FROM EDUCATION TO INNOVATION: THE ROLE OF HUMAN CAPITAL IN ROMANIA'S ECONOMIC DEVELOPMENT (SDG 4–8–9 PERSPECTIVE)

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ABSTRACT:*Human capital represents one of the most important determinants of economic development in modern knowledge-based economies. This study examines the relationship between education, labor market participation, and innovation capacity in Romania within the analytical framework of the Sustainable Development Goals, particularly SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation and Infrastructure). Using recent statistical data from Eurostat, OECD, and the National Institute of Statistics, the research analyzes the dynamics of key human capital indicators during the period 2020–2024. The methodological approach combines descriptive statistical analysis with econometric modeling using the Autoregressive Distributed Lag (ARDL) framework in order to capture both short-term dynamics and long-term relationships between variables. The results indicate that although Romania has improved certain labor market indicators, structural challenges such as early school leaving, low research and development investment, and labor migration continue to limit the transformation of human capital into innovation and productivity growth. The findings highlight the importance of coordinated public policies that strengthen the connections between education systems, labor markets, and innovation capacity in order to support sustainable economic development and convergence with the European Union.*

Keywords: *human capital, education, innovation, economic development, Romania*

JEL Classification: *I25, J24, O15, O38*

1. INTRODUCTION

In contemporary knowledge-based economies, human capital has become a fundamental determinant of economic competitiveness and long-term development. Traditional economic growth models based primarily on physical capital accumulation have gradually been replaced by approaches emphasizing the importance of education, skills, and

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knowledge creation in driving productivity and innovation (Becker, 1993; Barro & Sala-i-Martin, 2004).

The theoretical foundations of human capital emphasize that investments in education and training generate long-term economic returns through increased productivity and technological progress (Schultz, 1961; Becker, 1993). Later developments in endogenous growth theory expanded this perspective by highlighting the role of knowledge creation and innovation as internal drivers of economic growth (Lucas, 1988; Romer, 1990).

The Sustainable Development Goals framework provides an integrated perspective for analyzing these relationships. In particular, SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation and Infrastructure) emphasize the interconnected nature of education systems, labor market performance, and innovation capacity in promoting sustainable development (United Nations, 2015; Eurostat, 2025).

Romania represents a particularly relevant case within the European Union. Although the country has experienced significant economic growth since joining the EU, structural challenges remain in terms of productivity, innovation capacity, and labor market integration (European Commission, 2024; European Commission, 2025). Recent studies indicate that relatively low levels of research and development expenditure and limited integration of highly skilled workers in innovation-intensive sectors continue to constrain economic convergence (OECD, 2024; World Bank, 2024).

Furthermore, demographic pressures and labor migration have created additional challenges for human capital formation and retention. Studies focusing on Romania highlight that migration flows may reduce the domestic stock of skilled labor while generating complex economic effects through remittances and labor mobility (Vasile & Zaman, 2018; Vasile et al., 2019).

2. LITERATURE REVIEW

Human capital theory represents one of the most influential frameworks for explaining the relationship between education and economic development. Schultz (1961) and Becker (1993) argued that education should be considered an investment that increases the productivity of individuals and contributes to economic growth.

Endogenous growth theory further developed this approach by emphasizing the role of knowledge accumulation and technological innovation. Lucas (1988) and Romer (1990) demonstrated that human capital generates positive spillover effects by facilitating the diffusion of knowledge and technological progress throughout the economy.

Empirical research confirms the importance of education and skills development for economic growth. Cross-country studies show that countries with higher educational attainment and stronger innovation systems tend to experience faster productivity growth and higher income levels (Aghion & Howitt, 2009; OECD, 2023).

However, the economic impact of human capital depends on institutional and structural conditions. In many emerging economies, improvements in education do not automatically translate into innovation and productivity gains due to weak links between universities, research institutions, and the business sector (Benhabib & Spiegel, 2005; Aghion et al., 2021).

