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Financial development and innovation dynamics

Финансијски развој и динамика иновација

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Abstract

Purpose: The paper explores the relationship between financial development and innovation performance in selected economies of the Western Balkans and Central and Eastern Europe. It aims to determine whether the combination of bank-based and market-based financial development enhances national innovation capacity in transitional contexts.
Methodology: The study is based on panel data analysis covering ten countries over the period 2011–2020. It uses composite indices of financial institutions and financial markets developed by the International Monetary Fund to capture different dimensions of financial development, and the Global Innovation Index to assess innovation. To ensure methodological robustness, the study applies Feasible Generalized Least Squares, addressing heteroskedasticity, serial correlation, and cross-sectional dependence.
Findings: The results reveal that both bank-oriented and market-oriented financial structures have a positive and statistically significant effect on innovation performance. Their combined effect supports the hypothesis that a balanced and integrated financial system fosters innovation in economies undergoing structural transition.
Originality/value: The paper contributes to the literature by examining the dual role of financial systems in innovation development within under-researched transitional economies. It differentiates between institutional and market mechanisms and provides empirical support for their complementarity.
Practical implications: The findings suggest that policy efforts to develop inclusive and diversified financial systems can strengthen national innovation ecosystems. Policymakers are encouraged to adopt reforms that enhance access to financing across both banking and capital market channels.
Limitations: The study is limited by its geographic focus and the use of static models. Future research could include additional countries, dynamic modeling approaches, and qualitative assessments of financial-institutional environments.

Keywords: financial development, innovation, panel analysis, banking sector, capital markets.
JEL classification: G20, O31, C33

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Сажетак

Циљ: Рад испитује однос између финансијског развоја и иновационог учинка у одабраним економијама Западног Балкана и Централне и Источне Европе. Циљ је да се утврди да ли комбинација банкарски и тржишно оријентисаног финансијског развоја подстиче иновациони капацитет у транзиционим економијама.
Методологија: Истраживање се заснива на панел анализи података за десет земаља у периоду од 2011. до 2020. године. Користе се саставни индекси финансијских институција и финансијских тржишта, које је развио Међународни монетарни фонд, као мере финансијског развоја, и Глобални индекс иновација као мера иновационог учинка. За обезбеђивање методолошке поузданости примењена је метода изводљивих генерализованих најмањих квадрата (FGLS), која коригује хетероскедастичност, серијску корелацију и унакрсну зависност.
Резултати: Резултати показују да банкарски и тржишни финансијски системи имају позитиван и статистички значајан утицај на иновациони учинак. Њихов комбиновани ефекат потврђује хипотезу да уравнотежен финансијски систем подстиче иновације у економијама у транзицији.
Оригиналност/вредност: Рад доприноси литератури анализом двоструке улоге финансијског система у развоју иновација у недовољно истраженим транзиционим економијама. Разликује институционалне и тржишне механизме и емпиријски потврђује њихову комплементарност.
Практичне импликације: Резултати указују да реформе које подстичу развој инклузивног и диверсификованог финансијског система могу оснажити националне иновационе екосистеме. Препоручује се унапређење приступа финансирању у оба сегмента, банкарском и тржишном.
Ограничења: Истраживање је ограничено на одређен географски оквир и примену статичког модела. Будућа истраживања могу обухватити шири узорак, динамичке моделе и квалитативне анализе институционалног окружења.

Кључне речи: финансијски развој, иновације, панел анализа, банкарски сектор, тржишта капитала.
ЈЕЛ класификација: G20, O31, C33

Introduction

The interplay between financial development and innovation remains a pivotal area of research in contemporary economics, with significant implications for long-term competitiveness and sustainable growth. As economies across the globe increasingly transition toward knowledge-based and innovation-driven systems, understanding the mechanisms through which financial structures influence innovation becomes essential. This is especially relevant for countries in transition, where institutional frameworks and financial markets are still evolving, and where innovation is viewed as a catalyst for economic modernization and integration.

This study focuses on the Western Balkan Countries (WBC) and Central and Eastern European Countries (CEEC), which have undergone substantial economic, political, and institutional transformations since the early 1990s. Despite their common post-socialist legacy and ongoing efforts to integrate into the European Union, these countries exhibit considerable diversity in terms of financial system development and innovation performance. While some have succeeded in building relatively mature financial infrastructures, others continue to face challenges such as underdeveloped capital markets, limited access to financing, and fragmented innovation systems.

In many cases, financial intermediation in these countries remains dominated by the banking sector, while market-based financing mechanisms, such as equity and bond markets, are often underutilized. This raises an important research and policy question: how do different financial architectures, specifically bank-oriented and market-oriented systems, affect innovation performance in transitional economies? Financial development has been identified as a key driver of innovation in various empirical studies. For instance, Levine (2005) emphasized the role of banks in mobilizing savings and allocating resources toward productive investment, while Le et al. (2019) showed that both financial depth and market sophistication contribute to innovation outcomes. Yet, the extent to which these effects interact and complement each other in post-transition countries remains insufficiently explored.

