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Modeling the Nexus Between Technological Innovations and Institutional Quality for Entrepreneurial Development in Southeastern Europe

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Abstract: Entrepreneurship has been critical in fostering economic growth. The technological innovations and quality of institutions are crucial in promoting entrepreneurship and promoting an environment conducive to entrepreneurial activities. This study investigated the effect of technological innovations and institutional quality on entrepreneurial development with annual data from 2014 to 2021 across Southeastern European countries. The cross-sectional auto-regressive regressive distributed lag model (C-S ARDL), quantile regression and Granger causality were employed to achieve the objectives of this study. A dynamic panel generalized method of moments (GMM) estimator was also applied to perform a robust analysis. The findings revealed a significant long-term relationship between technological innovations and entrepreneurial development, with a coefficient of 0.088. There also exists a significant and positive impact on institutional quality and entrepreneurial development in the long run, with a coefficient of 5.912. Furthermore, the outcome revealed that the exchange rate negatively influences entrepreneurial development in Southeast Europe. The Granger causality reports a bi-directional relationship between technological innovations and entrepreneurial development in Southeastern Europe. The study concluded that a significant relationship exists between technological innovations, institutional quality, and entrepreneurial development in Southeastern Europe. The study recommends that governments of Southeastern European countries strengthen their regulatory structures and institutions to improve the welfare of society through a reduction in political, social, and economic unpredictability while boosting trust and investment from entrepreneurs.

Keywords: technological innovations; institutional quality; entrepreneurial development; ease of doing business; southeastern Europe

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1. Introduction

The influence of entrepreneurial development on the economic growth of both developing and developed nations cannot be over-emphasized. Entrepreneurial development is perceived to be the grease for economic development because a business-friendly environment enhances the growth of any economy [1]. Entrepreneurs play an important role in economic development and contribute significantly to employment generation and productivity. Therefore, entrepreneurial development is an essential determinant that directly influences economic growth, the investment climate, and the general business environment [2].

Several countries have continued establishing plans and programs supporting entrepreneurship within their communities [3]. Governments of most developed countries have invested extensive financial and material resources in promulgating policies with the aim of uplifting entrepreneurship [4]. For instance, Ref. [5] asserted that the government of the United States of America insisted that all universities include entrepreneurship training in the curriculum of all courses, allowing all students to learn about entrepreneurship before graduation. A study conducted in Pakistan by [6] affirms that students in higher institutions have benefited from the entrepreneur education curriculum. On the other hand, Ref. [7] opined that China, Brazil, Saudi Arabia, and Malaysia have various entrepreneurship programs established to create a suitable environment for the growth of small and medium-scale enterprises. Recent literature has emphasized how entrepreneurial education addresses the practical requirements and strong influence on entrepreneurship [8–10]. However, this feat has yet to be implemented in other countries, especially Southeastern European countries, Indonesia, and Ethiopia, where entrepreneurship education is still in its infancy [11–14].

These are countries where the need for entrepreneurship is most significant, but the supply of entrepreneurship teachers and role models is undermined.

Similarly, policies such as regulatory reforms and strengthened legal institutions were implemented to enhance the ease of doing business. However, Southeast Europe (SEE) countries need to perform better regarding their ease of doing business ranking. In the 2019 World Bank ranking of 190 countries, none of the countries in the region was ranked among the top 15 countries for ease of doing business [14,15].

Meanwhile, it is anticipated that technology development could be a strategy whose implementation can improve entrepreneurial development. Affirming this supposition, Ref. [16] assert that technology enhances affordability, convenience, and accessibility to financial services. Likewise, in [17] view, technology enables commerce between individuals and businesses formerly reserved for large corporations. The role of technology cannot be overemphasized.

