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The Impact of Human Capital on the Competitiveness of Central and Eastern European Countries in the Context of Institutional and Macroeconomic Determinants

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Abstract

The study analyses the determinants of national competitiveness in Central and Eastern Europe, with a primary focus on the role of human capital. The primary objective of this study is to identify disparities in the levels of competitiveness and human capital between the V4 countries and other countries in the Central and Eastern European region. The subsequent objective is to identify the impact of year-on-year changes in human capital on competitiveness across the entire region under study in the context of other key macroeconomic and institutional determinants. In the comparative section of the study, a panel regression model with random effects and robust standard errors according to Arellano was utilized. Conversely, a model with fixed effects and robust standard errors (PCSE), employing first differences of variables with a two-year lag, was employed to identify the determinants of competitiveness. The findings of the comparative analysis demonstrated the presence of statistically significant disparities between the V4 countries and other countries in the Central and Eastern European region, exclusively in the domain of human capital. The level of competitiveness is similar across the entire region. The findings of the panel regression analysis demonstrated that year-on-year changes in the quality of human capital do not exert a statistically significant impact on the WCI with a two-year lag. This finding contradicts the theoretical assumptions that underpin the WCI. The predominant factors influencing competitiveness were identified as the control variables of government effectiveness, the inflation rate, and the level of gross debt. The originality of the study lies primarily in the use of a comprehensive WCI instead of partial competitiveness indicators and in the integration of multiple institutional and macroeconomic aspects into the model, thereby filling an existing gap in literature.

Keywords: competitiveness; human capital; Central and Eastern European countries



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1. Introduction

In the contemporary global context, European economies confront formidable challenges associated with the climate crisis, the accelerated development of artificial intelligence, and persistent geopolitical tensions. These factors exert a direct influence on their economic stability and resilience. In this context, the ability to sustain Europe's role as a catalyst for sustainable growth and innovation is contingent on the effective utilization of human capital.

The extant literature examining the relationship between human capital and national competitiveness ([Bağ et al., 2022](#); [Debrah et al., 2018](#); [Gaona & Vásquez, 2021](#); [Leite &](#)

[Cardoso, 2023](#)) emphasizes that a country's ability to adapt to technological changes and external shocks depends primarily on the quality of the workforce, its education, and skills. However, this issue remains under-researched in the context of the Central and Eastern European region and exhibits several significant research gaps.

Existing research frequently focuses on the European Union as a whole ([Marčeta & Bojnec, 2023a, 2023b](#)) or on comparing old and new member states ([Tijanić & Obadić, 2015](#)). These broad approaches tend to overlook specific regional characteristics and often implicitly regard Central and Eastern Europe as a relatively homogeneous whole ([Guadagno et al., 2024](#)). In contrast to the majority of Western European countries, the economies of Central and Eastern European countries underwent a transformation from centrally planned to market economies after 1989. This transition had a substantial impact on their institutional environment, labor market structure, and human capital development. Concurrently, the countries in this region exhibit a heightened reliance on foreign investment, an export-oriented economic structure, and pervasive disparities in the quality of institutions and innovation performance. Additionally, the CEE region itself cannot be regarded as homogeneous due to the substantial structural disparities between the economies of the V4 countries and those of the other countries in the region ([Nölke & Vliegenthart, 2009](#)). The extant literature suggests that the mechanisms through which human capital exerts its impact on competitiveness are influenced not only by the quality of institutions but also by the broader macroeconomic environment ([Bobetko et al., 2017](#)). This broader context has frequently been overlooked in previous studies. This finding suggests that macroeconomic environment may be an important factor that has often been overlooked in previous studies. Moreover, certain studies have attempted to reduce the complexity of competitiveness to gross domestic product or labor productivity ([Pelinescu, 2015](#)), yet this simplification does not fully capture the multidimensional nature of competitiveness.

This study addresses the aforementioned shortcomings and establishes two related objectives as its primary goals: first, to identify disparities in the levels of competitiveness and human capital between the V4 countries and other countries in the Central and Eastern European region; and second, to subsequently identify the impact of year-on-year changes in human capital on competitiveness across the entire region under study in the context of other key macroeconomic and institutional determinants.

To achieve these objectives, a panel regression model with random effects is employed, with robust standard errors estimated via the Arellano estimator. Additionally, a fixed effects model with robust standard errors, corrected using PCSE, is used. These models are estimated for eleven Central and Eastern European countries over the period 2007–2023. The impact of independent variables on competitiveness is assessed with a two-year time lag to capture the dynamics of the effects. The concept of competitiveness is operationalized in this study through the utilization of the World Competitiveness Index, while the pivotal indicator of human capital is derived from an index within the Penn World Table database. This database integrates years of schooling with the rate of return on education, thereby offering a comprehensive perspective on human capital development. In order to ensure the robustness of the estimates, the panel regression model with fixed effects is employed to control for the impact of other variables on competitiveness. These additional variables include research and development expenditure, trade openness, government effectiveness, political stability, gross debt, inflation, and labor productivity. By employing this comprehensive approach, the study addresses an identified lacuna in the extant literature and provides a more profound insight into the structural factors influencing the economic development of Central and Eastern European countries.

The text of the study is divided into several sections. The initial section is dedicated to the theoretical framework underlying the subject of inquiry. Subsequent sections are

dedicated to the description of the methodology employed and the interpretation of the results. In the Section 5, the author's own findings are compared with existing theoretical studies. The study's findings are synthesized in its conclusion, which also includes recommendations for the formulation of economic policies.

2. Theoretical Framework

The concept of competitiveness is currently one of the most salient and extensively discussed concepts in professional literature. It represents a significant area of interest not only for European Union economic policymakers but also for the academic community and practitioners in the business world. This heightened interest is rooted in the perception of competitiveness as a fundamental prerequisite for long-term economic growth, prosperity, and sustainable development. Additionally, the concept of a nation's competitiveness must be comprehended as a complex and multidimensional construct, which cannot be reduced solely to economic growth or export performance.

The foundational principles of the contemporary concept of competitiveness were established by Michael E. Porter, who underscored the significance of productivity, industry structure, and competitive strategies as pivotal determinants of economic performance. He was among the first authors to methodically develop the concept of competitiveness at the international level, defining it as a nation's ability to maintain or increase the productivity of labor and capital relative to other economies (Porter, 1980). His approach laid the foundations for modern competitiveness theory, which focuses on identifying the sources and factors influencing competitiveness in a globalized economy. Subsequent developments in theoretical approaches have expanded this concept to include a broader spectrum of determinants, particularly institutional, macroeconomic, technological, and knowledge-based factors. Additionally, special attention has gradually shifted to the regional level.

The concept of regional competitiveness acknowledges that economic performance is influenced not only at the level of national economies, but also through interactions between regions that vary in their structure, resources, and institutional environment. Huovari et al. (2000) underscore the necessity to comprehend competitiveness within a comprehensive framework that extends beyond the mere quantification of outcomes, encompassing the prerequisites for development and the regional system's capacity to function efficaciously. This approach is further developed by Palinchak et al. (2021), who conceptualize a region's competitiveness as the result of the effective organization of economic processes, adequate infrastructure, a functional institutional environment, and the active engagement of market actors. However, a region's competitiveness is not solely determined by production indicators (Wokoun, 2016). It is also influenced by the structure of production, production capacities, innovation characteristics, the quality of the workforce, and the settlement structure. Huggins et al. (2013) also underscore the pivotal role of firms as the principal catalysts of knowledge creation, innovation, and job creation. They emphasize that a region's competitiveness is predominantly contingent on the presence of conditions that facilitate firms' successful competition in both domestic and international markets. A region that fosters a competitive environment is often attractive to investors and entrepreneurs, facilitating the transfer of knowledge and expertise (Wokoun, 2016). In a similar vein, Borovitskaya et al. (2019) conceptualize regional competitiveness as a region's capacity to prevail in competitive scenarios with other regions. The pivotal factors contributing to this competitiveness include innovation activity, population growth, and the cultivation of intellectual potential. These factors also contribute to increasing investment attractiveness and the quality of life for the population. The complexity of the concept is further substantiated by Kouskoura et al. (2024), who identified a comprehensive

range of competitiveness domains, encompassing the economy, the labor market, social inclusion, education, infrastructure, technology, and innovation.

In accordance with the theoretical approaches to understanding competitiveness outlined in the works of authors such as Porter (1980), Begg (1999), Annoni and Dijkstra (2019), Huggins et al. (2013), and Wokoun (2016), competitiveness can be viewed as the result of the interaction of several interconnected dimensions. In professional literature, competitiveness is identified as being determined by a variety of factors, including economic performance and productivity, the quality of the institutional and innovation environment, and the level of human capital, as well as the quality of life of the population. The prevailing theoretical frameworks interpret competitiveness as the capacity of the economy to establish and uphold conditions conducive to long-term productivity growth, escalating living standards, the cultivation of innovative performance, and the establishment of a superior institutional environment. In this context, it can be defined as an economy's ability to achieve high productivity, innovative performance, and economic prosperity over the long term. A fundamental prerequisite for this capacity is the presence of highly skilled individuals, the extent of which is primarily reflected in the population's educational attainment, competencies, physical well-being, and capacity for innovation. It is precisely these characteristics that enable economies to respond effectively to technological changes and maintain their competitiveness over the long term in a globalized economy.

In empirical research, national competitiveness is measured using several composite indicators, including the Global Competitiveness Index (GCI), the Regional Competitiveness Index (RCI) and the World Competitiveness Index (WCI). The present study employs the World Competitiveness Index developed by the International Institute for Management Development (IMD), as it captures competitiveness through a broad set of economic, institutional and business-related dimensions. The index employs a multifaceted approach to evaluate competitiveness, comprising four core pillars: economic performance, government effectiveness, business efficiency and infrastructure. Given its comprehensive coverage of economic, institutional and business-related factors, WCI provides a suitable framework for assessing the long-term competitiveness of national economies.