This paper addresses that gap by empirically examining the relationship between financial development and innovation in a panel of ten countries from the WBC and CEEC regions. It contributes to the literature by distinguishing between bank-based and market-based financial development, and by assessing their individual and combined effects on innovation capacity. The analysis relies on two composite indicators developed by the International Monetary Fund (IMF), the Index of Financial Institutions (IFI) and the Financial Markets Index (FMI), to measure the depth, efficiency, and accessibility of financial systems. Innovation performance is captured using the Global Innovation Index (GII), which offers a multidimensional framework for assessing a country's innovation ecosystem.

By applying robust panel data techniques and focusing on a region that remains underrepresented in the empirical literature, this study seeks to provide evidence-based insights that are relevant for both scholars and policymakers. In particular, it examines whether the coexistence and interaction of different financial structures can foster a more dynamic and sustainable innovation environment in transition economies.

The remainder of the paper is structured as follows. First, the relevant theoretical and empirical literature on the relationship between financial development and innovation is reviewed. This is followed by a description of the research methodology, including the data sources and indicators used for analysis. Next, the key empirical findings are presented and interpreted. Finally, the paper concludes with a discussion of the main implications, offering policy recommendations and suggestions for future research.

1. Literature Review

The nexus between financial development and innovation has become an increasingly important field of study, especially as countries seek to modernize their economies and enhance long-term competitiveness. In the context of global structural changes and the shift toward knowledge-intensive industries, both academic researchers and policymakers have recognized the enabling role of finance in stimulating innovation. At its core, financial development improves the efficiency of capital allocation, reduces transaction and information costs, and facilitates investment in long-term, high-risk projects, characteristics closely associated with innovation activities. As Gomes (2023) notes, the growth process itself is fueled by the generation and propagation of ideas, supported by the dynamic between

basic and applied research, and between radical and incremental innovation, domains often reliant on appropriate financial support structures. Levine (1997; 2005) emphasizes that financial intermediaries and capital markets play a central role in facilitating innovation and economic growth. By efficiently allocating capital, evaluating investment opportunities, and managing risk, the financial system contributes to technological advancement and long-term productivity gains.

The conceptual distinction between bank-based and market-based financial systems plays a central role in analyzing how finance influences innovation outcomes. Banks are typically associated with relationship-based financing, offering long-term loans, credit monitoring, and support for early-stage R&D activities. They are particularly suited to environments where information asymmetry is high and where innovation requires gradual investment and oversight. In contrast, capital markets facilitate access to equity financing, risk diversification, and liquidity, making them more appropriate for scaling up and commercializing innovations. As noted by Kapidani and Luci (2019), bank-based and market-based financial systems influence innovation through distinct mechanisms, reflecting functional differences rather than any inherent superiority. While capital markets offer flexibility and broader participation, banks provide stability and control. However, the stabilizing role of banks may depend on their level of capitalization. Novotna, Stiblarova, and Kocisova (2024) find that the positive relationship between market concentration and banking stability in the Euro Area becomes statistically significant only when banks are sufficiently capitalized. Their findings underscore that prudential regulation, particularly compliance with capital adequacy standards, plays a key role in strengthening systemic resilience, which, in the context of less mature financial systems, may represent an essential condition for sustainable innovation financing.

Empirical evidence increasingly supports the complementary nature of these two financial architectures. Le et al. (2019), in their study on emerging Asian economies, find that financial institutions and markets both positively affect innovation, but through different transmission channels. Similarly, Rey (2022) emphasizes the importance of capital market depth and macroeconomic stability in fostering innovation ecosystems. Levine (2005) shows that banks are instrumental in mitigating credit risk at the early stages of innovation, whereas capital markets drive innovation by supporting high-growth firms and financing scale-intensive industries. These findings underline that the integration of bank-oriented and market-oriented finance could provide a more holistic support system for the entire innovation process, from idea to market implementation. A similar pattern is observed in the Western Balkan countries, where financial development, especially improved credit access and interest rate mechanisms, has a significant impact on economic growth, reinforcing the role of finance as a driver of structural transformation (Bilalli, Beka, & Gara, 2023).

Nonetheless, the effectiveness of each model appears to be context-specific and influenced by the maturity of institutions, legal frameworks, and financial infrastructure. Kapidani and Luci (2019) argue that the combination of these financial channels does not always yield linear results, particularly in transitional economies where governance structures may still be fragile. In some contexts, the dominance of one system over the other has led to resource misallocation or underutilization of innovation potential. Therefore, a

balanced financial structure, where both banks and capital markets are developed and function synergistically, may offer the most robust foundation for supporting national innovation capacity.