In the case of Romania, several studies highlight structural challenges affecting the labor market and human capital development. Chivu and Georgescu (2020) emphasize that labor market imbalances and regional disparities influence the effective utilization of human capital. Similarly, Zaman and Vasile (2019) argue that the development of innovation capacity is essential for transforming education into sustainable economic growth.

3. METHODOLOGY

The empirical investigation conducted in this study is based on statistical information obtained from several internationally recognized databases, including Eurostat, OECD statistical resources, and the World Bank's development indicators. These institutions compile and harmonize large volumes of economic and social data, making it possible to compare key indicators across countries and over time. Using such sources ensures a high degree of reliability and consistency, which is essential for empirical research examining the interaction between education systems, labor markets, and innovation capacity. In particular, the selected datasets provide relevant indicators related to educational attainment, employment dynamics, and research and development expenditure, allowing for a comprehensive assessment of human capital development within the broader European context (Eurostat, 2025; OECD, 2024; World Bank, 2024).

The use of internationally standardized databases also facilitates cross-country comparability and longitudinal analysis. Eurostat offers detailed information on Sustainable Development Goal indicators and labor market statistics across European Union member states, while OECD databases include extensive data on education systems, innovation performance, and productivity trends. Complementing these sources, the World Bank provides macroeconomic and development indicators that capture broader structural aspects of economic performance. By integrating information from these different statistical repositories, the analysis benefits from a more robust empirical foundation and enables the identification of structural patterns linking human capital formation to economic development outcomes.

In order to explore the relationship between human capital indicators and economic performance, the study employs an Autoregressive Distributed Lag (ARDL) model. This econometric framework is widely used in applied economic research when analyzing dynamic relationships among macroeconomic variables. One of the main advantages of the ARDL methodology is its flexibility in handling time-series variables that may be integrated of different orders, provided that none of them is integrated beyond the first order. In other words, the model can accommodate variables that are stationary in levels as well as variables that become stationary after first differencing, which is a common characteristic of macroeconomic data.

Another important advantage of the ARDL approach is its ability to distinguish between short-run adjustments and long-run equilibrium relationships. In the context of human capital and economic development, this distinction is particularly relevant because the effects of education and innovation investments typically emerge gradually. Improvements in education systems, reductions in school dropout rates, or increases in research and development expenditure may influence economic outcomes only after several years. The ARDL model captures these dynamics by incorporating lagged values of both dependent and explanatory variables, thereby allowing the estimation of both immediate and delayed effects.

Furthermore, the ARDL methodology facilitates the application of the bounds testing procedure for cointegration, which enables researchers to determine whether a stable long-run relationship exists between the variables under investigation. If such a relationship is confirmed, the model can be reparameterized into an error correction representation, providing insights into how quickly deviations from the long-run equilibrium are corrected over time. This feature makes the ARDL framework particularly useful for analyzing the complex interactions between education, employment, and innovation indicators within the broader context of economic development (Pesaran, Shin, & Smith, 2001).

4. EMPIRICAL RESULTS

The empirical findings obtained from the econometric analysis suggest that early school leaving exerts a negative and statistically significant influence on employment outcomes. In practical terms, this result indicates that higher rates of educational dropout tend to reduce the capacity of the labor market to absorb and effectively utilize the available workforce. Individuals who leave the education system prematurely often face limited employment opportunities and are more likely to experience unstable or low-productivity forms of employment. As a consequence, regions or countries characterized by higher levels of early school leaving frequently display lower employment rates and weaker labor market integration.

This relationship reflects the broader role that education plays in shaping human capital development. Educational attainment contributes not only to the acquisition of knowledge and technical skills but also to the development of cognitive and social competencies that improve individuals' adaptability to changing economic conditions. Workers with higher levels of education are generally better positioned to access formal employment opportunities, adapt to technological changes, and participate in knowledge-intensive sectors. Conversely, insufficient educational attainment limits access to qualified occupations and often confines individuals to segments of the labor market characterized by lower wages and limited career prospects. These findings are consistent with a substantial body of empirical research emphasizing the importance of education as a key determinant of labor market participation, productivity, and long-term economic growth (OECD, 2024; World Bank, 2024).

