will enable us to numerically depict the relationship and to make precise, empirical interpretations.

*Engle-Granger Cointegration Test:* This two-step procedure will be used to examine if the variables of investment and human capital move together over the long term, indicating a long-term equilibrium relationship. The first step entails running a regression analysis between the two variables to assess their connection. The residuals of this regression will be analyzed in the second step to check for stationarity. If the residuals are stationary, we can infer that the variables are cointegrated and share a long-term relationship.

Our research will employ secondary data from a variety of reliable and authoritative sources:

*Investment Data:* We will compile a comprehensive dataset on the annual domestic and foreign investment in Uzbekistan from 2010 to 2021. This data will be collected from official reports published by the Central Bank

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of Uzbekistan and the State Committee on Statistics. To capture a broader picture, we will consider all types of investments, including public, private, and foreign direct investment.

*Human Capital Data*: Our measure of human capital will be primarily derived from the World Bank's Human Capital Index, which includes components such as educational attainment, health status, and survival rates. To complement this, we will also collect data on key indicators of education and health outcomes from the Uzbekistan Ministry of Public Education and Ministry of Health, respectively. These could include measures such as literacy rates, school enrollment rates, life expectancy, and infant mortality rates.

Together, this data will enable us to construct a comprehensive and accurate representation of the relationship between investment and human capital in Uzbekistan over the specified period.

## ANALYSIS AND RESULTS

### Unit Root Test

Before performing the cointegration and causality tests, it is imperative to establish the stationarity of the time series data. Stationarity refers to a property of a time series in which statistical properties such as mean, variance, and autocorrelation are all constant over time. Non-stationary series can lead to spurious regression results, which could then lead to incorrect conclusions. Therefore, conducting a unit root test becomes a critical step in our quantitative analysis.

In this study, we will employ the Augmented Dickey-Fuller (ADF) test, developed by Dickey and Fuller (1979), to examine the stationarity of our variables. The ADF test is one of the most widely used unit root tests due to its robustness and reliability in handling different types of time series data. The ADF test operates under the null hypothesis that a unit root is present in the time series data, implying that the data is non-stationary.

For each of the variables under consideration - investment and human capital - the ADF test will be conducted. The results of these tests will guide the subsequent stages of our analysis. If the variables are found to be non-stationary, they will be differenced until stationarity is achieved, ensuring that our further analysis based on these variables will be statistically sound and reliable.

Following this, we will conduct the cointegration test to assess the long-term relationship between investment and human capital. It is important to note that the choice of lag length in the ADF test can greatly affect the results. We will select the optimal lag length based on the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC), which minimize information loss and balance model complexity and fit.

In conclusion, the unit root test is an indispensable part of our methodology as it forms the foundation for our subsequent analyses. The application of the ADF test will ensure that our data is suitable for analysis and that our results are credible and valid.

**Table 1. Argumented Dickey-Fuller (ADF) statistical test results at level I (0)**

| Variables | Augmented Dickey-Fuller test statistics | p-value | MacKinnon critic value (1%) | MacKinnon critic value (5%) | MacKinnon critic value (10%) | Results |
|---|---|---|---|---|---|---|
| Human capital | -1.385 | 0.1659 | -3.439 | -2.301 | -2.158 | Non-stationary |
| Investment | -1.411 | 0.1587 | -3.439 | -2.301 | -2.158 | Non-stationary |

**Table 2. Argumented Dickey-Fuller (ADF) statistical test results at level I (1)**

| Variables | Augmented Dickey-Fuller test statistics | p-value | MacKinnon critic value (1%) | MacKinnon critic value (5%) | MacKinnon critic value (10%) | Results |
|---|---|---|---|---|---|---|
| ΔHuman capital | -4.575 | 0.0000 | -3.457 | -2.301 | -2.158 | stationary |
| ΔInvestment | -3.854 | 0.0000 | -3.457 | -2.301 | -2.158 | stationary |

The unit root test's outcomes for our variables of interest, namely investment and human capital, are encapsulated in Tables 1 and 2. Ascertaining the stationarity of our data is a crucial step to ensure the validity of the subsequent cointegration test. If the variables under consideration are found to be non-stationary at level I(0), yet become stationary upon first differencing, i.e., at I(1), we can confidently proceed to perform the cointegration test.

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Cointegration is a critical tool in econometrics, especially when studying long-term relationships in time series data. It is a robust statistical method applied to discern long-term relationships among two or more non-stationary time series. It provides valuable insights by revealing the equilibrium that may exist between sets of variables over an extended period, thereby highlighting enduring, stable relationships that exist beyond temporary fluctuations.