In the specific context of the WBC and CEEC, the question of how financial development shapes innovation becomes even more pressing. These countries have undergone deep transformations over the past three decades, transitioning from centrally planned to market-oriented systems. However, the development of financial systems in these regions has not always kept pace with innovation needs. According to Uvalić and Cvijanović (2018), many countries in the region continue to suffer from insufficient integration of financial and innovation policies, resulting in fragmented systems and limited entrepreneurial support. Capital markets remain underdeveloped, while banking sectors, though dominant, are often characterized by high foreign ownership and risk aversion. This structural weakness has been confirmed for the Serbian context as well, where institutional inefficiencies and regulatory bottlenecks continue to hinder capital market development (Petrović, Orlandić, & Marković, 2024).

Several studies point to the need for strengthening both financial pillars in the region. Vangjel and Mamo (2022) stress that a well-structured financial sector is essential for promoting entrepreneurship and technology transfer in the Western Balkans. Popović and Erić (2018) highlight that attracting foreign direct investment and implementing targeted financial reforms can improve the innovation environment. Despotović et al. (2014) link the effectiveness of innovation policy to financial support mechanisms, particularly in terms of competitiveness and SME development. Ziberi and Alili (2021) further emphasize that the structure and maturity of financial markets influence the extent to which financial development translates into innovation output.

Despite the growing body of literature that acknowledges the roles of banks and markets in fostering innovation, a crucial analytical gap remains, particularly for transitional economies. While prior studies have often isolated the effects of either bank-based or market-based financial development, few have examined their combined and potentially complementary influence on innovation outcomes. This omission is especially significant in the context of WBC and CEEC, where both financial segments are still in the process of institutional consolidation and may function in interdependent ways.

The reviewed theoretical perspectives and empirical findings suggest that a synergistic interaction between banking and market finance could provide a more comprehensive support system for innovation, encompassing both early-stage development and large-scale implementation. In light of these insights, and in response to the institutional and financial realities of the studied regions, this paper formulates and tests the following hypothesis:

H_1: The interaction between bank-oriented and market-oriented financial development has a statistically significant and positive effect on innovation performance.

This hypothesis reflects the theoretical proposition that a balanced and integrated financial structure, where institutions and markets complement rather than substitute one

another, can enhance innovation outcomes more effectively than either channel alone. By empirically testing this assumption, the study aims to extend existing knowledge and offer policy-relevant findings that resonate with the specific challenges and opportunities present in transitional economies.

2. Methodology of empirical research

The study includes Albania, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Hungary, North Macedonia, Poland, Serbia, and Romania as sample countries. These nations have been selected based on their shared historical trajectory from socialist to market-oriented economies. This transition provides a compelling context for examining the interplay between financial development and innovation capabilities. Each country in the sample presents a unique blend of historical, economic, and social dynamics but shares a significant pathway of economic reforms and integration into European and global markets. This commonality is crucial for analyzing how similar starting conditions influence diverse developmental paths in financial structures and innovative capacities across the CEEC and WBC. These nations offer a spectrum of financial systems, predominantly dominated by banking sectors, along with varied levels of innovation output and infrastructure. The dominance of the banking sector in these countries is largely attributed to historical factors, such as the absence of well-functioning, transparent, and efficient capital markets, which has positioned banks as pivotal mediums for financial intermediation. As these nations have progressed through their economic transitions, many have initiated efforts to establish stock market systems and promote stock exchange participation. Despite these developments, their financial systems remain predominantly bank-centric, characterized by significant foreign bank ownership.

Additionally, another trend worth noting in both groups of countries is the presence of relatively modest innovative potential and the concentration of technological infrastructure. Despite collaborative efforts to enhance innovative infrastructure, several systemic challenges persist, including strong state intervention, limited competitive dynamics, lack of private initiatives, and suboptimal conditions for fostering innovation.

The dataset used in this study covers the period from 2011 to 2020, allowing for a longitudinal assessment of financial development and innovation dynamics in the selected countries.

In the study, two indices of financial development are used to capture distinct aspects of financial systems within the sample countries: the Index of Financial Institutions (IFI) and the Financial Markets Index (FMI), representing banking-oriented and market-oriented financial development, respectively. Both indices are components of the broader Financial Development Index (FDI) constructed by the International Monetary Fund (IMF), and the data for IFI and FMI were obtained from the IMF Financial Development Database (IMF, n.d.; Svirydzenka, 2016). This bifurcated approach allows for a detailed analysis of how both institutional and market mechanisms contribute to financial development. The IFI focuses on the depth, efficiency, and accessibility of banks and other financial institutions, measuring factors such as the size and liquidity of banks, the diversity of financial services available,

and the efficiency with which these institutions operate. The FMI, on the other hand, evaluates the development of financial markets, including stock exchanges and bond markets, providing insights into market size, liquidity, and the diversity of financial instruments available. The holistic nature of indices allows for a nuanced evaluation of financial systems, emphasizing the multifaceted nature of financial development (Svirydzenka, 2016).