Given the role of technology, the six Southeast European economies of Albania, Kosovo, Bosnia and Herzegovina, the Former Yugoslav Republic of Macedonia, Serbia, and Montenegro adopted a Multi-annual Action Plan (MAP) such as digital integration. This emphasizes establishing far-reaching interventions like future-proof digitization strategies, improved broadband infrastructure, an updated regulatory environment, and strategies for access and digital literacy to open up the economy more widely and improve the ease of business in Southeast Europe [18,19]. However, Southeast European countries have much smaller value added from digital sectors (as a percentage of GDP) than the United States [20]. According to [21], SEE countries need to catch up in creating building blocks for a thriving digital economy and entrepreneurial development by other regional industries.

Moreover, Ref. [22] opined that the quality of institutions impacts entrepreneurial development. Their gravity model and other prior studies posited that institutional quality indices impact the economy [23]. Robust institutions are anticipated to restrict misconduct and ensure a fair and equitable environment for all participants in economic transactions. The importance of institutional quality in entrepreneurial development propelled researchers' interest in investigating it [24–26]. However, only some studies have considered this phenomenon in other parts of the world, while there is limited evidence of it in SEE economies.

Furthermore, previous studies have considered one or a few dimensions of institutional quality, such as the rule of law, regulatory quality, political stability, government effectiveness, voice and accountability, and control of corruption [27–31]. Meanwhile, this study created an institutional quality index using the six components—regulatory qual-

ity, the rule of law, political stability, voice and accountability, government effectiveness, and control of corruption. In addition, few studies (such as [32] considered technological innovations and entrepreneurial development; while there is no evidence of studies of technological innovations and entrepreneurial development in SSE economies, technological innovations help to communicate and connect with people and businesses internationally.

Given the above, this study emphasizes how institutional quality and technological innovation affect the connection with entrepreneurial development. It makes the case that countries with higher institutional quality and technical innovation are more likely to experience more substantial impacts of entrepreneurial development on economic expansion. This research contributes to the literature by highlighting the importance of creating a conducive atmosphere that encourages entrepreneurship through institutional quality and technological breakthroughs. The study provides insight into SEE economies' technical innovation, institutional quality, and entrepreneurial development. The study sheds light on how governments and policymakers can solve the obstacles impeding progress and unleash their country's economic growth potential by examining the trends and difficulties in these areas.

Additionally, this study constructed a technological innovation index using research and development expenditure and trademark application for residents. Similarly, previous studies neglected using the cross-sectional (panel data) ARDL model and Granger Causality Tests in appraising entrepreneurial development, technological innovations, and ease of doing business in Southeastern Europe. This study applied quantile regression to appraise the correlations of technological innovations and institutional quality with entrepreneurial development in Southeastern Europe. The remaining sections of this study are structured as follows: The theoretical background and literature on technological innovation, institutional quality, and entrepreneurial development are reviewed in the following section. Section 3 presents the empirical outcomes and deliberations. Section 4 presents the methodology, describing the data and definitions, model specification, and estimation techniques. Section 5 presents the empirical findings, conclusions, recommendations, and additional research suggestions.

2. Theoretical and Empirical Review

2.1. Theoretical Background

Exploring the impact of institutional quality and technological innovation on entrepreneurial development involves several vital theories that explain how institutions and technology impact entrepreneurship and economic growth. These theories include institutional theory, Schumpeterian Theory of Innovation, Technology-Push and Demand-Pull Theories, Resource-Based View (RBV), and so on.

For instance, the institutional theory examines how formal and informal rules, norms, and beliefs within a society shape economic behaviors, particularly entrepreneurship [33–35]. Institutions provide the framework within which entrepreneurs operate, and this framework can either support or hinder entrepreneurial activity. According to Douglas North's theory of institutions, institutions are the "rules of the game" in a society and play a critical role in economic performance [36]. North identified formal institutions (laws, property rights) and informal institutions (norms, values) as essential for economic stability and growth. When institutions promote transparency, enforce property rights, and reduce corruption, they create an environment conducive to entrepreneurship and innovation.

Hinging on North's theory, the New Institutional Economics builds on North's ideas and emphasizes that institutional quality impacts transaction costs, reducing uncertainties and fostering a stable environment for entrepreneurial activities [37,38]. Good institutions lower business costs, incentivizing innovation and allowing entrepreneurs to focus on

growth rather than navigating complex regulatory environments [39]. This theory plays a vital role in understanding this topic.