From a theoretical perspective, the determinants of competitiveness should not be viewed as isolated factors. Human capital contributes to competitiveness primarily through its impact on labor productivity, innovation capacity and the ability of firms and economies to absorb new technologies. The strength of these effects is conditioned by the quality of institutions, which shape the business environment, investment incentives and the effectiveness of public policies. Macroeconomic stability provides the conditions under which these mechanisms can operate effectively. Recent studies likewise emphasize that national competitiveness is shaped by the interaction of human capital, institutional quality, innovation capacity and macroeconomic conditions rather than by the isolated effect of individual determinants (Marčeta & Bojnec, 2023b; Guadagno et al., 2024; Kordos, 2024). Competitiveness therefore emerges from the interaction of human capital, institutional quality and macroeconomic conditions, which jointly shape the capacity of economies to achieve sustained productivity growth, innovation and long-term prosperity (Acemoglu & Autor, 2011; Hanushek & Woessmann, 2012; Acemoglu & Robinson, 2012; Annoni & Dijkstra, 2019). In this framework, human capital can be viewed as a foundational resource, while institutional quality and macroeconomic stability determine the extent to which its potential is transformed into productivity gains, innovation and competitive performance.

Competitiveness is a pivotal factor in Central and Eastern European (CEE) countries, influencing their economic growth, their capacity to attract foreign investment, and their successful integration into global markets. The countries of this region are united by a shared historical experience of post-communist transformation, as well as the process

of integration into the European Union and gradual economic convergence with more developed member states. At present, the CEE countries that are members of the European Union are Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, and the Baltic states—Estonia, Lithuania, and Latvia. Collectively, these nations comprise a substantial socio-economic region, with a population exceeding 100 million. Despite the absence of an administratively defined unit, the CEE region is frequently conceptualized in academic discourse as an analytical macroregion employed for comparative purposes. This is due to its demonstration of analogous historical, economic, and institutional characteristics (Gorzelak & Smętkowski, 2010; Pellényi, 2020; Holobiuc, 2021; Török, 2025; Rácz et al., 2025). The specific nature of competitiveness in this region is determined by a combination of common features and a distinct developmental trajectory when compared to the traditional economies of Western Europe.

An examination of competitiveness in CEE countries, or more broadly in the region of Southeast Europe, therefore assumes particular significance. These economies are distinguished by significant internal heterogeneity, which is also evident in variations in their competitive performance. Rusu and Roman (2018) underscore the significance of macroeconomic, institutional, and development factors in shaping the competitiveness of CEE countries, while emphasizing the necessity to analyze this region as a distinct analytical unit. However, within the region, the presence of groups of countries with distinct development trajectories and models of capitalism can also be identified. The Visegrad Four (V4) countries occupy a distinctive position, demonstrating superior economic performance, institutional quality, and overall competitiveness across multiple indicators. Nölke and Vliegenthart (2009) have observed that in the aftermath of the transition, these countries have become increasingly integrated into global production chains, primarily through the medium of foreign direct investment. Bohle and Greskovits (2012) also emphasize the presence of discrete models of capitalism within the region, delineating between the neoliberal model of the Baltic states, the established neoliberal model of the V4 countries, and the neocorporatist model exemplified by Slovenia, as well as the southeastern economies of Romania, Bulgaria, and Croatia.

These discrepancies underscore the intricacy and heterogeneity of competitiveness models within the CEE region, emphasizing the necessity for a more profound examination of the determinants of competitiveness. This examination must account for the distinct economic, institutional, and historical contexts that characterize individual countries. The competitiveness of Central and Eastern European countries is the result of the interaction of several interrelated factors, among which macroeconomic conditions, the quality of the institutional environment, and the structural characteristics of economies play a significant role. However, recent academic literature has placed increasing emphasis on the importance of human capital as one of the key determinants of long-term competitiveness.

The specific focus on Central and Eastern Europe is theoretically relevant because the determinants of competitiveness may operate differently in transforming economies than in more mature Western European economies. While many studies examine competitiveness at the level of the European Union as a whole, such an approach may conceal important differences in historical development, institutional quality, innovation systems and labor market structures. The countries of Central and Eastern Europe share a common legacy of economic transition, but they differ substantially in their ability to transform human capital into productivity growth, innovation performance and competitive advantage (Campos & Coricelli, 2002; Fidrmuc, 2003; Nölke & Vliegenthart, 2009; Bohle & Greskovits, 2012). Consequently, findings derived from broader European samples may not be fully transferable to the CEE context (Rusu & Roman, 2018). Examining this region separately therefore provides an opportunity to better understand how human capital,

institutional quality and macroeconomic conditions interact in economies that continue to experience the long-term effects of post-transition development and economic convergence. The quality of the workforce, the level of education, skills, and health of the population are essential prerequisites for building a knowledge-based economy and strengthening countries' competitive positions. In professional literature, human capital is regarded as a pivotal factor in determining competitiveness. This is due to its influence on various aspects of economic performance, including labor productivity, adaptability to technological advances, innovation capacity, and the quality of decision-making processes within the economy. [Mulliqli et al. \(2018\)](#) conducted an empirical examination of the impact of human capital on international competitiveness in Europe, with a particular focus on the transition economies of Central and Eastern Europe. Their analysis employed longitudinal data from 27 European economies during the period 1995–2010, thereby confirming a positive relationship between the level of the workforce's educational structure and competitiveness. This research provides a significant theoretical and empirical basis for the assumption that human capital can be a substantial source of competitive advantage for CEE countries. From a theoretical perspective, the influence of human capital on competitiveness is expected to operate through several interconnected channels. A more educated and skilled workforce enhances labor productivity, facilitates the adoption and diffusion of new technologies, strengthens innovation capacity and improves the ability of firms to adapt to changing market conditions. These mechanisms contribute to higher economic performance and, ultimately, to stronger international competitiveness. However, the effects of human capital are often indirect and may materialize only over time, as they depend on complementary factors such as institutional quality, innovation systems and the broader macroeconomic environment. [Hanushek and Woessmann \(2012\)](#) and [Kordos \(2024\)](#) emphasize that educational quality, as measured by cognitive skills, is a critical factor in economic performance, surpassing the importance of quantity. This distinction is also relevant from a measurement perspective. Although composite indicators such as the Human Capital Index of the Penn World Table provide a widely used proxy for human capital, they primarily capture the educational dimension of human capital and may not fully reflect other important aspects discussed in the literature, such as innovation capability, adaptability, workforce quality or the ability to absorb and utilize new technologies. Consequently, empirical estimates based on aggregate human capital indicators may capture only part of the broader theoretical concept, which may contribute to weaker or statistically insignificant relationships between human capital and competitiveness. This limitation is also important for interpreting empirical results, as the effects of human capital may be manifested indirectly through productivity, innovation or the absorptive capacity of the economy rather than through a direct impact on competitiveness. In a similar way, [Acemoglu and Autor \(2011\)](#) emphasize the significance of skills, technology, and labor market conditions, proposing that merely increasing the level of human capital may not inherently result in greater competitiveness without an adequate technological and institutional environment. Within the context of Central and Eastern European countries, it can be posited that the impact of human capital on competitiveness manifests itself indirectly and with a certain time lag through productivity, innovation performance, and the economy's capacity to absorb new technologies. In accordance with prevailing theoretical frameworks, competitiveness can be conceptualized as the outcome of the interplay among human capital, the macroeconomic environment, the quality of institutions, and a nation's innovation capacity. Consequently, these factors establish the foundation for productivity growth, innovation development, and long-term economic prosperity. The economies of CEE countries have undergone a transition toward a market economy, and their competitive model has long been based primarily on cost advantages and the inflow of foreign investment. This strategy is no

longer adequate in the current global economic environment, which is characterized by interconnected macroeconomic and institutional factors that influence competitiveness. Macroeconomic stability is a fundamental prerequisite for competitiveness. It is evident that factors such as inflation, public debt, and overall fiscal stability exert a significant influence on various economic variables. These variables include the cost of doing business, investment decisions, and the confidence of economic agents. In the context of CEE countries, this dimension assumes particular importance, as these are open economies susceptible to external shocks, energy price fluctuations, changes in interest rates, and fiscal tensions. Research focused on the determinants of competitiveness in both the EU and CEE therefore repeatedly confirms the importance of the macroeconomic environment as one of the pillars of competitiveness (Marčeta & Bojnec, 2023b; Rusu & Roman, 2018). Inflation is among the factors that determine the stability and international position of national economies. The impact of inflation differentials on competitiveness is particularly evident when these differentials are long-term, as evidenced by Mitrović-Mijatović and Ivanović (2017). According to these researchers, such differentials result in a gradual weakening of export performance. For instance, the declining competitiveness of Southern European countries can be attributed to high inflation rates, which have placed domestic goods at a disadvantage in the international market (Sinn, 2014). Another critical factor that must be considered is the level of public debt. According to Mihajlovic (2025), the correlation between the gross debt-to-GDP ratio and economic growth is nuanced. When the ratio falls below 64.4%, debt has been shown to promote economic growth. Conversely, when the ratio exceeds this level, debt has been demonstrated to impede economic growth. In advanced economies, the debt-to-GDP ratio can reach as high as 69.8%. Greiner and Fincke (2015) also posit that debt does not inherently impede economic development; rather, they contend that when utilized for investment purposes, debt can function as a catalyst for growth during specific periods. Productivity is also a salient factor. According to Dinh Nguyen (2025) and Kordos (2026), productivity enhances competitiveness, with intellectual capital also playing a significant role. However, it is imperative to acknowledge the temporal dynamics of the relationship between productivity and competitiveness. The impact of a novel technological advancement on productivity may only become evident after a substantial temporal interval. This is because, in response to the introduction of new technologies, productivity levels may initially experience a decline or stagnation. This is due to the necessity for firms to allocate resources towards the training of their human capital and the adaptation of their business processes to the new technological landscape (Brynjolfsson et al., 2021). The efficiency of state institutions is also a critical component of the framework that governs the functioning of economic competition and the shaping of economic competitiveness. In accordance with the perspective articulated by Acemoglu and Robinson (2012), the presence of political stability and government effectiveness engenders the fundamental conditions necessary for technological advancement, the evolution of economic competition, and the fortification of a nation's global standing. Conversely, the absence of these conditions can result in economic stagnation. The significance of these factors is further underscored by Bontempo (2022), who contends that the degree of competitiveness is contingent, to a considerable extent, on the caliber of governance. The business environment, investor confidence, the efficiency of public spending, and the economy's ability to implement long-term development strategies are influenced by institutional determinants, particularly government effectiveness and political stability. In the context of a broader set of determinants of competitiveness, trade openness also plays a significant role. However, its impact is not straightforward and may vary depending on the structure of the economy and its level of development. Marčeta and Bojnec (2023a) underscored the correlation between trade openness, innovation capacity, research and