Furthermore, to capture the innovation landscape, the study utilizes the GII, a leading measure for evaluating the innovation capabilities and achievements of countries. Developed by the World Intellectual Property Organization (WIPO), the data used in this study were extracted from the WIPO Global Innovation Index database (WIPO, n.d.). The GII provides a comprehensive view of innovation, taking into account various factors that contribute to a country's innovation performance, including technological advancements, creative outputs, business sophistication, and infrastructural development. It is recognized as a significant reference for national innovation assessments, offering insights that extend beyond conventional innovation measures (Bilic et al., 2018).

By integrating these indices into our analytical framework, the study aims to explore the relationship between financial development and innovation capacity. The inclusion of both the FDI and GII in our methodology supports a broader understanding of how well-developed financial systems can facilitate or hinder the innovation environment in transitioning economies. This approach is intended to provide a deeper insight into the mechanisms through which financial and innovation ecosystems interact, potentially influencing overall economic growth and development.

Table 1 presents a comprehensive statistical analysis of the variables - GII, IFI, and FMI. The analysis includes both descriptive statistics and correlation measures, enabling us to draw substantive conclusions regarding the dataset's characteristics. For the GII, the arithmetic mean and median are closely aligned, suggesting a symmetric distribution. This proximity indicates that the innovation performance across the sampled countries does not exhibit extreme variation, with most countries clustering around the central tendency. The standard deviation is moderate, which confirms the spread around the mean is not excessively wide, suggesting relative consistency in innovation performance across nations. The IFI data show a mild right skew, as evidenced by a significant result from the Jarque-Bera test, confirming a deviation from normality. This skew indicates that while most countries have moderately developed financial institutions, a few outliers possess highly developed financial institutions, which tilt the distribution rightward. Conversely, the FMI is characterized by a significant right skew, with a distribution that deviates markedly from normality, confirmed by a robust Jarque-Bera test result. This indicates the presence of extreme values at the higher end of financial market development, suggesting that some countries have exceptionally developed financial markets compared to other countries.

The correlation analysis reveals a moderate positive correlation of 0.3733 between GII and IFI. This correlation suggests a positive association where countries with more developed financial institutions tend to exhibit better innovation performance, albeit the relationship is not particularly strong. In contrast, a much stronger correlation of 0.7914

between GII and FMI indicates a robust positive relationship, suggesting that better-developed financial markets are closely associated with higher levels of innovation.

Finally, the correlation between IFI and FMI stands at 0.2919, indicating a weak positive relationship. This finding suggests that the development of financial institutions and markets may occur somewhat independently within different national contexts. The relatively low correlation further implies that the inclusion of both IFI and FMI in regression models would not result in significant multicollinearity, facilitating accurate and independent evaluations of each variable's impact on innovation performance.

Table 1: Descriptive statistics and Correlation matrix of the variables

Variables	*GII*	*IFI*	*FMI*
Mean	38.40664	0.508619	0.164498
Median	38.06000	0.493166	0.062972
Minimum	23.10000	0.357028	0,000636
Maximum	51.30000	0.688055	0,591462
St. Dev.	6.003439	0.092257	0,168915
Skewness	0.127018	0.603725	0,594831
Kurtosis	2.618913	2.427583	1,844188
Jarque-Bera	0.961407	8.183990	12,60966
Probability	0.618348	0.016706	0,001827
Obs.	110	110	110
Correlation			
Variables			
GII	1		
IFI	0,3733	1	
FMI	0,7914	0,2919	1

Source: Authors' calculations

Overall, these statistical insights highlight the nuanced relationships between financial development and innovation across countries, providing a solid foundation for further analysis.

Panel datasets often manifest cross-sectional dependence, which is influenced by the nature of the dependency across sections as well as the level of inter-sectional correlations (De Hoyos & Sarafidis, 2006). This phenomenon introduces complexities when assessing the stationarity of data (Shariff & Hamzah, 2015). Therefore, it is crucial to address cross-sectional dependence to select the proper tests for analyzing the order of data integration and for evaluating the robustness of the resulting model. To this end, the analysis of cross-sectional dependence will utilize the Breusch–Pagan LM test and the Pesaran-scaled LM test, acknowledging that standard LM tests may be biased in certain panel settings (Baltagi, Feng, & Kao, 2012).