Another theory is Joseph Schumpeter's Theory of Economic Development. This theory emphasizes the role of innovation in entrepreneurial activities [40]. Schumpeter described entrepreneurs as "creative disruptors" who bring about economic change through innovation, which he called "creative destruction". Schumpeter suggested that institutions indirectly influence entrepreneurial development by shaping the environment in which innovation occurs [38]. Strong institutions that enforce intellectual property rights encourage entrepreneurs to innovate by offering exclusive benefits from their inventions, thus fostering entrepreneurial development [41].

Also, technology-push theories posit that technological advancements drive innovation and entrepreneurial development [42,43] while demand-pull theory emphasizes that market demand for new products and services drives innovation and entrepreneurship. Entrepreneurs respond to market needs by creating innovative solutions [44,45]. The Resource-Based View (RBV) in entrepreneurship suggests that the unique resources of a firm or entrepreneur, such as knowledge, skills, and technology, determine its competitive advantage and success. Technological innovation and institutional quality can be seen as resources that drive entrepreneurial growth.

The theories above reveal that institutional quality provides the necessary foundation and infrastructure for technological innovation, stimulating entrepreneurial development. From creating a favorable business environment (Institutional Theory) to fostering a conducive setting for innovation (Schumpeterian Theory) and promoting sustainability, the synergy among institutions, technology, and entrepreneurship is essential for economic growth and development. Institutions can guide technology and entrepreneurship toward inclusive, sustainable, and long-term growth by establishing supportive policies, regulations, and infrastructure.

2.2. Institutional Quality and Entrepreneurial Development

The relationship between institutional quality and entrepreneurial development has attracted considerable attention in empirical research due to its implications for economic growth, innovation, and job creation. Studies revealed that institutional quality has an effect on entrepreneurial development, which had a spillover effect on economic development and growth in the studied areas [26,46,47]. Institutions encompassing legal, regulatory, political, and social structures significantly influence the entrepreneurial environment. Quality institutions foster entrepreneurship by reducing uncertainties, establishing property rights, and creating a conducive business climate. This review explores the empirical literature examining the impact of various dimensions of institutional quality on entrepreneurial activity, focusing on the rule of law, property rights, political stability, regulatory environment, and government effectiveness.

Institutional quality often represents attributes that ensure effective governance, reduce corruption, and uphold legal frameworks that protect entrepreneurs and investors [26,48,49]. Empirical studies frequently operationalize institutional quality using indices such as the Worldwide Governance Indicators (WGI) by the World Bank, which includes measures like political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. These indices are commonly used in cross-country [50,51] empirical analyses to investigate how institutional variations impact entrepreneurial outcomes.

For instance, Ref. [49], in their study on institutional quality, entrepreneurship, and unemployment, found that opportunity-driven entrepreneurship and total-early-stage entrepreneurship can significantly reduce unemployment, while institutional quality can

substantially increase the unemployment-reducing effect of entrepreneurship. Likewise, Ref. [26] revealed a minute positive effect that exists during a predeterminant period between dimensions of institutional quality and unemployment rate and entrepreneurship. These studies used institutional quality analyses to investigate how institutional variations impact entrepreneurial outcomes.

Likewise, Ref. [52] demonstrated that countries with efficient legal systems attract more entrepreneurial activity since property rights guarantee that entrepreneurs can retain profits from their innovations and efforts. Equally, Ref. [53] found that better enforcement of property rights positively correlates with entrepreneurial aspirations and activity in transition economies, where institutional instability is often high. In another study, Ref. [54] found that high political instability deterred entrepreneurial development, as entrepreneurs were less likely to undertake risks in volatile environments.