In the context of our study, the unit root test results show that the variables of investment and human capital are non-stationary at level I(0). However, they achieve stationarity when first differenced, i.e., they are I(1). This finding is significant because it allows us to proceed with the two-step Engle and Granger cointegration test to assess the long-term relationship between investment and human capital in the context of Uzbekistan.

***ENGLE-GRANGER COINTEGRATION TEST***

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t \quad \text{(Regression Equation 1)}$$

$$GDP_t = \beta_0 + \beta_1 * GovBudEx_t + \varepsilon_t \quad \text{(Regression Equation 1.1)}$$

$$GovBudEx_t = \beta_0 + \beta_1 * GDP_t + \varepsilon_t \quad \text{(Regression Equation 1.2)}$$

In the analysis, we employ two cointegration equations. In these equations, each variable is alternately treated as a dependent variable and an independent variable (as depicted in Regression equations 1.1 and 1.2). Following this, we calculate the residuals from these regression equations and conduct tests to determine their stationarity.

If the residuals derived from the Ordinary Least Squares (OLS) regression (referred to as εt -residuals) are found to be stationary at level I(0), we can infer the presence of a long-term relationship between the variables of investment and human capital. This indicates a cointegration between these variables, implying a stable, long-term equilibrium relationship.

The outcomes of the stationarity tests for the OLS residuals (εt -residuals) are presented in Table 3. This table provides crucial empirical evidence to affirm or refute our hypothesis of a long-term relationship between investment and human capital in the context of Uzbekistan.

**Table 3. Argumented Dickey-Fuller (ADF) stationary statistical test results of residuals**

| Variables | Augmented Dickey-Fuller test statistics | p-value | MacKinnon critic value (1%) | MacKinnon critic value (5%) | MacKinnon critic value (10%) | Results |
|---|---|---|---|---|---|---|
| Human capital | -3.345 | 0.0000 | -2.503 | -1.780 | -1.211 | stationary |
| Investment | -4.767 | 0.0000 | -2.503 | -1.780 | -1.211 | stationary |

Table 3 reveals that all residuals derived from the regression equations demonstrate stationarity at level I(0). This finding suggests a stable long-term relationship between government budget expenditures and the Gross Domestic Product (GDP) within the country. This cointegration underscores a steady equilibrium connection in the long run, despite any short-term fluctuations.

Following the establishment of this cointegration, the subsequent step is to utilize the Error Correction Model (ECM) to further analyze the relationship between government budget expenditures and GDP (as depicted in Regression Equation 2).

The ECM integrates short-term dynamics with long-term equilibrium without losing information about the short-term adjustments towards the long-term state. A key component of the ECM is the error correction term (ECT), which represents the speed at which the system corrects itself back to the equilibrium after a disturbance. The ECT, also known as the adjustment coefficient, should ideally be negative and statistically significant. This implies that any deviation from the long-term equilibrium will induce adjustments that drive the system back towards the equilibrium state. The magnitude and sign of the ECT indicate the speed and direction of this adjustment process, respectively.

Hence, our next step in the analysis will focus on the examination of the ECT within the ECM to offer further insights into the dynamics of the relationship between government budget expenditures and GDP.

***ERROR CORRECTION MODEL***

$$\Delta y_t = c + \beta_0 \Delta x_t + \gamma ect_{t-1} + u_t \quad \text{(Regression equation 2)}$$

The Error Correction Model (ECM) is a vital statistical tool used to investigate both the short-term and long-term dynamics between variables. After confirming the cointegration or long-term equilibrium relationship between investment and human capital in Uzbekistan through the Engle-Granger cointegration test, we can proceed with the ECM.

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**Table 4. Results of the Error Correction Model (ECM)**

**a) Human Capital**

| Equation | Coefficients | t-statistics | p-value |
|---|---|---|---|
| ΔHuman_capitalt =c+β0 ΔInvestmentt +γectt-1 +ut | | | |
| Constant (c) | 0.03 | 1.46 | 0.15 |
| ΔInvestmentt (β0) | 0.48 | 10.87 | 0.000 |
| ectt-1 (γ) | -0.28 | -3.54 | 0.001 |

$R^2$ =0.65, Adj. $R^2$ =0.33, DW=2.22, Prob (F-statistic)=0.000

**b) Investment**

| Equation | Coefficients | t-statistics | p-value |
|---|---|---|---|
| ΔInvestmentt =c+β0 ΔHuman_capitalt +γectt-1 +ut | | | |
| Constant (c) | 0.06 | 0.37 | 0.72 |
| ΔHuman_capitalt (β0) | 1.10 | 11.1 | 0.000 |
| ectt-1 (γ) | -0.90 | -7.97 | 0.000 |

$R^2$ =0.77, Adj. $R^2$ =0.73, DW=2.12, Prob (F-statistic)=0.000

## INTERPRETATION AND DISCUSSION OF RESULTS

The Error Correction Model (ECM) allows us to unpack the complex relationship between human capital and investment. Not only does it let us analyze the short-term fluctuations, but it also reveals the long-term equilibrium relationship and the speed at which our variables adjust back to this equilibrium after a disruption.