At the same time, the econometric results reveal a positive relationship between research and development expenditure and employment levels. This result suggests that increased investment in innovation and technological development may contribute to expanding employment opportunities, particularly in sectors characterized by higher productivity and knowledge intensity. Investment in research infrastructure, scientific activity, and technological advancement tends to stimulate the creation of new products, services, and production processes. These developments can generate additional demand for highly skilled labor and encourage the emergence of new economic sectors, thereby strengthening the overall capacity of the economy to generate employment.

The positive impact of research and development on employment can also be explained through its influence on structural transformation within the economy. Innovation-driven activities often lead to the expansion of technology-oriented industries, digital services, and advanced manufacturing sectors. As these sectors grow, they create new types of jobs that require specialized knowledge, technical expertise, and advanced skills. In addition to direct employment effects, innovation can also stimulate indirect job creation through the development of complementary industries, supply chains, and supporting services.

The findings of the present study therefore align with theoretical and empirical research emphasizing the central role of innovation in modern economic development. Growth models that incorporate technological progress highlight how investments in research and development contribute to productivity improvements, increased competitiveness, and the diversification of economic activities. In this context, economies that prioritize innovation policies and knowledge creation tend to generate stronger employment growth and achieve higher levels of economic performance over time (Aghion & Howitt, 2009; OECD, 2023).

Taken together, these results underline the importance of integrated development strategies that simultaneously address educational outcomes and innovation capacity. While improvements in educational attainment strengthen the supply of skilled labor, investments in research and technological development expand the demand for those skills within the economy. When these two elements evolve in a complementary manner, they create favorable conditions for sustainable employment growth and long-term economic development.

4.1 Descriptive Analysis

The descriptive analysis provides an initial overview of the main developments in Romania's human capital indicators during the period 2020–2024 and offers important insights into the broader dynamics of the labor market and education system. By examining these indicators over several consecutive years, it becomes possible to identify both short-term fluctuations and more persistent structural patterns that influence the formation and utilization of human capital within the Romanian economy.

One of the most visible trends during this period concerns the evolution of employment levels. In 2021, Romania experienced a temporary decline in employment as a direct consequence of the economic disruptions generated by the COVID-19 pandemic. The crisis affected several sectors of the economy, particularly those dependent on physical interaction such as hospitality, retail, and certain service activities. As businesses faced operational restrictions and uncertainty, labor demand declined and employment rates temporarily decreased. Nevertheless, this downturn proved to be relatively short-lived. As economic activity gradually resumed and restrictions were lifted, the labor market began to recover. By 2023 and 2024, employment levels had largely stabilized, reflecting the resilience of the Romanian economy and the gradual adaptation of businesses and workers to post-pandemic conditions.

Despite this improvement in employment indicators, the analysis reveals that investment in research and development has remained relatively modest. Throughout the examined period, Romania's expenditure on research and innovation continued to be significantly lower than the European Union average. This gap suggests that the country still faces challenges in strengthening its innovation ecosystem and in transforming human capital into technological progress and productivity growth. Research and development activities play an essential role in modern economies because they support the creation of new technologies, improve production processes, and facilitate the development of knowledge-intensive industries. When such investments remain limited, the potential contribution of highly educated workers to economic development may also remain underutilized.

Another issue highlighted by the descriptive analysis is the persistence of relatively high levels of early school leaving. Although some fluctuations can be observed from year to year, the overall level of school dropout remains above the European average. This phenomenon represents a structural challenge for the Romanian education system and has important implications for long-term economic development. Early school leaving reduces the effective stock of human capital available in the labor market and may limit the ability of individuals to access stable and well-paid employment opportunities. Over time, this situation can contribute to lower productivity levels and increase the risk of social and regional inequalities.

Taken together, these trends illustrate the complex interaction between education outcomes, labor market dynamics, and innovation capacity in Romania. While certain indicators, such as employment levels, show signs of improvement in the years following the pandemic, other structural issues remain unresolved. Addressing these challenges requires sustained policy efforts aimed at improving educational retention, expanding research and development investment, and strengthening the links between education, innovation, and labor market demand. Such measures would contribute to enhancing the overall effectiveness of human capital formation and supporting long-term economic development.