development spending, ICT adoption, GDP per capita, and the Global Competitiveness Index (GCI). According to this perspective, heightened trade openness has the potential to exert a negative influence on the GCI, a phenomenon that may be attributed to the occurrence of structural changes and an increase in market volatility on a global scale. In contrast, Pilinkiene (2016) has observed a positive correlation between competitiveness and trade openness, although this correlation is more pronounced with other indicators, such as GDP. In the 21st century, research and development (R&D) expenditure has emerged as a critical factor in determining competitiveness. According to Pouris (2025), the expenditures of nations on research support, as well as the intensity of such expenditures, are indicative of technological progress and global competitiveness. This phenomenon is evident in increased productivity and efficiency across various sectors. In a similar vein, Islam et al. (2024) posit that individual countries should allocate sufficient financial resources to support research and development. This is due to the fact that it is one of the primary ways to ensure technological and infrastructural progress that supports sustainable economic growth as well as overall competitiveness. This assertion is corroborated by Abramo and D'Angelo (2024), who observe a robust correlation between research performance and economic competitiveness. Silaghi et al. (2014) examined the effects of public and corporate spending on research and development in CEE countries, noting that although these economies often possess a relatively high level of human capital, their spending on research and development is lower and significantly heterogeneous compared to more advanced economies. This observation indicates that the full translation of human capital into competitiveness may be impeded in the absence of adequate support from innovation infrastructure and investment in research and development.

The research design combines two complementary levels of analysis that reflect the theoretical assumption that competitiveness is shaped by both structural differences between countries and the interaction of key economic and institutional determinants. The first level focuses on differences between the V4 countries and the remaining Central and Eastern European economies, reflecting the assumption that distinct development trajectories, institutional arrangements and patterns of economic transformation may lead to different levels of competitiveness and human capital. The second level examines whether human capital contributes to competitiveness across the entire region after controlling selected macroeconomic and institutional determinants. Together, these two analytical perspectives allow not only the identification of differences within the region but also a deeper understanding of the mechanisms through which competitiveness is formed in transforming economies.

A synthesis of theoretical approaches, empirical findings, and the identified research gap highlights the need to examine the competitiveness of Central and Eastern European countries from two complementary perspectives. The initial perspective is predicated on the notion that the divergent developmental trajectories and institutional arrangements of the V4 countries may result in disparate levels of competitiveness and human capital in comparison to other countries within the region. The second perspective focuses on testing the assumption that human capital is a significant determinant of competitiveness even after controlling for selected macroeconomic and institutional factors. The following hypotheses were formulated based on these theoretical foundations:

H1. *The V4 countries, understood here as dependent market economies, are expected to exhibit a higher level of competitiveness in comparison to other countries within the Central and Eastern European region.*

H2. *The V4 countries, understood here as dependent market economies, are expected to exhibit a higher level of human capital development in comparison to other countries within the Central and Eastern European region.*

H3. *Year-over-year changes in human capital levels are expected to be a statistically significant positive determinant of the competitiveness of Central and Eastern European countries, after controlling for the effects of macroeconomic and institutional determinants.*

3. Methodology

The present study pursues two interrelated objectives that directly shape our empirical strategy. The initial objective is to identify disparities in the degree of competitiveness and human capital between the Visegrad Four countries (Slovakia, the Czech Republic, Poland, and Hungary) and other countries in the Central and Eastern European region (Bulgaria, Romania, Croatia, Slovenia, Estonia, Latvia, and Lithuania). This objective is supported by hypotheses H1 and H2, which assume the existence of significant differences between these two groups of countries. The second objective is to identify the impact of year-over-year changes in human capital on competitiveness across the entire Central and Eastern European region under study, in the context of other key macroeconomic and institutional determinants. Hypothesis H3 is a logical extension of this objective. Econometric analysis primarily uses panel data from eleven Central and Eastern European countries from 2007 to 2023. The impact of the independent variables on competitiveness is assessed with a two-year lag. When applying a two-year lag, it was hypothesized that the impact of human capital and other variables on competitiveness is not immediately apparent. This approach aligns with the extant literature (You et al., 2022; B. H. Hall et al., 1983), which posits that the effects of certain variables manifest only after a period of two years. While the full effects of human capital often manifest over a longer time horizon, a two-year lag allows for the capture of its earlier effects, such as increased productivity (Griffith et al., 2003). Furthermore, to assess the sensitivity of the selected model's outcomes to the selection of time lag, a control analysis was conducted using three-, four-, and ten-year lags. This approach enabled the evaluation of whether extending the time horizon would result in a shift in the nature of the observed relationships. The estimates indicated that the results demonstrated relative stability. The coefficient of change in human capital remained statistically insignificant for three-year (p -value = 0.2878), four-year (p -value = 0.5302), and ten-year (p -value = 0.3038) time lags. These supplementary estimates indicate that the statistical insignificance of human capital in relation to competitiveness in Central and Eastern European countries remains stable irrespective of the selected time lag.

Specific indicators and data sources to model these relationships were employed. Competitiveness is measured using the World Competitiveness Index (WCI), published by the International Institute for Management Development. The Penn World Table database index, which considers the average number of years of schooling and the expected rate of return on education, was used as a key indicator of human capital. While this indicator has found widespread application in international comparative analyses, its primary focus on the educational dimension of human capital might limit its ability to fully capture additional aspects such as the quality of skills, innovative capacity, workforce adaptability, or digital competencies. The selection of the index was primarily motivated by its high degree of international comparability, its methodological consistency, and the availability of long-term time series suitable for panel analysis.

Additional explanatory variables were included in the panel regression analysis to ensure the robustness of the estimates: research and development expenditure (expressed as a percentage of the country's GDP), trade openness (measured by the percentage of foreign

trade in GDP), government effectiveness and political stability (data drawn from the World Governance Indicators from the World bank), gross debt (expressed as a percentage of the country's GDP), inflation (expressed as CPI %), and labor productivity (per hour worked).

To examine differences in competitiveness and human capital levels between the V4 countries and other Central and Eastern European countries, a panel regression model with random effects was used, which allowed for testing differences between groups of countries while accounting for the panel structure of the data. Due to the presence of heteroscedasticity and serial correlation, the standard errors of the coefficients were estimated using the Arellan estimate to ensure that p -values and test statistics were not biased by repeated observations of the same objects over time. The regression model was defined as follows:

$$y_{it} = \beta_0 + \beta_1 V4_{it} + v_i + \epsilon_{it} \quad (1)$$

where

y_{it} —the value of the observed indicator (competitiveness/human capital) for country i at time t

$V4_{it}$ —a dummy variable taking the value 1 if the country belongs to the V4 group, and 0 for other countries

β_0 —a constant representing the average value of the indicator for countries outside the V4

β_1 —a difference coefficient that directly quantifies the difference in means between the two groups

v_i —a random individual effect specific to each country

ϵ_{it} —a random component.

The assumptions of the panel regression model were verified through a series of tests. The Levin-Lin-Chu (LLC) test was employed to ascertain the presence of unit roots in all variables incorporated within the panel regression framework. This approach is particularly well-suited for panel data with medium-length time series, as evidenced by previous research (Levin et al., 2002). The following formula was employed in the calculation:

$$\Delta y_{it} = \alpha_i + \rho y_{i,t-1} + \sum_{j=1}^{P_i} \beta_{ij} \Delta y_{i,t-j} + \epsilon_{it} \quad (2)$$

where

y_{it} —the value for unit i at time t ;

α_i —individual intercept for unit i ;

ρ —unit root coefficient;

$\Delta y_{it} = y_{it} - y_{i,t-1}$ —first differentiation of a variable;

$\sum \beta_{ij} \Delta y_{i,t-j}$ —lagged differences (to remove autocorrelation);

ϵ_{it} —random error.

The presence of multicollinearity among the independent variables was assessed using the correlation matrix and the Variance Inflation Factor (VIF). Dirir (2023) also used this method to detect multicollinearity in his study. The following formula was used to calculate the VIF:

$$VIF = \frac{1}{(1 - r^2)} \quad (3)$$

where r^2 represents the coefficient of determination from the auxiliary regression, in which one independent variable is explained by all other independent variables in the model.

The robustness of the estimates was verified using diagnostic tests. The absence of cross-sectional dependence among panel units was confirmed using Pesaran's CD test, which is suitable for smaller data samples (Pesaran, 2004). The presence of cross-

sectional dependence could lead to inefficient parameter estimates and incorrect statistical conclusions. The following formula was used:

$$CD = \sqrt{\frac{2TN(N-1)}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right) \quad (4)$$

where

N—number of countries (units in the panel);

T—number of time periods (years);

ρ_{ij} —the estimated value of the pairwise correlation of the residuals between country *i* and country *j*.

To verify the presence of heteroscedasticity within the panel, the Wald test for group heteroscedasticity was applied. This test examines the equality of residual variances across individual panel units (Baum, 2024). The following formula was used for the calculation:

$$W = \sum_{i=1}^N \frac{(s_i^2 - \hat{\sigma}^2)^2}{V_i} \quad (5)$$

where

s_i^2 —is the estimated residual variance for the *i*-th group;

$\hat{\sigma}^2$ —is the joint variance under the assumption of homoscedasticity;

V_i —is the variance of the estimated variance s_i^2 .