*Human Capital and Investment*

In our model, the first equation has human capital as the dependent variable. Here, the coefficient for investment (β0) is 0.48. This implies that for every 1% increase in investment, there is a corresponding 0.48% increase in human capital, all other things being equal. The statistical significance of this relationship is indicated by a high t-statistic (10.87) and a p-value that is practically zero.

This result signifies the critical role that investment plays in enhancing human capital, possibly through mechanisms such as improved educational infrastructure, enhanced training programs, better healthcare, and so forth. The development of human capital can potentially lead to an increase in productivity and growth. It's an indication that policy measures increasing investment, whether they're in education, health, or other sectors affecting human potential, can have significant and positive short-term effects on the human capital stock in Uzbekistan.

The coefficient of the error correction term (ectt-1), -0.28, is noteworthy as it tells us about the adjustment speed back to long-term equilibrium. The negative sign is theoretically consistent as it indicates that any deviation from the long-term equilibrium is counteracted. Specifically, 28% of the disequilibrium of the previous year's shock corrects itself annually. Although the adjustment speed might not be swift, there is a mechanism at work that ensures that any short-term shocks or imbalances are gradually corrected.

*Investment and Human Capital*

Turning to the second equation, with investment as the dependent variable, the human capital coefficient (β0) is 1.10. This means that a 1% increase in human capital results in an approximately 1.10% increase in investment in the short run, holding everything else constant. With a t-statistic of 11.1 and a p-value of 0.000, the relationship is highly statistically significant.

This indicates the importance of human capital in driving investment. As the level of human capital increases, the capacity for innovative thought and skilled labor also rises. This, in turn, can make the country a more attractive destination for both domestic and foreign investment. Increased education levels and improved health could signal a capable workforce, incentivizing companies to invest more.

The error correction term (ectt-1) in this equation is -0.90, suggesting a very rapid adjustment speed. Almost 90% of the disequilibrium from the long-term relationship is corrected within a year. This fast adjustment speed signifies the resilience of the investment to shocks with respect to changes in human capital.

## CONCLUSION

The exploration of the relationship between human capital and investment in Uzbekistan over the span of a decade (2010-2021) has yielded insightful findings. Utilizing the Error Correction Model (ECM), we have unearthed the nuanced dynamics of this economic relationship, the short-term impact of one variable on another, and the speed at which they return to a long-term equilibrium following a shock.

Our findings suggest a strong and statistically significant relationship between human capital and investment. This relationship appears to be bidirectional: investment positively impacts the development of human

capital, while the accumulation of human capital, in turn, attracts more investment. In both cases, the relationship is immediate, showing its influence within the same year of the change.

However, this immediate impact is not the only influence at play. Our analysis also highlighted the presence of a mechanism that ensures the system adjusts to long-term equilibrium after a disruption. This means that even when short-term shocks lead to disequilibrium between human capital and investment, there is an inherent economic 'correction' that gradually reverts the system back to equilibrium. The speed of this adjustment differs in each case, with the investment adjusting more quickly than human capital.

These findings provide crucial insights for policymakers in Uzbekistan. First, there's the confirmation of the mutual reinforcement between investment and human capital. This implies that strategies aimed at fostering economic growth and development should holistically consider these two facets. Investment in areas such as education and health sectors can lead to improvements in human capital, which in turn can make the country more attractive for further domestic and foreign investments.

Furthermore, the understanding that the economy has mechanisms to revert back to a long-term equilibrium following shocks can provide some level of assurance during policy implementation. It suggests that any negative short-term impacts could be potentially mitigated in the long run.

However, the disparity in the speed of adjustment between investment and human capital signifies that the effects of certain policies might take longer to become fully apparent. While this might require a degree of patience and long-term planning, it's crucial for ensuring the sustainability of growth and development initiatives.

In conclusion, the results of this study emphasize the importance of coordinated policy efforts aimed at both promoting investment and developing human capital. Such a balanced approach can contribute to creating a resilient and vibrant economic environment, setting Uzbekistan on a path to sustained and inclusive growth.

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