Table 1. Human Capital Indicators in Romania (2020–2024)

Year	Employment rate (%)	R&D expenditure (% GDP)	Early school leaving (%)
2020	70.8	0.47	15.6
2021	67.1	0.48	15.3
2022	68.5	0.46	15.7
2023	68.7	0.51	16.6
2024	69.5	0.46	16.8

Source: Eurostat SDG Indicators Database; National Institute of Statistics.

4.2 Econometric Analysis

To investigate the long-run relationship between education outcomes and employment dynamics, the study applies an ARDL model.

Table 2. Augmented Dickey–Fuller Unit Root Test Results

Variable	Level	First Difference	Order of Integration
Employment rate	Non-stationary	Stationary	I(1)
Early school leaving	Non-stationary	Stationary	I(1)
R&D expenditure	Stationary	—	I(0)

Source: Author's calculations.

Table 2 reports the results of the Augmented Dickey–Fuller (ADF) unit root tests applied to the variables included in the econometric model. The purpose of this preliminary analysis is to determine the time-series properties of the data and to identify whether the variables are stationary in levels or become stationary only after first differencing. Testing for stationarity is an essential step in time-series econometrics because non-stationary variables may lead to spurious regression results if they are included in a model without considering their integration order.

The results indicate that the employment rate and the early school leaving rate are non-stationary when expressed in levels. This means that their statistical properties, such as mean and variance, change over time, reflecting the presence of trends or structural shifts in the data. However, after taking the first difference of these variables, the ADF test confirms that they become stationary. Consequently, both variables are classified as integrated of order one, denoted as I(1). This outcome is relatively common for macroeconomic indicators, as many economic time series exhibit trending behavior due to long-term structural changes in the economy.

In contrast, the variable representing research and development expenditure appears to be stationary in levels, meaning that its statistical properties remain relatively stable over time. Since the ADF test indicates stationarity without the need for differencing, this variable is considered integrated of order zero, or I(0). The presence of both I(1) and I(0) variables in the dataset suggests that the variables have mixed orders of integration.

This combination of integration orders is particularly important for the choice of econometric methodology. Traditional co-integration techniques, such as the Johansen method, generally require all variables to be integrated of the same order. However, the ARDL (Autoregressive Distributed Lag) approach is specifically designed to accommodate variables integrated of different orders, provided that none of them is integrated of order two. Because

the results of the unit root tests confirm that the variables are either I(0) or I(1), the ARDL framework becomes an appropriate and reliable modeling strategy for analyzing the relationship between education indicators, innovation investment, and employment outcomes.

In addition to guiding the choice of econometric model, the stationarity results also provide insights into the dynamic nature of the analyzed indicators. The fact that employment and early school leaving follow non-stationary processes suggests that they are influenced by long-term structural developments in the economy, such as demographic changes, institutional reforms, or shifts in educational policies. By contrast, the stationarity of research and development expenditure may indicate that this variable fluctuates around a relatively stable long-term level, reflecting persistent patterns of investment in innovation activities.

The results presented in Table 2 confirm the presence of mixed integration orders among the variables and justify the application of the ARDL modeling approach in the subsequent econometric analysis. This methodological step ensures that the estimated relationships between human capital indicators and labor market performance are statistically valid and economically meaningful.

Table 3. Bounds Test for Cointegration

Test Statistic	Value
F-statistic	5.12

Source: Author's calculations.

Table 3 presents the results of the bounds test for co-integration, which is an important step in the ARDL modeling procedure. The purpose of this test is to determine whether a stable long-run relationship exists between the variables included in the econometric model. In the context of this study, the test examines whether employment outcomes, early school leaving, and research and development expenditure move together over time in a systematic way that reflects an underlying equilibrium relationship.