Due to the nature of the data and the assumption of unobserved, country-specific, individual effects, the impact of macroeconomic and institutional determinants on competitiveness was analyzed using a fixed-effects model estimated with the Least Squares Dummy Variable (LSDV) method. In this model, a two-year lag ($t - 2$) was applied to the independent variables. Welch's F-test and the Hausman test confirmed the appropriateness of its use. To eliminate bias in the results due to cross-sectional dependence, standard errors were adjusted using the PCSE (Beck-Katz standard errors) approach. The following formula was used in the regression calculation:

$$y_{it} = \beta_0 + \sum_{k=1}^K \beta_k x_{kit} + \alpha_i + \epsilon_{it} \quad (6)$$

where

y_{it} —dependent variable (WCI) for the country at time *t*;

x_{kit} —explanatory variables;

β_k —estimated coefficients;

β_0 —constant;

α_i —a fixed effect specific to each country;

ϵ_{it} —a random component.;

All calculations were performed using the statistical software, Gretl.

4. Results

In order to make a comparison of the levels of competitiveness and human capital between the V4 countries and other countries in the Central and Eastern European region, a random-effects panel model with robust standard errors was employed. This model was estimated by means of the Arellano estimator.

The findings of the WCI did not substantiate a statistically significant discrepancy between the V4 countries and the other countries in the Central and Eastern European region ($p = 0.4451$) (see Table 1). The V4 countries exhibit an average WCI level of 63.45, while the other observed countries in the region demonstrate a level of 60.29. However, after controlling for heteroscedasticity and serial correlation, the observed difference of

3.16 points was determined to be statistically insignificant. The initial hypothesis, which postulated that “the V4 countries, defined as dependent market economies, achieve a higher level of competitiveness compared to other countries in the Central and Eastern European region,” was not statistically validated.

Table 1. Comparison of WCI between the V4 countries and other countries in Central and Eastern Europe.

Independent Variable	Coefficient β	Standard Error	z-Statistic	p-Value
Constant β_0 (reference mean for countries outside the V4)	60.29	2.97	20.30	<0.001
V4 β_1 (difference relative to countries outside the V4)	3.16	4.14	0.76	0.4451

Source: own calculations based on data from the IMD.

In the case of the human capital index, a statistically significant difference ($p = 0.0488$) was confirmed between the V4 countries and the other countries in the Central and Eastern European region (see Table 2), in contrast to the findings of the WCI. The V4 countries demonstrate a comparatively higher average level of human capital (3.51) in comparison to the other countries that were analyzed (3.28). Despite the negligible absolute differences in average values, given the minimal year-on-year variability of this indicator and after adjusting for heteroscedasticity and serial correlation, this discrepancy can be regarded as statistically significant. Pursuant to the findings, it can be posited that Hypothesis H2, which postulates that “the V4 countries, defined as dependent market economies, achieve a higher level of human capital development compared to other countries in the Central and Eastern European region,” has been verified.

Table 2. Comparison of the Human Capital Index between the V4 countries and other countries in Central and Eastern Europe.

Independent Variable	Coefficient β	Standard Error	z-Statistic	p-Value
Constan β_0 (reference mean for countries outside the V4)	3.28	0.063	52.03	<0.001
V4 β_1 (difference relative to countries outside the V4)	0.23	0.115	1.97	0.0488

Source: own calculations based on data from Penn World Table.

In the subsequent section of this study, a panel regression analysis is conducted for a sample of 11 countries. Prior to estimating the model, the stability of the data and the stationarity of the observed variables were verified by conducting unit root tests.

The results of the LLC test (see Table 3) revealed a mixed pattern of data integration. The variables WCI, inflation, gross debt, government effectiveness, and political stability were stable in their original form, i.e., stationary (p -values < 0.05). The remaining variables, including human capital, R&D expenditure, trade openness, and labor productivity, exhibited p -values greater than 0.05, suggesting their non-stationarity and the presence of a unit root. Subsequently, these non-stationary variables were transformed using first-order differentiation. This methodological approach entailed the analysis of their year-over-year changes rather than their actual values. Following the implementation of the differentiation process, the data manifested as stationary with a p -value < 0.05.

Table 3. Levin-Lin-Chu test.

Variable	Tested Form	<i>p</i> -Value (LLC)	Conclusion
WCI	Actual level	0.0037	stationary
Inflation	Actual level	0.0002	stationary
Gross debt	Actual level	0.0000	stationary
Government effectiveness	Actual level	0.0057	stationary
Political stability	Actual level	0.0093	stationary
<i>d</i> _Human capital	1. difference	0.0000	stationary after first difference
<i>d</i> _Research and development expenditures	1. difference	0.0000	stationary after first difference
<i>d</i> _Openness of the economy	1. difference	0.0000	stationary after first difference
<i>d</i> _Labor productivity	1. difference	0.0000	stationary after first difference

Source: own calculations based on data from the Eurostat, OECD, Penn World Table, IMD, World bank. Note: The symbol *d*_ is employed to denote variables in first-order differential equations.

The degree of linear interdependence between the independent variables was verified using a correlation matrix (see Table 4). The majority of correlation coefficients fell within the range of low to moderate values, ranging from 0.000 to 0.723, indicating a relationship between government effectiveness and political stability. The second-highest value, $r = 0.413$, reflects the relationship between the year-over-year change in human capital and gross public debt. The remaining correlation coefficients are below 0.400. Given that one of the values marginally exceeds the threshold of 0.70, multicollinearity was additionally verified using the Variance Inflation Factor (VIF), which assesses multicollinearity more comprehensively (see Table 5).

The calculated VIF values range from 1.062 to 2.257, falling well below the critical thresholds of 5 and 10, respectively. This suggests that multicollinearity among the independent variables included in the regression model is not severe and will not significantly affect the reliability of estimates in the panel regression.

Subsequent to confirming multicollinearity among the explanatory independent variables, supplementary diagnostic tests characteristic of panel data was executed. Initially, the cross-country dependence was examined, a phenomenon that can emerge, for instance, as a consequence of globalization and economic integration. The cross-country dependence was assessed by conducting the Pesaran CD test (see Table 6).

The statistical analysis yielded a highly significant relationship among the countries under study, as evidenced by the test result ($z = 7.142$; $p = 0.000$) and the average correlation of the residuals (0.325). This phenomenon is indicative of a high degree of integration and economic interdependence among countries in the Central and Eastern European region. Consequently, an economic event in one country is likely to influence economic developments in other countries. Therefore, robust standard errors adjusted by means of the PCSE approach (or Beck-Katz standard errors) were employed in the fixed-effects model estimation. The objective was to ensure maximum reliability of the estimated coefficients and to minimize the risk of underestimating standard errors in the presence of cross-sectional correlation among units.

Table 4. Correlation Matrix.

	Government Effectiveness	Political Stability	Inflation	Gross Debt	<i>d</i> _Openness of the Economy	<i>d</i> _Research and Development Expenditures	<i>d</i> _Human Capital	<i>d</i> _Labor Productivity
Government effectiveness	1							
Political stability	0.723 ***	1						
Inflation	−0.230 ***	−0.170 **	1					
Gross debt	0.147	0.172 **	−0.316 ***	1				
<i>d</i> _Openness of the economy	−0.002	−0.029	0.137	0.054	1			
<i>d</i> _Research and development expenditures	0.058	0.099	0.112	−0.044	0.141	1		
<i>d</i> _Human capital	−0.147	−0.028	0.009	0.413 ***	0.049	0.087	1	
<i>d</i> _Labor productivity	−0.019	−0.097	0.047	−0.048	0.357 ***	0.026	−0.011	1

Source: own calculations based on data from the Eurostat, Penn World Table, IMD, World bank. Note: The symbol *d*_ is employed to denote variables in first-order differential equations. The asterisks *** indicate statistical significance of the correlation coefficient at the 1% significance level, and ** indicate statistical significance of the correlation coefficient at the 5% significance level (the critical value for 5% is 0.1582; for 1% is 0.2070) with a panel sample size of N = 154.

Table 5. Variance Inflation Factor.

Variable	VIF Value
Inflation	1.169
Gross debt	1.399
Government effectiveness	2.257
Political stability	2.213
<i>d</i> _Human capital	1.306
<i>d</i> _Research and development expenditures	1.062
<i>d</i> _Openness of the economy	1.202
<i>d</i> _Labor productivity	1.166

Source: own calculations based on data from the Eurostat, Penn World Table, IMD, World bank. Note: The symbol *d*_ is employed to denote variables in first-order differential equations.

Table 6. Pesaran CD test.

Test	Test Statistic (z)	<i>p</i> -Value	Average Absolute Correlation
Pesaran CD	7.142	0.000	0.325

Source: own calculations based on data from the Eurostat, Penn World Table, IMD, World bank.

The Wald test for group heteroscedasticity (see Table 7) did not indicate the presence of heteroscedasticity ($\chi^2 = 15.438$; $p = 0.163$), suggesting that the variance of the error terms is stable across the countries under study (homoscedasticity). The Wald test's results demonstrate that variations among countries do not introduce unwanted variability in the error term, thereby enhancing the efficiency of the estimated coefficients. In conjunction with the preceding treatment of cross-sectional dependence, the model thus meets the fundamental diagnostic assumptions for a reliable analysis of the macroeconomic and institutional determinants of competitiveness.

Table 7. Wald’s test for group heteroscedasticity.

Test	Chi-Square	df	p-Value	Pooled Error Variance
Distribution-Free Wald	15.438	11	0.163	19.988

Source: own calculations based on data from the Eurostat, Penn World Table, IMD, World bank.

The model’s suitability was assessed through the implementation of Welch’s F-test for heteroscedasticity. The test statistic F was determined to be 7.69, with a *p*-value less than 0.001, thereby confirming the presence of unobserved fixed effects. This result indicates that the null hypothesis of a common constant was rejected, thereby providing a statistically sound rationale for preferring the fixed-effects model over the Pooled OLS model. The model’s adequacy was subsequently validated by the Hausman test ($\chi^2 = 163.178$; $p = 0.000$), which rejected the null hypothesis concerning the consistency of estimates derived from the Random Effects method, yielding a substantial statistical significance. The findings of this study (see Table 8) suggest that the fixed-effects model is the most suitable for this particular analysis.