Given the high degree of interactivity in the functioning of the economies of the countries under study, the effects of spatial spillover, which is one of the causes of cross-sectional dependence, are becoming increasingly apparent. Consequently, it is assumed that the panel data will exhibit cross-sectional dependence, necessitating the use of second-

generation unit root tests to assess the nature of the series' stationarity. Pesaran (2007) introduced a unit root test known as the IPS test with cross-section adjustment. In this study, the CIPS test will be applied, which utilizes an extended version of the Dickey-Fuller statistic adjusted for cross-sectional dependence.

This study will employ a static panel model due to the limited number of observations available. This approach is particularly relevant given the characteristics of the data derived from GII. Until 2009, the GII utilized a scoring system ranging from 1 to 5 to assess the innovation performance of countries. However, the scoring system was later expanded to a range from 0 to 100, enabling a more detailed and nuanced assessment of innovation capabilities. Such adjustments in scoring methodologies are common as organizations strive to improve the precision and relevance of their indices over time.

To analyze the static panel model, the study will initially explore three common approaches: pooled ordinary least squares (OLS), fixed effects, and random effects models. Among these, the pooled OLS method is often critiqued for its inability to account for unobserved heterogeneity, as it neglects variations between countries and assumes uniformity across all observations (Asteriou & Hall, 2021). Recognizing this limitation, the study will evaluate the fixed and random effects models to account for entity-specific characteristics.

The Hausman test will determine whether the fixed or random effects model is more appropriate. If the null hypothesis of no correlation is rejected, the fixed effects model will be used; otherwise, the random effects model will be preferred (Kennedy, 2008). Additionally, diagnostic tests, including the Wald test (heteroscedasticity), Wooldridge test (serial correlation), and Pesaran CD test (cross-sectional dependence), will be conducted. If violations of classical regression assumptions are detected, the study will apply Feasible Generalized Least Squares (FGLS) for robustness. FGLS will be utilized to correct for heteroscedasticity and autocorrelation, ensuring efficient and unbiased parameter estimation. Unlike fixed or random effects models, which address specific structural features of panel data, FGLS adapts to correct for issues such as non-constant variance and correlated errors across time or entities (Baltagi, 2008). This flexibility makes it particularly well-suited for analyzing the nuanced interplay between financial development and innovation, as these relationships are likely influenced by complex, non-uniform dynamics across countries.

The strength of FGLS lies in its ability to estimate the variance-covariance matrix of error terms feasibly and incorporate these adjustments into the model. For example, if the Wald test identifies heteroscedasticity, FGLS will transform the model to stabilize the variance across observations. Similarly, if the Wooldridge test detects serial correlation, FGLS will account for the correlation patterns within entities over time. Furthermore, if cross-sectional dependence is detected through the Pesaran CD test, FGLS will adjust for correlations among countries, enhancing the reliability of parameter estimates (Asteriou & Hall, 2021; Vangjel & Mamo, 2022).

By adopting this methodological framework, the study aims to provide robust insights into the role of financial development in driving innovation. FGLS will not only address diagnostic challenges but also facilitate a nuanced understanding of the economic contexts

of WBC and CEEC. This approach ensures that the findings are statistically reliable, policy-relevant, and theoretically informed.

3. Results and Discussion

In line with the findings from the Breusch–Pagan LM and Pesaran-scaled LM tests, as presented in Table 2, there is compelling evidence of cross-sectional dependence. This evidence suggests that the economies of the countries under study are intricately integrated, which enhances the likelihood of spatial spillover effects. As a result, when a disturbance occurs in one country, it is likely to have repercussions in others. Consequently, these results provide a strong justification for the use of second-generation unit root tests, which are designed to specifically address cross-sectional dependencies.

Table 2: Cross-sectional dependence test results

	Breusch–Pagan LM		*Pesaran-scaled LM*	
Dependent variable	Statistic	Probability	Statistic	Probability
GII	154.2209	0.0000	11.51289	0.0000

Source: Authors' calculations

Table 3 presents the outcomes of the CIPS test, demonstrating that while all variables exhibit non-stationarity when analyzed at their levels, they achieve stationarity upon first differencing. This transformation indicates that the variables, although initially non-stationary, stabilize and exhibit consistent statistical properties over time when first differences are considered.

Table 3: Unit root test results

Variables	*GII*	*IFI*	*FMI*
CIPS (level)	-2.148	-2.009	-2.166
CIPS (first difference)	-3.247*	-2.305*	-2.936*
*Note: * symbolizes the rejection of the null hypothesis of unit root*			

Source: Authors' calculations

In assessing the impact of financial development on the innovativeness of countries using panel data, fixed and random effects methods were employed, and the Hausman test was applied to identify the more efficient and consistent method. Table 4 displays the results of the random effects method, suggesting that the Hausman test fails to reject the null hypothesis, leading to the conclusion that the estimation of random effects is more appropriate. However, before interpreting the results, it is necessary to conduct additional diagnostic tests. Tests, including group-wise heteroscedasticity, serial correlation, and examining cross-sectional independence, aim to examine the reliability of the model outcomes. Conducting diagnostic tests is crucial for ensuring the robustness and credibility of the findings derived from the random effects estimation methods.