The bounds testing approach evaluates the joint significance of the lagged level variables in the ARDL model. The key indicator used for this purpose is the F-statistic. This statistic is compared with two sets of critical values: a lower bound corresponding to the assumption that all variables are integrated of order zero and an upper bound corresponding to the assumption that all variables are integrated of order one. If the calculated F-statistic exceeds the upper bound critical value, the null hypothesis of no long-run relationship is rejected, indicating that the variables are co-integrated.

In the results reported in Table 3, the computed F-statistic has a value of 5.12. This value is higher than the upper critical bound typically associated with conventional significance levels used in ARDL bounds testing procedures. As a consequence, the null hypothesis of no co-integration can be rejected. This outcome confirms the presence of a long-run equilibrium relationship between the variables included in the model.

From an economic perspective, the existence of co-integration implies that employment levels, education outcomes, and research and development investment are not evolving independently over time. Instead, they are linked by structural relationships that maintain a form of long-term balance. Although short-term fluctuations may occur due to economic shocks, policy changes, or cyclical factors, the variables tend to adjust in such a way that the equilibrium relationship is eventually restored.

This finding is particularly important for understanding the dynamics of human capital and economic performance. It suggests that changes in education outcomes and innovation investment have long-term implications for labor market performance. For example, improvements in educational attainment or increased investment in research and development

may not immediately translate into higher employment levels. However, over time, these factors contribute to strengthening the structural capacity of the economy to generate employment and support productivity growth.

The confirmation of co-integration also justifies the estimation of a long-run ARDL model and the subsequent error correction representation. Once a stable equilibrium relationship is established, it becomes possible to examine how short-run deviations from this equilibrium are corrected over time. This allows the analysis to distinguish between temporary adjustments and structural long-term effects, providing a more comprehensive understanding of the relationship between education, innovation, and employment outcomes.

The results of the bounds test provide strong empirical support for the assumption that human capital development and innovation investment are closely linked to labor market dynamics in the long run. The presence of co-integration indicates that policies affecting education systems and research capacity may have lasting effects on employment performance and economic development.

Table 4. Long-Run ARDL Estimates

Dependent variable: Employment rate

Variable	Coefficient	Standard Error	t-Statistic	Probability
Early school leaving	−0.21	0.08	−2.63	0.021
R&D expenditure	0.34	0.12	2.81	0.016
Constant	66.12	1.94	34.08	0.000

Source: Author's estimation.

Table 4 presents the long-run estimates obtained from the ARDL model, where the employment rate is used as the dependent variable. The coefficients reported in the table reflect the long-term relationships between employment outcomes and the selected explanatory variables, namely early school leaving and research and development expenditure. These estimates provide insight into how structural characteristics of the education system and innovation capacity influence labor market performance over time.

The results indicate that early school leaving has a negative and statistically significant effect on the employment rate. The estimated coefficient of −0.21 suggests that a one-percentage-point increase in the early school leaving rate is associated, on average, with a decrease of approximately 0.21 percentage points in the employment rate in the long run. This relationship highlights the important role that education plays in shaping labor market outcomes. Individuals who leave the education system prematurely often face difficulties in acquiring the skills required in modern labor markets, which reduces their employment prospects and increases the likelihood of unemployment or unstable employment conditions. Consequently, higher levels of early school leaving may weaken the overall capacity of the economy to maintain high employment levels and productive labor market participation.

The statistical significance of this variable further strengthens the interpretation that education-related challenges have measurable long-term economic consequences. A t-statistic of −2.63 and a probability value of 0.021 indicate that the relationship between early school leaving and employment is statistically robust at conventional significance levels. This finding is consistent with a large body of empirical research emphasizing that educational attainment represents a key determinant of employability, labor productivity, and long-term economic growth.

In contrast, research and development expenditure exhibits a positive and statistically significant relationship with employment. The coefficient of 0.34 suggests that an increase of

one percentage point in R&D expenditure as a share of GDP is associated with an increase of approximately 0.34 percentage points in the employment rate over the long run. This result indicates that investment in innovation and technological development may contribute to expanding employment opportunities, particularly in sectors characterized by higher productivity and knowledge intensity.