Table 8. Regression Analysis.

Variable	Regression Coefficient (Robust Standard Error)	p-Value
Constant	13.047 (15.902)	0.431
Government effectiveness	0.625 (0.197)	0.01
Political stability	0.075 (0.121)	0.55
Inflation	−0.839 (0.277)	0.013
Gross debt	0.122 (0.051)	0.038
<i>d</i> _Openness of the economy	−0.083 (0.067)	0.24
<i>d</i> _Research and development expenditures	−6.081 (3.411)	0.105
<i>d</i> _Human capital	5.615 (32.745)	0.867
<i>d</i> _Labor productivity	0.162 (0.145)	0.288
Diagnostics		Value
Number of observations		154
LSDV R ²		0.776
Within R ²		0.47
F-test (<i>p</i> -value)		85.15 ($p < 0.001$)
Welch F (<i>p</i> -value)		7.68831 ($p < 0.001$)
Hausman test (<i>p</i> -value)		163.18 ($p < 0.001$)

Source: own calculations based on data from the Eurostat, Penn World Table, IMD, World bank. Note: The symbol *d*_ is employed to denote variables in first-order differential equations. Therefore, the model does not estimate the effect of these variables’ absolute levels on the WCI; rather, it estimates the effect of their year-over-year change on the WCI.

The quality of the panel regression analysis estimate was assessed using two coefficients of determination. The obtained LSDV R² value of 0.776 indicates that the model as a whole, including the included country fixed effects, can explain nearly 78% of the variability in the WCI. This finding suggests the presence of substantial fixed differences among Central and Eastern European countries, which are attributed to their historical development, geographical location, or unique economic structures. From an economic interpretation perspective, however, the key indicator is Within R² = 0.469. This value

indicates that the selected independent variables, when accounting for a two-year time lag, explain 47% of the changes in competitiveness occurring within individual countries. The overall statistical significance of the model was confirmed by the F-test ($F = 85.15$; $p < 0.001$). Considering the inherent characteristics of the panel data and the detection of cross-sectional dependence through Pesaran CD test, the model incorporated robust standard errors, which were adjusted by means of the PCSE approach. This methodological approach ensured consistent estimates even in instances where the assumption of independence of the residuals was violated.

Among the independent variables, government effectiveness emerged as the most statistically significant factor ($p = 0.01$). The regression coefficient of 0.625 indicates that an increase of one unit in government effectiveness leads to an average increase in the WCI of 0.625 points. In terms of practical economic significance and the magnitude of the effect, this represents a stable contribution of institutional factors to the overall variance in competitiveness. This suggests that the quality of the institutional environment in the Central and Eastern European region is a pivotal factor in development. This suggests that transparency, the quality of institutions, and the government's capacity to effectively implement policies have a direct impact on the competitiveness of the countries under study. As anticipated, the inflation rate exerts a statistically significant negative influence on the WCI ($p = 0.013$). The regression coefficient of -0.839 indicates that a one-unit increase in inflation reduces the competitiveness score by approximately 0.839 points. In terms of economic impact, inflation is thus the most significant determinant in the model. In the case of a sudden spike in inflation, for instance, by 5 percentage points, the WCI would undergo an estimated decline of 4.20 points, signifying a substantial drop. In the countries under study, high inflation exerts a negative impact on the growth of competitiveness. A noteworthy discovery is the presence of a statistically significant positive correlation between gross debt and the WCI (0.038). The coefficient of 0.122 indicates that a one-unit increase in public debt is associated with a slight increase in competitiveness of 0.122 points. Within the context of countries in the Central and Eastern European region, this finding suggests that debt financing was effectively directed toward supporting growth, infrastructure development, and related economic activities during the period under review. However, when evaluated in practical terms, the impact of this phenomenon is found to be considerably less pronounced in comparison to inflation or government effectiveness. It is evident that an augmentation in the aggregate WCI by a single point would necessitate an escalation in debt financing that exceeds 8 percentage points of GDP. The remaining variables (political stability, R&D expenditure, human capital, labor productivity, and trade openness) did not prove statistically significant in this model, as evidenced by low t-statistic values due to high robust standard errors. This phenomenon may be attributed to various factors, including the low variability of these indicators during the period under analysis and the potential for their effects to manifest with a time lag that exceeds the 2-year period considered in this model. In consideration of the results, the subsequent conclusions are proposed:

- Hypothesis H3, which states that “year-over-year changes in human capital constitute a statistically significant positive determinant of the competitiveness of Central and Eastern European countries after controlling for the effects of macroeconomic and institutional control variables,” was not verified. After controlling for the influence of control variables and applying panel-corrected standard errors (PCSE), the impact of year-on-year changes in human capital on competitiveness in the Central and Eastern European region appears to be statistically insignificant ($p = 0.867$). This result reveals a discrepancy between the expected macroeconomic theoretical relationship, according

to which human capital is a significant determinant of competitiveness, and the reality in the transforming economies of Central and Eastern Europe.

5. Discussion

The Central and Eastern European region is not an administratively defined entity; however, it is established in professional literature as an analytical macroregion used for comparative and empirical analyses. This approach is predicated on the notion that the countries of the region have experienced analogous historical developments in their transition from centrally planned economies to market-based systems. They have also undergone a comparable process of integration into European and global economic structures (Fidrmuc, 2003; Campos & Coricelli, 2002; Lane, 2006).

Despite the noted homogeneity, the present study focused on examining differences in competitiveness levels and human capital levels between the V4 countries, which are part of this region, and other countries in Central and Eastern Europe. A statistically significant discrepancy was identified between the two groups of countries, yet this was exclusively in the domain of human capital. No considerable variance was observed in terms of competitiveness. This provides a novel perspective on the theoretical concept proposed by Nölke and Vliegenthart (2009), which posits that the V4 countries have developed a distinct model known as “dependent market economies.” This model is characterized by the presence of assembly plants owned by multinational corporations and the transfer of technology from foreign entities, thereby resulting in a distinct structural differentiation from other post-communist economies. The findings of this study suggest that the development of human capital may have been a necessary prerequisite for the integration of the V4 countries into the aforementioned model. This hypothesis is supported by the observation that the V4 countries exhibit a higher average level of human capital compared to the rest of the region. The absence of a statistically significant difference in overall competitiveness may be a consequence of certain shared characteristics. In accordance with the findings of Bohle and Greskovits (2007) and Myant and Drahokoupil (2012), the Central and Eastern European region as a whole displays common characteristics of reliance on foreign capital and technology transfer, which may serve to mitigate differences in their overall market position. The higher level of human capital in the V4 countries has not yet translated into overall competitiveness, given the emerging “middle-income trap” in the countries under study (Myant, 2018) and the persistent assembly line model. In a practical context, these findings suggest that higher levels of human capital in the V4 countries do not systematically lead to an increase in overall competitiveness. This suggests that the persistent model focused on lower-value-added production has limitations. However, within the context of real-world economic practice, this marginal discrepancy (0.23 points) does not yet signify a substantial structural divergence in the region’s aggregate performance. Instead, it signifies a prospective comparative advantage that the V4 countries are incapable of completely converting into augmented macroeconomic value added, owing to the intrinsic constraints of the prevailing economic model.

A panel regression analysis was conducted to examine the relationship between the WCI and eight independent variables with a two-year lag, using fixed effects estimated by the Least Squares Dummy Variable method. The analysis revealed that the key factors influencing the competitiveness of Central and Eastern European countries are government effectiveness, inflation, and gross debt. This finding aligns with the assertions put forth by Schwab and WEF (2015), who contend that the cultivation of competitiveness is predominantly attributed to the interplay of multiple factors rather than the influence of a solitary element. The impact of government effectiveness on competitiveness in the Central and Eastern European region is particularly significant, aligning with the findings of Bontempo

(2022). Bontempo's research indicates that reforms designed to enhance public governance, reduce bureaucracy, combat corruption, and optimize the efficiency of public administration can substantially enhance competitiveness. Furthermore, Kaufmann et al. (2010), the authors of the Worldwide Governance Indicators, establish a direct correlation between government effectiveness and economic development, when the quality of regulation, the enforceability of the law, and the state's ability to effectively implement public policies serve as the primary mediators in this relationship. The robust impact of government effectiveness in our model underscores the pivotal role of institutional quality in Central and Eastern European countries, functioning as an overarching determinant of competitiveness. This quality, in turn, conditions the effectiveness of other factors, including human capital.

The inflation rate exhibited a robust negative and statistically significant impact on the WCI ($p = 0.017$). This finding corroborates the theory of Ha et al. (2019), which posits that in emerging economies—which include the Central and Eastern European region—inflation tends to distort price signals, leading to inefficient resource allocation and a loss of market share in global markets.

A noteworthy and somewhat unanticipated discovery is the presence of a statistically significant positive correlation between gross public debt and the WCI. This outcome is at odds with the majority of studies, which have demonstrated a correlation between an increase in public debt, in both the short and long term, and adverse effects on economic growth and competitiveness (Onofrei et al., 2022; Toth et al., 2025; Konatar et al., 2022). In the specific context of the Central and Eastern European region, this coefficient ($\beta = 0.122$, $p = 0.038$) should be interpreted with a degree of caution. This finding does not imply that higher public debt is inherently beneficial for competitiveness or that it automatically stimulates economic development. The pivotal factor in comprehending this relationship is to precisely differentiate between the purpose and the level of debt.