Table 4: Results of random effects methods

Dependent variable GII	*Coefficients*	*p-value*
IFI	6.154424	0.465
FMI	25.92045	0.000
R-sq within	0.0883	
R-sq between	0.7324	
R-sq overall	0.6456	
Hausman test	0.38	0.8280

Source: Authors' calculations

The results of the diagnostic tests are presented in Table 5, which shows the outcomes of the Pesaran CD test, the Wald test for heteroscedasticity, and the Wooldridge test for detecting serial correlation. Specifically, the Wald test yields a test statistic of approximately 77.400 and a p-value of 0.0000, strongly indicating the presence of group-wise heteroscedasticity in the data. This suggests that the error variances are not constant across different groups within the panel. Additionally, the Wooldridge test for autocorrelation presents a test statistic of F(1, 9) = 32.006 with a p-value of 0.0003, confirming the presence of autocorrelation in the panel data. This result implies that there are serial correlations in the error terms across different time periods. Furthermore, the Pesaran CD test shows strong evidence of cross-sectional dependence with a test statistic of 10.740 and a p-value of 0.0000.

Because of these issues, the standard errors of the estimated coefficients may be incorrect, impacting the statistical significance of the coefficient IFI in Table 4. In this context, the lack of statistical significance for one of the coefficients could be attributed to these econometric problems. The inflated or deflated standard errors may lead to incorrect conclusions about the significance of the coefficient. Additionally, broader systemic disruptions may have compounded these econometric challenges. For instance, Pavlović (2024) demonstrates that the COVID-19 pandemic had a depreciating effect on human capital in Serbian banks, leading to short-term instability and long-term erosion of performance. Such context-specific volatility in banking efficiency could partially explain the inconsistent statistical behavior of the IFI variable.

Table 5: Diagnostic test results

Test	*Statistics*	*p-value*	*Indication*
Pesaran CD	10.740	<0.0001	Presence of cross-sectional dependence
Wald test	7.74e+04	0.0000	Presence of group heteroscedasticity
Wooldridge test	F(1, 9) = 32.006	0.0003	Presence of autocorrelation

Source: Authors' calculations

The outcomes of the diagnostic tests conducted on the panel data have significant implications for the reliability of the random effects method initially employed. Given these results, it is evident that the random effects model's results are compromised and unreliable. The presence of group heteroscedasticity, autocorrelation, and cross-sectional dependence in the panel data undermines the assumptions underpinning the random effects method,

potentially leading to biased and inefficient estimates. Consequently, the assessment of the interaction effects of bank-oriented and market-oriented financial development on countries' innovation was conducted using FGLS. FGLS adjusts for heteroscedasticity and autocorrelation within the panel data, thereby providing more robust and reliable estimates. Moreover, it accounts for the cross-sectional dependence identified in the data, ensuring that the interconnections among the different units in the panel are appropriately considered in the analysis.

Table 6 presents the results of the FGLS regression, which accounts for heteroscedasticity and cross-sectional dependence, using a common AR(1) autocorrelation coefficient among the panels. The analysis, based on 110 observations, yields statistically significant results, as evidenced by a Wald chi2 statistic of 942.64 with a corresponding p-value of 0.0000. The robust significance level underscores the reliability of the model in capturing the dynamics of the studied relationship. The coefficient for IFI is 10.79964 with a p-value of 0.0000, indicating a highly significant positive relationship between IFI and GII. Practically, the result suggests that improvements in the depth, efficiency, and accessibility of banking sector services are associated with a substantial increase in a country's innovation capacity. Specifically, an increase of one unit in IFI is associated with an approximate increase of 10.80 in GII, holding other factors constant. The 95% confidence interval for this coefficient ranges from 7.29208 to 14.3072, reinforcing the precision of the estimate. A more pronounced effect is observed with the FMI. The estimated coefficient of 26.51352 and a p-value of zero indicate a highly significant relationship with GII. The coefficient implies that for every one-unit increase in FMI, there is an associated increase of approximately 26.51 in GII. The results suggest that the depth, efficiency, and accessibility of capital markets, as captured by FMI, play a crucial role in fostering the innovation ecosystem of economies. In conclusion, the results of the FGLS regression analysis provide compelling evidence of a positive and statistically significant relationship between the structures of the financial system (both banking and capital markets) and the innovation capacity of countries. The coefficient magnitudes for both IFI and FMI emphasize the critical role these financial indices play in shaping the innovation landscape.