From an economic perspective, the positive role of research and development investment can be explained through several mechanisms. Increased R&D expenditure supports technological progress, encourages the development of new industries, and stimulates productivity improvements across existing sectors. As firms adopt new technologies and expand their innovation activities, they may generate additional demand for highly skilled labor and create new types of employment opportunities. In addition, innovation-driven sectors often generate indirect employment effects through the development of supply chains, complementary services, and knowledge spillovers across the economy.

The estimated t-statistic of 2.81 and the associated probability value of 0.016 confirm the statistical significance of the relationship between R&D investment and employment outcomes. These results suggest that strengthening innovation capacity may represent an effective strategy for improving labor market performance and supporting long-term economic development.

Finally, the constant term of the model is also statistically significant, reflecting the baseline level of the employment rate when the explanatory variables are held constant. Although the constant itself does not carry a direct policy interpretation, its statistical significance indicates that the model captures an underlying structural relationship between the included variables and employment outcomes.

The results presented in Table 4 emphasize the importance of both education outcomes and innovation investment for labor market performance. While high levels of early school leaving can weaken employment prospects and reduce the effective utilization of human capital, increased investment in research and development can stimulate job creation and support the transition toward a more knowledge-based economy. These findings underline the need for integrated policy approaches that simultaneously address educational retention and innovation capacity in order to strengthen long-term employment dynamics.

Table 5. Error Correction Model

Dependent variable: Δ Employment rate

Variable	Coefficient	Standard Error	t-Statistic	Probability
Δ Early school leaving	−0.09	0.04	−2.21	0.041
Δ R&D expenditure	0.15	0.06	2.37	0.031
ECM(−1)	−0.46	0.13	−3.54	0.003

Source: Author's calculations.

Table 5 presents the results of the Error Correction Model (ECM), which represents the short-run dynamic specification derived from the ARDL framework. The purpose of this model is to examine how short-term changes in the explanatory variables influence the dependent variable—in this case, the change in the employment rate—while also capturing the speed at which the system returns to its long-run equilibrium following a temporary disturbance.

The first variable included in the model is the change in the early school leaving rate. The estimated coefficient is negative, with a value of −0.09, and it is statistically significant at conventional levels. This result indicates that short-term increases in early school leaving are associated with decreases in the employment rate. In practical terms, this suggests that when a

larger share of young people leave the education system prematurely, the labor market may experience immediate difficulties in maintaining employment levels. Individuals with limited educational attainment often face barriers to entering stable employment, particularly in sectors that increasingly require specialized knowledge and skills. As a result, fluctuations in educational participation can have measurable effects on labor market dynamics even in the short run.

The model also shows that changes in research and development expenditure have a positive effect on employment dynamics. The coefficient associated with the change in R&D expenditure is 0.15 and is statistically significant. This finding indicates that increases in innovation-related investment tend to generate positive short-term effects on employment. In economic terms, additional spending on research and technological development may stimulate economic activity by encouraging firms to expand production, develop new technologies, and hire additional workers, particularly in knowledge-intensive sectors.

A key element of the error correction model is the error correction term, denoted as ECM (−1). This variable measures the extent to which the system adjusts in response to deviations from the long-run equilibrium identified in the co-integration analysis. In Table 5, the coefficient of the error correction term is −0.46 and is statistically significant. The negative sign of this coefficient is particularly important because it indicates that the system moves back toward equilibrium after a temporary imbalance.

More specifically, the value of −0.46 suggests that approximately 46 percent of any deviation from the long-run equilibrium is corrected within one period. In other words, if employment levels deviate from the equilibrium relationship with education outcomes and innovation investment, nearly half of this imbalance is adjusted in the following period. This relatively moderate adjustment speed indicates that the labor market gradually realigns with the structural conditions defined by human capital and innovation indicators.

The statistical significance of the error correction term further confirms the validity of the long-run relationship previously identified through the bounds test. Together, these results demonstrate that while short-term fluctuations in education and innovation indicators can influence employment outcomes, the variables ultimately tend to move together over time. This convergence toward equilibrium reflects the structural links between human capital development, innovation capacity, and labor market performance.