On the one hand, this result could be interpreted in favor of the theory of productive debt, whereby debt financing in the examined transition economies may have been effectively directed toward growth-oriented measures such as infrastructure development, modernization of public services, or support for innovation and education during the period under review. These investments, even when financed through debt, have the potential to positively impact competitiveness. For instance, Greiner and Fincke (2015) have noted that the utilization of debt for investments that enhance productivity does not inherently result in an economic slowdown. Instead, it can function as a growth stimulant during a specific period. Considering the institutional framework characteristic of Central and Eastern European countries, it can be posited that public debt, when utilized in conjunction with an effective institutional framework, has the potential to function as a mechanism for addressing investment disparities. However, it is imperative to distinctly differentiate this productive approach from a scenario in which debt accumulates excessively to cover current consumption, which poses a significant risk to competitiveness. The uncontrolled accumulation of public debt, in the absence of concomitant growth in productivity, has the potential to compromise the long-term fiscal sustainability and stability of the entire region. Consequently, the presence of a positive coefficient in the model should not be interpreted as an endorsement of expansionary debt policy. Conversely, this phenomenon may be indicative of reverse causality, where more competitive nations possess greater fiscal capacity and superior access to financial markets, enabling them to sustain higher levels of debt without immediate adverse outcomes.

The impact of the European Union's investment cycles must also be taken into account. A significant proportion of development projects that are financed by EU structural funds necessitate national co-financing. Consequently, an increase in government debt could be considered a secondary outcome of accessing European funds, which contributed to

a short-term enhancement in competitiveness (OECD, 2020). However, the regression coefficient's low value indicates that the impact of debt on competitiveness is constrained. Exceeding critical debt thresholds could rapidly reverse existing benefits and compromise macroeconomic stability. The remaining variables (political stability, d_{research} and development expenditure, $d_{\text{human capital}}$, $d_{\text{labor productivity}}$, and $d_{\text{trade openness}}$) were found to be statistically insignificant in the regression model ($p > 0.05$). Despite the frequent identification of these factors in academic literature as significant determinants of competitiveness, their insignificance in the regression model does not necessarily imply the absence of an economic impact. Instead, the findings indicate that their impact did not manifest as an independent and immediate factor in Central and Eastern European countries, after accounting for the influence of other variables.

Despite the assertion by Ábel et al. (2025) that innovation and technological development play a pivotal role in the context of competitiveness, year-over-year fluctuations in research and development expenditures failed to demonstrate a statistically significant impact on the WCI (p -value = 0.105). However, given the structural characteristics of Central and Eastern European countries, which are comparatively less developed in these domains, investments in research and development may not result in an immediate enhancement of competitiveness. Furthermore, as Bykova et al. (2021) have noted, research itself does not receive sufficient attention; rather, technologies enter these countries from abroad through parent companies. This observation is further reinforced by Prokop et al. (2021), who contend that in these nations, external sources of technology and foreign expertise frequently assume a more significant role compared to domestic research and development initiatives.

The findings show that the impact of changes in trade openness on the WCI is not statistically significant (p -value = 0.24). Despite the assertion in international trade theory that there is a positive relationship between economic openness and competitiveness, the findings for Central and Eastern European countries suggest that this relationship may not be as straightforward as initially hypothesized. Pilinkiene (2016) posits that elevated trade openness does not inherently ensure enhanced competitiveness, as individual nations may attain disparate outcomes despite analogous levels of integration into global trade. One potential explanation for this phenomenon is the structural nature of foreign trade in numerous regional economies, which persist in their role as manufacturing and assembly hubs that are intricately woven into global value chains. As Stöllinger (2016) has noted, a considerable proportion of these countries' export performance is attributable to activities with relatively low domestic value added, while key decision-making, research, and innovation processes remain concentrated outside their domestic economies. Consequently, an increase in foreign trade volume or greater trade openness may not necessarily result in heightened competitiveness, as measured by the WCI. This is because the economic benefits of trade integration are only partially reflected in domestic value-added creation and long-term productivity growth.

The statistical insignificance of the political stability variable (p -value = 0.55) stands in contrast to the high significance of government effectiveness. This phenomenon may be attributed to the fact that while many countries frequently experience changes in government, the fundamental direction (EU accession, Euro-Atlantic orientation, legislative framework) remains relatively stable. Altun (2017) reached a similar conclusion in his study, according to which government effectiveness has a significant and robust impact on economic and social development. The study also found that elections and changes in government do not have a significant impact on development, regardless of the political system or the country's level of development. However, in addition to a factual interpretation, it is imperative to consider the relatively high correlation coefficient ($r = 0.723$) between political stability and government effectiveness. This coefficient could have resulted in the statistically more

dominant variable—government effectiveness—in the model overshadowing the influence of political stability, thereby leading to its identified insignificance, despite the Variance Inflation Factor not exhibiting a high value.

Although there are many studies that consider labor productivity as a significant factor of competitiveness (Bangun, 2017; Šteinbuka et al., 2024), the regression model used in this study showed that year-on-year changes in productivity did not have a statistically significant impact on WCI (p -value = 0.288). One potential explanation for this phenomenon is that labor productivity operates through several mediating mechanisms, including the level of technology, structural changes in the economy, and the quality of institutions. Pariboni and Tridico (2020) have demonstrated that labor productivity trends are significantly influenced by the institutional and structural environment of the economy. Consequently, once variables representing the quality of governance and macroeconomic stability are incorporated into the model, the independent contribution of labor productivity may be statistically diminished.

The most surprising finding was that the regression analysis did not confirm a significant impact of changes in human capital levels on competitiveness for the Central and Eastern European region ($p = 0.867$). This finding contradicts many theoretical studies (Leite & Cardoso, 2023; Mulliqi et al., 2018; Kirkpatrick et al., 2020). This finding is a significant contribution of the study, as it challenges the assumption of an automatic positive link between human capital growth and competitiveness in the context of Central and Eastern European countries. It shifts the discussion from the expected effect to the question of the conditional validity of this relationship. In accordance with the literature and the econometric properties of the model that have been previously delineated, this identified insignificance can be systematically categorized into three levels.

The initial methodological determinant may be the very method of quantifying the variables. As Popova and Petrov (2020) have noted, measuring competitiveness as an aggregate of many sub-indices (using the WCI) can lead to the effect of human capital being dispersed across various components of the index, and therefore appearing insignificant. However, it is important to note that limitations may also exist on the side of the independent variable. The OECD (2022) observes that models employing education as the sole representative of human capital frequently exhibit inconsistently significant outcomes, a phenomenon that is exemplified in this instance by the utilization of the Penn World Table index, which is based on educational attainment, to express the level of human capital.

Another potential explanation for the absence of significance, as previously discussed in the regression model interpretation, may reside in the specification itself, the econometric transformation of the data, or the designated time lag. The majority of studies referenced in the literature review are predicated on the notion that the level of human capital itself is a pivotal factor influencing competitiveness. However, our model tested the impact of year-over-year changes in human capital on the WCI—rather than its absolute level—to ensure data stationarity. Given the negligible fluctuations observed in the human capital index during the specified period, its impact within the fixed-effects model could be disregarded, along with other time-independent country characteristics. Furthermore, Diebolt and Hippe (2019) posit that historical human capital accumulation is significantly associated with current economic prosperity in European regions, thus allowing for a time lag much longer than the two-year lag included in the model.

The insignificance of the variable may be indicative of the economic model and the prevailing economic structure in Central and Eastern Europe. Positive changes in the level of human capital do not guarantee increased competitiveness unless they are absorbed by the labor market. Despite the documented annual growth in human capital across the countries under scrutiny, there appears to be a discrepancy between this development and

the demands of the labor market. The countries in the region under study continue to predominantly function as industrial economies that prioritize low labor costs and production efficiency, as opposed to innovation based on high-quality human capital, where demand for it remains constrained. This assertion is further substantiated by extant literature on dependent market economies, which underscores the structural reliance of these economies on foreign investors and the limited autonomy in their innovation processes (Nölke & Vliegenthart, 2009). Concurrently, P. A. Hall and Soskice (2001) have indicated that the institutional framework of an economy exerts a fundamental influence on the transformation of human capital into economic performance. This observation is consistent with the low absorption capacity exhibited by certain economies in the observed region.

In consideration of the previously mentioned points, it is imperative to underscore that the statistical insignificance of certain variables does not necessarily imply their economic insignificance. Competitiveness is a complex and multidimensional phenomenon, the significance of which depends on the broader economic and institutional context. It cannot be assessed in isolation.

The findings concerning the control variables also suggest, to a certain degree, the structural nature of the economies. In contrast to the observed changes in the level of human capital, the present study found that these variables exhibited a statistically significant impact on the WCI. The findings underscore the significance of government effectiveness ($p = 0.01$) and the inflation rate ($p = 0.013$) as pivotal factors in determining competitiveness within the region, thereby underscoring the pivotal role of the institutional and macroeconomic environment. In light of these considerations, it can be posited that in an environment characterized by dynamic macroeconomic and institutional changes, the impact of year-over-year fluctuations in human capital is more challenging to capture in the short or medium term, as it may manifest itself indirectly or with a longer time lag. This finding indicates that, while the extant literature frequently assumes a significant direct effect of human capital on competitiveness, in the context of Central and Eastern European countries, this relationship may appear weaker precisely due to the dominant influence of institutional and macroeconomic factors in the short term.

6. Conclusions

The primary objective of this study was to identify disparities in competitiveness and human capital levels between the V4 countries and other Central and Eastern European countries. The subsequent analysis sought to examine the impact of year-over-year changes in human capital on overall competitiveness across the region. The findings of a comparative random-effects panel model indicated the presence of statistically significant disparities between the two groups of countries under examination, with the exception of human capital, where V4 countries demonstrated higher average values. The degree of competitiveness exhibited is consistent across the entire region under scrutiny. The findings of the fixed-effects panel regression analysis indicated that the anticipated direct influence of annual fluctuations in human capital on competitiveness, when considering a two-year time lag, was not substantiated. The prevailing factors influencing competitiveness in the region during the period under review were government effectiveness, the inflation rate, and, to a lesser extent, the level of gross debt. The remaining variables included in the model (political stability, $d_R\&D$ expenditure, d_labor productivity, and d_trade openness) proved to be statistically insignificant.