Table 6: FGLS Results

Variables (Dependent Variable: GII)	Coefficients	p-value	95% Confidence Interval
IFI	10.79964	0.0000	7.29208 14.3072
FMI	26.51352	0.0000	24.8065 28.22055
Wald chi2	942.64	0.0000	
Notes: Coefficients: Generalized Least Squares; Panels: Heteroskedastic with Cross-Sectional Correlation; Correlation: Common AR(1) Coefficient for All Panels			

Source: Authors' calculations

Given the corrective nature of the FGLS approach, the need for additional corrective and diagnostic testing post-estimation is significantly reduced. In traditional regression frameworks, such tests are imperative to confirm the absence of issues like heteroskedasticity or autocorrelation, which could invalidate the results. However, with FGLS, these problems are preemptively addressed during the estimation process. Consequently, the focus shifts

from diagnosing and resolving these issues to ensuring the robustness of the model specification and the accuracy of data input from the outset. Therefore, corrective and diagnostic tests are not required for testing the model as FGLS is employed as a solution (Olive, 2017).

The hypothesis that the interaction between banking-oriented and market-oriented financial development has a statistically significant and positive effect on innovation performance has been confirmed. The results suggest that both banking-oriented and market-oriented financial development play a crucial role in enhancing the innovation performance of WBC and CEEC, as measured through GII. The findings indicate a synergistic effect, where both parts of the financial system complement each other. While banks provide necessary funds and support for initial research and development, capital markets facilitate the growth and scaling of innovative ideas by offering broader financing avenues and liquidity options. These factors collectively create a favorable environment for innovation. The observed positive effects of the IFI and FMI on the GII demonstrate how these dual aspects of financial development interact to support innovative activities. Previous studies align with these findings, illustrating how the convergence of financial sectors enhances innovation. Mullineux (2007) argues that the integration of banking and capital markets improves corporate governance, reduces market frictions, and creates a more conducive environment for innovation. A well-integrated financial system, combining banking functions and market mechanisms, facilitates more efficient capital allocation and risk management, which are essential for sustaining innovation. This supports the observed synergistic effect in WBC and CEEC, where both sectors significantly contribute to innovation-driven growth. Moreover, Laureti,Costantiello, and Leogrande (2020) emphasize that financial accessibility plays a pivotal role in fostering innovation, particularly in European nations with advanced financial institutions. Their findings illustrate how the integration of banking- and market-oriented development enhances access to diverse funding sources, enabling firms to invest in innovative activities. Similarly, Janković (2019) highlights that in Serbia, Croatia, and Slovenia, banking institutions remain dominant financial intermediaries, while capital markets are still underdeveloped. The study emphasizes that strengthening both financial institutions and market mechanisms is crucial for long-term economic development. This underscores the critical role of a coherent financial system in driving innovation and aligns with the observed positive impacts of IFI and FMI in this study. Although the results emphasize the importance of banking sector and capital market development in fostering innovation, they must be contextualized within a broader spectrum of research. Specifically, Le et al. (2019) found no significant impact of the interaction between these sectors on innovation. Similarly, Kapidani and Luci (2019) suggest that combined analysis of banking and non-banking institutions (including stock markets) can be ineffective in channeling capital flows toward innovative practices. In line with this diversity, Tee et al. (2014) provide evidence from East Asian countries, emphasizing the differing roles of financial systems in fostering innovation. Their study demonstrates that banking sector development significantly enhances innovation, particularly in supporting patent applications and other inventive activities. In contrast, the stock market's role appears less influential in the same context, suggesting that the banking sector often serves as the primary driver of innovation funding, especially in economies where stock markets are still