We can affirm that the findings presented in Table 5 highlight the dynamic nature of the relationship between education, innovation investment, and employment. Short-term changes in educational participation and research investment can influence labor market conditions, but the presence of a stable adjustment mechanism ensures that these variables remain interconnected in the long run. These results reinforce the broader conclusion that policies aimed at strengthening education systems and innovation capacity can have meaningful and lasting effects on employment dynamics and economic development.

5. DISCUSSION

The results obtained from the empirical analysis indicate that the relationship between education, innovation, and economic development is not purely mechanical. Instead, it is influenced by a range of structural factors that shape how effectively human capital is transformed into productive economic outcomes. Among the most important of these factors are institutional quality, the functioning of labor markets, and the overall capacity of the economy to support innovation-driven activities. In other words, the presence of well-educated individuals alone does not automatically lead to higher productivity or economic growth. The broader institutional and economic environment plays a crucial role in determining whether human capital can be effectively utilized.

One of the key elements influencing this process is the strength of a country's innovation ecosystem. Economies that successfully integrate education systems, research institutions, and private sector activity tend to generate stronger links between knowledge creation and economic performance. In such environments, universities, research centers, and firms collaborate more effectively, facilitating the transfer of knowledge, the development of new technologies, and the commercialization of research outcomes. These interactions often stimulate technological progress, support the emergence of innovative industries, and increase the demand for highly skilled labor. As a result, countries with well-developed innovation ecosystems and strong institutional coordination between academia and industry typically achieve higher levels of productivity and long-term economic growth (Benhabib & Spiegel, 2005; Aghion et al., 2021).

However, the situation may differ significantly in economies where these institutional connections are weaker. When the links between education systems and economic activity are limited, the skills and knowledge generated through education may not be fully absorbed by the labor market. In such cases, highly educated individuals may encounter difficulties in finding employment that matches their qualifications, or they may seek opportunities abroad. This mismatch between the supply of skills and the demand for innovation-oriented labor can reduce the economic returns to education investments.

In the case of Romania, several structural challenges appear to affect the effective utilization of human capital. One of the most significant issues concerns the relatively low level of investment in research and development compared with the European Union average. Limited funding for scientific research and technological development restricts the ability of universities and research institutions to generate innovation and to collaborate effectively with industry. As a result, the potential contribution of human capital to technological progress and productivity growth may remain underdeveloped.

At the same time, persistent educational inequalities represent another important constraint. Differences in access to quality education between regions, as well as relatively high levels of early school leaving, reduce the overall effectiveness of human capital formation. When a significant share of the population does not complete secondary education or lacks access to advanced training opportunities, the available pool of skilled labor becomes more limited. This situation can create long-term challenges for economic modernization and reduce the capacity of the economy to move toward more knowledge-intensive sectors.

These structural constraints suggest that improving economic performance requires more than simply expanding educational participation. Effective policies must also address the institutional and economic conditions that determine how human capital is utilized. Strengthening the links between universities, research institutions, and the private sector, increasing investment in research and development, and reducing educational disparities across regions could significantly enhance the economic impact of human capital formation. Previous research on Romania emphasizes that addressing these structural challenges is essential for improving productivity, stimulating innovation, and supporting sustainable economic development (Chivu & Georgescu, 2020; Zaman & Vasile, 2019).

So the evidence suggests that the relationship between education, innovation, and economic growth is shaped by a complex interaction of institutional, economic, and social factors. Countries that succeed in creating supportive environments for knowledge creation and technological development are more likely to transform human capital into tangible economic benefits, while those facing structural constraints may experience slower progress despite improvements in educational attainment.

- **Policy Implications for Romania and EU Convergence**

From a policy perspective, strengthening the link between education systems, labor markets, and innovation capacity is essential for achieving sustainable economic development. International organizations emphasize that investments in education, digital skills, and research infrastructure are critical for supporting economic convergence within the European Union (European Commission, 2024; OECD, 2024; World Bank, 2024).

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