The primary contribution of this study to the extant literature is the implementation of the synthetic WCI in lieu of the conventional partial indicators of national competitiveness. Additionally, it integrates multiple institutional and macroeconomic dimensions into the model, thereby facilitating a more nuanced comprehension of how structural characteris-

tics and governance quality influence the market environment within the specific context of transition economies in Central and Eastern Europe. From a theoretical contribution perspective, our findings also, to a certain extent, challenge traditional macroeconomic assumptions that the development of human capital should automatically and linearly increase competitiveness. The insignificance of the human capital variable in our model suggests the presence of an obstacle in Central and Eastern European countries that hinders the conversion of knowledge and skills into genuine market competitiveness. This suggests that, in future research, the focus should shift from the mere volume or quantity of human capital to its qualitative structure and its connection to practical application. Indeed, it appears that in the absence of effective institutions and a stable macroeconomic environment, which the model identified as the most significant determinants of competitiveness, the potential of human capital remains untapped, and countries struggle to move beyond their current economic model.

The findings of the regression analysis result in several key recommendations for economic policymaking in the countries under study, with priorities that should strictly reflect the observed statistical significance and strength of the effect of individual determinants. Since inflation is the most significant negative determinant in the regression model, the primary objective of economic policy should be to ensure macroeconomic stability. A substantial surge in inflation has the potential to impede the competitiveness of Central and Eastern European countries. Consequently, effective coordination of fiscal and monetary policy is imperative to mitigate inflationary pressures and stabilize the price environment. The second most significant determinant of competitiveness in the model was found to be government effectiveness, which represents the influence of institutional factors. Consequently, economic policy ought to prioritize the development of institutional capacity and the enhancement of administrative quality. However, it is imperative to recognize that reforms should not be confined to indiscriminate reductions in administrative burdens. Instead, the primary objective of such reforms should be to ensure the predictability of the regulatory environment, the establishment of a high degree of transparency, and the retention of experts in public administration. These factors are instrumental in determining the state's capacity to implement effective policies. While the model exhibited a statistically significant positive relationship between gross debt and competitiveness, its actual economic impact is substantially weaker compared to inflation and government effectiveness. The positive coefficient suggests that debt financing may have contributed to the region's development in the past. However, it is essential for fiscal policy to adopt a highly cautious stance regarding further borrowing to ensure sustainable growth and stability. Considering the potential risks and the fiscal capacity of the respective nations, it is imperative that debt financing is not utilized to fund current consumption. Instead, it should be strictly associated with strategic investments that can provide a quantifiable return. The model's other variables were not statistically significant in determining competitiveness. These findings imply that a rudimentary and quantitative increase in investment in education or innovation is not a viable solution for Central and Eastern European countries. Conversely, the absence of a direct statistical impact suggests the presence of structural deficiencies and a low efficiency of the allocated funds. Consequently, policymakers ought to prioritize the qualitative dimensions and the identification of synergies within the innovation ecosystem. This approach will ensure that these factors translate into genuine growth in competitiveness in the future.

Notwithstanding the value of these findings, it is also necessary to point out the possible limitations of the research. While consistent with theoretical assumptions, the potential indirect effects of human capital may require a longer time lag to manifest. However, the observed two-year time lag was deemed inadequate to capture these effects. Consequently,

future research endeavors should prioritize the application of models with a more extended time lag. A notable constraint pertains to the incorporation of key variables (human capital, research and development expenditure, trade openness, and labor productivity) into the model as first differences, a necessity dictated by the pursuit of data stability. However, subsequent analysis revealed that these variables were statistically insignificant within the model. While the transition to first differences effectively addressed the stationarity issue, it did not adequately capture long-term trends in the values. The majority of indicators have demonstrated only minor year-over-year fluctuations; therefore, a model predicated on differences may have been incapable of capturing their immediate impact.

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Abbreviations

The following abbreviations are used in this manuscript:

IMD	Institute for Management Development
OECD	Organisation for Economic Co-operation and Development
WCI	World Competitiveness Index
CEE	Central and Eastern European

References

- Abramo, G., & D’Angelo, C. A. (2024). The scientific standing of nations and its relationship with economic competitiveness. *PLoS ONE*, 19(6), e0304299. [CrossRef] [PubMed]
- Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In *Handbook of labor economics* (Volume 4, pp. 1043–1171). Elsevier B.V. [CrossRef]
- Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty* (579p). Crown Publishers. Available online: <https://ia801506.us.archive.org/27/items/WhyNationsFailTheOriginsODaronAcemoglu/Why-Nations-Fail-The-Origins-o-Daron-Acemoglu.pdf> (accessed on 28 January 2026).
- Altun, R. K. (2017). *The effect of political stability and governance on economic development* (SSRN scholarly paper Č. 2948652). Social Science Research Network. [CrossRef]
- Annoni, P., & Dijkstra, L. (2019). *The EU regional competitiveness index 2019*. Publications Office of the European Union. Available online: https://ec.europa.eu/regional_policy/sources/work/2019_03_rci2019.pdf (accessed on 30 January 2026).

- Ábel, I., Lóga, M., Szabó, I. A., & Tóth, O. É. (2025). Az Európai Unió versenyképessége a humán tőke tükrében—Ami a Draghi-jelentésből kimaradt. *Public Finance Quarterly*, 71(1), 9–30. [CrossRef]
- Bangun, W. (2017). Labor productivity and competitiveness (A study: The comparison of Indonesian with ASEAN). *International Journal of Applied Business and Economic Research*, 15, 289–294.
- Baum, C. F. (2024). *XTTEST3: Stata module to compute modified wald statistic for groupwise heteroskedasticity*. Statistical Software Components. Available online: <https://ideas.repec.org/c/boc/bocode/s414801.html> (accessed on 7 May 2026).
- Bąk, I., Wawrzyniak, K., & Oesterreich, M. (2022). Competitiveness of the regions of the European Union in a sustainable knowledge-based economy. *Sustainability*, 14(7), 3788. [CrossRef]
- Begg, I. (1999). Cities and competitiveness. *Urban Studies*, 36(5/6), 795–809. [CrossRef]
- Bobetko, A., Draženović, I., & Funda, J. (2017). *Human capital and economic growth in CEE countries and other emerging markets*. Croatian National Bank. Available online: <https://www.hnb.hr/documents/20182/1133385/23-dec-bobetko-drazenovic-funda.pdf/1d36c43b-4a9d-449a-b1dd-02596c455d44?previewFileIndex=&version=1.0&utm> (accessed on 1 February 2026).
- Bohle, D., & Greskovits, B. (2007). Neoliberalism, embedded neoliberalism and neocorporatism: Towards transnational capitalism in central-eastern Europe. *West European Politics*, 30(3), 443–466. [CrossRef]
- Bohle, D., & Greskovits, B. (2012). *Capitalist diversity on Europe's periphery*. Cornell Studies in Political Economy. Cornell University Press. Available online: <https://hdl.handle.net/1814/24382> (accessed on 29 April 2026).
- Bontempo, P. C. (2022). Countries' governance and competitiveness: Business environment mediating effect. *RAUSP Management Journal*, 57(1), 49–64. [CrossRef]
- Borovitskaya, M., Strelnikov, E., Khayrullina, R., Kolesnikov, M., & Mukhniuk, M. (2019). A basis for regional competitiveness: Socio-economic potential. *Revista de la Universidad del Zulia*, 10(28), 345–356.
- Brynjolfsson, E., Rock, D., & Syverson, C. (2021). The Productivity J-Curve: How Intangibles Complement General Purpose Technologies. *American Economic Journal: Macroeconomics*, 13(1), 333–372. [CrossRef]
- Bykova, A., Grieveson, R., Hanzl-Weiss, D., Hunya, G., Korpar, N., Podkaminer, L., Stehrer, R., & Stöllinger, R. (2021). *Avoiding a trap and embracing the megatrends: Proposals for a new growth model in EU-CEE*. Wiiw research reports 458. Available online: <https://ideas.repec.org/p/wii/rpaper/rr458.html> (accessed on 25 January 2026).
- Campos, N. F., & Coricelli, F. (2002). Growth in transition: What we know, what we don't, and what we should. *Journal of Economic Literature*, 40(3), 793–836. [CrossRef]
- Debrah, Y. A., Oseghale, R. O., & Adams, K. (2018). Human capital, innovation and international competitiveness in sub-Saharan Africa. In *Africa's competitiveness in the global economy* (pp. 219–248). Palgrave Macmillan. [CrossRef]
- Diebolt, C., & Hippe, R. (2019). The long-run impact of human capital on innovation and economic development in the regions of Europe. *Applied Economics*, 51(5), 542–563. [CrossRef]
- Dinh Nguyen, P. (2025). The impact of intellectual capital on firm productivity: A consideration of global crises. *Knowledge Management Research & Practice*, 1–15. [CrossRef]
- Dirir, S. A. (2023). The effect of institutional quality on economic growth: Evidence from tripartite approaches in the context of war-torn countries. *Organizations and Markets in Emerging Economies*, 14(3), 508–535. [CrossRef]
- Fidrmuc, J. (2003). Economic reform, democracy and growth during post-communist transition. *European Journal of Political Economy*, 19(3), 583–604. [CrossRef]
- Gaona, L. B., & Vásquez, E. I. (2021). Capital humano, desigualdad y crecimiento económico en América Latina. *Revista de Economía Institucional*, 23(45), 265–283. [CrossRef]
- Gorzela, G., & Smetkowski, M. (2010). Regional development dynamics in central and eastern European countries. In *Regional development in central and eastern Europe* (1st ed., 25p). Routledge. [CrossRef]
- Greiner, A., & Fincke, B. (2015). *Public debt and economic growth*. Springer International Publishing.
- Griffith, R., Redding, S., & Van Reenen, J. (2003). R&D and Absorptive Capacity: Theory and Empirical Evidence. *The Scandinavian Journal of Economics*, 105(1), 99–118. [CrossRef]
- Guadagno, F., Ferrazzi, M., Hanzl-Weiss, D., Schanz, J., Slačik, T., & Stehrer, R. (2024). *The future of the EU's competitive position: The role of central eastern European countries*. Available online: <https://wiiw.ac.at/the-future-of-the-eu-s-competitive-position-the-role-of-central-eastern-european-countries-dlp-7280.pdf> (accessed on 29 April 2026).
- Ha, J., Kose, M. A., & Ohnsorge, F. (2019). *Inflation in emerging and developing economies*. World Bank Publications—Books. World Bank. Available online: <https://ideas.repec.org/b/wbk/wbpubs/30657.html> (accessed on 11 May 2026).
- Hall, B. H., Griliches, Z., & Hausman, J. A. (1983). *Patents and R&D: Searching for a lag structure (working paper 1227)*. National Bureau of Economic Research. [CrossRef]
- Hall, P. A., & Soskice, D. W. (2001). *Varieties of capitalism: The institutional foundations of comparative advantage* (540p). Oxford University Press.
- Hanushek, E. A., & Woessmann, L. (2012). Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation. *Journal of Economic Growth*, 17, 267–321. [CrossRef]