emerging. These findings reinforce the importance of context when analyzing the financial-innovation nexus, as the relative contributions of banking and market-oriented systems may vary depending on economic and institutional development. In the established model, the GII's comprehensive assessment of innovation performance might explain the differing outcomes compared to studies using patent applications as the primary metric. While patent counts are a direct measure of innovation output, the GII captures a broader innovation ecosystem, including institutional quality, human capital, infrastructure, market sophistication, and knowledge outputs. This holistic approach reveals the impacts of financial development that may not be immediately apparent when focusing solely on patents. Grabowski and Maciejczyk-Bujnowicz (2016), in their study of the Polish economy, demonstrate that financial development fosters innovation when both banking and market mechanisms are effectively utilized. Their findings support the notion that a coordinated financial system lowers barriers to funding and increases financial inclusivity, which are critical for fostering innovation. Similarly, Melnyk, Melnychenko and Reznikova (2019) reinforce this argument by showing how an integrated financial system reduces transaction costs and allows a more streamlined capital flow, underscoring the importance of leveraging both banking and market mechanisms to create a stable, accessible environment for innovation. The investigation into the interaction between banking-oriented financial development and capital markets reveals an essential, previously underexplored avenue in understanding how financial systems influence innovation. Empirical evidence highlights a significant, positive relationship between IFI and FMI with overall innovation, as these elements of financial development interact to stimulate economic growth and foster innovative outputs. This synergistic effect suggests that financial systems encompassing both banking and capital market mechanisms are better positioned to support comprehensive innovation outcomes. For WBC and CEEC, where financial structures are still evolving to achieve an optimal balance, these findings are particularly relevant. A strategic approach that equally emphasizes the growth of the banking sector and the development of capital markets could lead to broader innovation benefits, as opposed to strategies that prioritize one aspect of the financial system. By recognizing the value of a dual-focused financial approach, policymakers can effectively harness the strengths of both banking and market-oriented institutions. This dual development facilitates greater capital accessibility and liquidity for innovative firms, providing resources necessary for early-stage research and development, as well as growth-phase expansion supported by capital market liquidity. Furthermore, the approach of balancing banking sector and capital market growth counters traditional models that might prioritize banking over market development or vice versa. Metrics such as patent applications often overlook broader dimensions of the innovation ecosystem. The GII, by capturing a range of innovation activities—including institutional quality, human capital, infrastructure, market sophistication, and technology outputs—offers a more holistic view of the innovation landscape, particularly in dynamic financial contexts. Ultimately, understanding that various aspects of financial development impact different types of innovation outcomes allow policymakers to tailor their strategies more precisely. By aligning financial development policies with specific national goals for innovation and economic growth, countries can stimulate innovation across sectors, making the most of their unique financial and economic conditions. For WBC and CEEC, where the need for a balanced,

integrated approach to financial development is prominent, adopting policies that advance both banking and capital market functions offers a pathway to cultivating a sustainable and diversified innovation landscape.

Conclusion

The study has provided valuable insights into the critical interplay between financial development and innovation within the specific contexts of WBC and CEEC. Using a robust empirical framework based on panel data analysis, the findings underscore the importance of both banking-oriented and market-oriented financial development in fostering national innovation capabilities, as measured by GII. The results reveal that both IFI and FMI contribute significantly to innovation. These findings confirm the central hypothesis of this study (H_1), which proposed that the interaction between bank-oriented and market-oriented financial development has a statistically significant and positive effect on innovation performance. Specifically, the analysis highlights the complementary nature of these two components: while banking institutions are instrumental in supporting early-stage research and development activities, financial markets play a pivotal role in scaling and commercializing innovative ideas. This dual mechanism not only bolsters national innovation ecosystems but also enhances economic dynamism and competitiveness. The use of FGLS method to address issues such as heteroscedasticity, serial correlation, and cross-sectional dependence has ensured that the conclusions drawn are both statistically robust and reliable. By correcting these econometric challenges, the study has provided a nuanced and comprehensive understanding of how financial systems interact with innovation, particularly in transition countries.

These findings carry significant policy implications. For countries in WBC and CEEC, where financial infrastructure is still maturing, a balanced and coordinated approach to financial development is essential. Policymakers should aim to (1) strengthen access to long-term financing for SMEs and startups, particularly by expanding credit guarantee schemes; (2) foster financial literacy and investor confidence to deepen capital markets through education and regulatory reform; and (3) promote public-private co-financing mechanisms, including innovation vouchers and state-matching grants, to reduce risk and encourage private investment in innovation. Collaboration between banking and capital market institutions, through blended finance models or innovation-focused credit lines, can significantly improve capital allocation and innovation diffusion.

Beyond economics, the broader societal relevance of this study lies in its contribution to innovation policy, higher education, and entrepreneurial development. Encouraging an inclusive and dynamic financial ecosystem supports not only R&D investment but also the broader culture of innovation, which is essential for human capital development, institutional modernization, and technological resilience.

The study also reaffirms the importance of adopting comprehensive innovation metrics. Unlike traditional proxies such as patent counts, the GII captures a more holistic innovation landscape, including institutional quality, infrastructure, and market sophistication, offering more actionable insights for decision-makers across sectors.

While the findings are compelling, this study acknowledges several limitations. First, expanding the scope to include additional regions could reveal comparative effects of financial architectures on innovation. Second, applying dynamic panel models might uncover lagged or time-sensitive relationships. Third, incorporating qualitative insights from case studies or stakeholder interviews could offer deeper contextual understanding of how financial mechanisms operate on the ground.

In conclusion, this study contributes to the growing body of literature on the finance-innovation nexus by providing empirical evidence of the significant and synergistic roles played by banking-oriented and market-oriented financial development. For WBC and CEEC, leveraging this dual approach offers a strategic pathway to achieving sustainable innovation and long-term economic growth. By fostering inclusive, diversified, and well-integrated financial systems, these countries can position themselves as dynamic innovation-driven economies in the increasingly competitive global landscape.

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