- Holobiuc, A.-M. (2021). Real convergence in central and eastern Europe: A comparative analysis of countries and regions. *Proceedings of the International Conference on Business Excellence*, 15(1), 824–837. [CrossRef]
- Huggins, R., Izushi, H., & Thompson, P. (2013). Regional competitiveness: Theories and methodologies for empirical analysis. *The Business and Economics Research Journal*, 6(2), 155–172. [CrossRef]
- Huovari, J., Kangasharju, A., & Alanen, A. (2000). *Regional competitiveness in Finland*. ERSA 40th European Congress. Pellervo Economic Research Institute. Available online: <https://hdl.handle.net/10419/114862> (accessed on 27 January 2026).
- Islam, M. Z., Rahaman, S. H., & Chen, F. (2024). How do R&D and remittances affect economic growth? Evidence from middle-income countries. *Heliyon*, 10(9), e30160. [CrossRef] [PubMed]
- Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). *The worldwide governance indicators: Methodology and analytical issues* (SSRN scholarly paper n. 1682130). Social Science Research Network. Available online: <https://papers.ssrn.com/abstract=1682130> (accessed on 25 February 2026).
- Kirkpatrick, I. C. M., Horvat, T., & Bobek, V. (2020). Improving competitiveness between EU rural regions through access to tertiary education and sources of innovation. *International Journal of Diplomacy and Economy*, 6(1), 26–40. [CrossRef]
- Konatar, M., Đurašković, J., Cerović Smolović, J., & Radović, M. (2022). Does public debt affect economic growth? Panel evidence from central and eastern Europe. *Politička Ekonomija*, 70(5), 574–596. [CrossRef]
- Kordos, M. (2024). The impact of brexit on slovak healthcare professionals in the United Kingdom—The fallouts and consequences. *Economics & Sociology*, 17(2), 273–291. [CrossRef]
- Kordos, M. (2026). Digitization processes implementation as an innovation management tool within sustainable development. *Sustainability*, 18(6), 2809. [CrossRef]
- Kouskoura, A., Kalliontzi, E., Skalkos, D., & Bakouros, I. (2024). Assessing the key factors measuring regional competitiveness. *Sustainability*, 16(6), 2574. [CrossRef]
- Lane, P. R. (2006). The real effects of European monetary union. *Journal of Economic Perspectives*, 21(4), 47–66. [CrossRef]
- Leite, D. W., & Cardoso, L. C. B. (2023). Human capital and technology in the growth of economic structure. *Investigacion Economica*, 82(323), 27–52. [CrossRef]
- Levin, A., Lin, C.-F., & James Chu, C.-S. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108(1), 1–24. [CrossRef]
- Marčeta, M., & Bojnec, Š. (2023a). Trade openness, global competitiveness, and catching up between the European Union countries. *Review of International Business and Strategy*, 33(4), 691–714. [CrossRef]
- Marčeta, M., & Bojnec, Š. (2023b). What drives global competitiveness in the European Union countries? *Acta Oeconomica*, 73(3), 347–364. [CrossRef]
- Mihajlovic, V. (2025). Debt-threshold effects on growth in post-communist EU economies: Does institutional quality matter? *Post-Communist Economies*, 37(7), 770–788. [CrossRef]
- Mitrović-Mijatović, M., & Ivanović, M. (2017). Inflation in a fully-euroised economy: Could inflation differentials threaten competitiveness? *Journal of Central Banking Theory and Practice*, 6(2), 101–124. [CrossRef]
- Mulliqli, A., Adnett, N., Hisarciklilar, M., & Rizvanolli, A. (2018). Human capital and international competitiveness in Europe, with special reference to transition economies. *Eastern European Economics*, 56, 541–563. [CrossRef]
- Myant, M. (2018). Dependent capitalism and the middle-income trap in Europe na east central Europe. *International Journal of Management and Economics*, 54, 291–303. [CrossRef]
- Myant, M., & Drahokoupil, J. (2012). International integration, varieties of capitalism and resilience to crisis in transition economies. *Europe-Asia Studies*, 64(1), 1–33. [CrossRef]
- Nölke, A., & Vliegthart, A. (2009). Enlarging the varieties of capitalism: The Emergence of dependent market economies in east central Europe. *World Politics*, 61(4), 670–702. [CrossRef]
- OECD. (2020). *Strengthening governance of EU funds under cohesion policy: Administrative capacity building roadmaps*. OECD multi-level governance studies. OECD Publishing. [CrossRef]
- OECD. (2022). *Value for money in school education: Smart investments, quality outcomes, equal opportunities*. OECD Publishing. [CrossRef]
- Onofrei, M., Bostan, I., Firtescu, B. N., Roman, A., & Rusu, V. D. (2022). Public debt and economic growth in EU Countries. *Economies*, 10(10), 254. [CrossRef]
- Palinchak, M., Tsalan, M., Brenzovych, K., Kucher, A., Kajánek, T., & Grešš, M. (2021). Competitiveness as the basis of EU regional Policy: Smart specialization and sustainability. *European Journal of Sustainable Development*, 10(4), 227. [CrossRef]
- Pariboni, R., & Tridico, P. (2020). Structural change, institutions and the dynamics of labor productivity in Europe. *Journal of Evolutionary Economics*, 30(5), 1275–1300. [CrossRef]
- Pelinescu, E. (2015). The impact of human capital on economic growth. *Procedia Economics and Finance*, 22, 184–190. [CrossRef]
- Pellényi, G. M. (2020). *The role of central and eastern Europe in global value chains* (European economy economic briefs No. 062). European Commission. Available online: https://economy-finance.ec.europa.eu/publications/role-central-and-eastern-europe-global-value-chains-evidence-occupation-level-employment-data_en (accessed on 28 April 2026).

- Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. *SSRN Electronic Journal*. [CrossRef]
- Pilinkienė, V. (2016). Trade openness, economic growth and competitiveness. The case of the central and eastern European countries. *Engineering Economics*, 27(2), 185–194. [CrossRef]
- Popova, Y., & Petrov, I. (2020). *Impact of the human capital factors on the country competitiveness* (pp. 662–671). Springer. [CrossRef]
- Porter, M. E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. The Free Press.
- Pouris, A. (2025). Sensitivity of GERD/GDP to time academics spend on R&D in South Africa, 2022/2023. *South African Journal of Science*, 121(9–10), 21903. [CrossRef] [PubMed]
- Prokop, V., Stejskal, J., Klimova, V., & Zitek, V. (2021). The role of foreign technologies and R&D in innovation processes within catching-up CEE countries. *PLoS ONE*, 16(4), e0250307. [CrossRef] [PubMed]
- Rácz, S., Egyed, I., & Horeczki, R. (2025). Central and Eastern Europe: 20 Years in the European Union. *Deturope*, 17(3), 8–23. [CrossRef]
- Rusu, V. D., & Roman, A. (2018). An empirical analysis of factors affecting competitiveness of C.E.E. countries. *Economic Research-Ekonomska Istraživanja*, 31(1), 2044–2059. [CrossRef]
- Schwab, K., & WEF. (2015). *The global competitiveness report 2015–2016*. Available online: http://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf (accessed on 28 January 2026).
- Silaghi, M. I. P., Alexa, D., Jude, C., & Litan, C. (2014). Do business and public sector research and development expenditures contribute to economic growth in central and eastern European countries? A dynamic panel estimation. *Economic Modelling*, 36, 108–119. [CrossRef]
- Sinn, H. W. (2014). *The Euro trap. On bursting bubbles, budgets, and beliefs* (416p). Oxford University Press.
- Stöllinger, R. (2016). Structural change and global value chains in the EU. *Empirica*, 43(4), 801–829. [CrossRef]
- Šteinkuba, I., Barānovs, O., Salmiņš, J., & Skribāne, I. (2024). Productivity and competitiveness: Future challenges. In *Contemporary studies in economic and financial analysis* (Volume 115, pp. 83–97). Emerald Publishing Limited. Available online: <https://ideas.repec.org/h/eme/csefzz/s1569-375920240000115006.html> (accessed on 19 January 2026).
- Tijanić, L., & Obadić, A. (2015). Can we boost the competitiveness of the European union through reducing regional inequalities in human capital? *Engineering Economics*, 26(3), 295–305. [CrossRef]
- Toth, P., Tkacova, A., & Gavurova, B. (2025). The impact of public debt on economic growth: Evidence from advanced economies and the European Union. *Journal of International Studies*, 18(3), 163–178. [CrossRef]
- Török, L. (2025). Economic convergence of central and eastern European countries in the European Union. *Political Research Exchange*, 7(1), 2507633. [CrossRef]
- Wokoun, R. (2016). *Fundamentals problems of regional competitiveness and regional development factors in the Czech Republic, 19th international colloquium on regional sciences* (pp. 59–64). Masaryk University. Available online: https://www.researchgate.net/publication/304343847_Fundamentals_problems_of_regional_competitiveness_and_regional_development_factors_in_the_Czech_Republic (accessed on 8 May 2026).
- You, X., Monahan, K., Yang, W., Wei, S., & Chen, Z. (2022). How long do we wait to innovate? Understanding causal relationships between economic and innovation performance with temporal lags: Evidence from a dynamic panel of 282 cities in China. *Technology Analysis & Strategic Management*, 36(5), 841–855. [CrossRef]

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