Similarly to the above studies, Ref. [55] examined entrepreneurship in Eastern Europe and found that political stability significantly predicted the extent and success of entrepreneurial ventures in the region. Entrepreneurs avoid politically unstable areas because they fear sudden policy shifts, expropriation, or civil unrest, which can lead to business disruptions or financial losses. Ref. [24] examined the impact of institutional profiles on entrepreneurship promotion in three emerging economies in Eastern Europe (Bulgaria, Hungary, and Latvia). The results indicate that institutional profiles (regulatory, cognitive, and normative) influenced the entrepreneurial development in those countries despite their differences in cultural norms and values, traditions, and institutional heritage. Ref. [56] found that countries with burdensome entry regulations tend to have lower firm creation rates. In their analysis of 85 countries, they observed that simplified procedures for starting a business are positively correlated with higher entrepreneurship rates, especially among small and medium enterprises (SMEs).

On governance and business environment, the empirical study of [57] suggests that effective governance fosters a favorable business environment by reducing uncertainties and supporting infrastructure and service provision. An exegesis of the above literature unveils that the empirical literature consistently underscores the importance of institutional quality for entrepreneurial development. Institutions that enforce property rights, reduce corruption, maintain political stability, and ensure government effectiveness are associated with higher entrepreneurship and business growth rates.

2.3. Technological Innovation and Entrepreneurial Development

Technological innovation and entrepreneurial development are closely intertwined, as new technologies often create opportunities for entrepreneurs to build novel products, optimize processes, and access new markets. Empirically, Ref. [58] found that mobile phone penetration in sub-Saharan Africa significantly boosted entrepreneurial activities by providing access to information and enabling financial transactions, especially in remote areas. Similarly, adopting broadband internet has increased firm formation rates in developed economies [59]. The authors argue that the internet reduces informational asymmetries and operational costs, enabling entrepreneurs to start and expand businesses.

Aligning with the above assertions, research acknowledges that technological innovation fosters "innovation-driven entrepreneurship", characterized by high growth, scalability, and often disruptive business models. For instance, Ref. [60] observed that countries investing heavily in research and development (R&D) see a higher emergence of innovative startups. Their analysis of 27 European countries found that R&D spending positively impacts the number and success rates of technology-driven startups, suggesting that public and private investment in technology can stimulate entrepreneurial growth.

Altogether, the rise of digital platforms has revolutionized the entrepreneurial landscape by creating new business models and revenue streams. Platforms like Amazon, Alibaba, and Uber provide entrepreneurs with tools to reach global markets, leverage big data, and benefit from network effects [61]. It is highlighted that digital platforms reduce entry costs, making it easier for small-scale entrepreneurs to compete with larger firms [62]. Platforms also support innovation by creating ecosystems where entrepreneurs can offer complementary products and services, leading to increased consumer choice and market competition.

More studies provide empirical evidence for the correlation between technological innovation and growth of a business enterprise. For instance, a recent study found that technological innovation was also positively related to ease of doing business [63]. Also, several studies, such as [64–67], reported that innovation, new technology, opportunity, and motivation are essential drivers for the early internationalization of entrepreneurs in the SEE region. The study conducted by [68] states that technological innovation increases the competitive environment of entrepreneurial sectors, thereby contributing to the growth of startup businesses across nations. Similar studies, such as [69–71], reported a significant positive relationship between innovation in the form of technology transfer and spillover and ease of doing business and wealth creation.

Aside from the above novel scientific contributions, Refs. [72,73] reported an exhibition of a higher proportion of high-tech firm creations that enhance the ease of doing business. Empirical evidence underscores the critical role of technological innovation in fostering entrepreneurial development. Access to technology, innovation-driven entrepreneurship, and the proliferation of digital platforms all create conditions that empower entrepreneurs to launch and grow businesses. However, the disruptive nature of technological advancements requires entrepreneurs and policymakers alike to focus on building adaptable and resilient ecosystems to capitalize on the opportunities presented by innovation. Technological innovation drives entrepreneurial ecosystems, supporting job creation, economic growth, and societal advancement.

This study emphasizes the necessity of thoroughly examining the effects of technological innovation, institutional quality, and entrepreneurial development with other macroeconomic variables (interest and exchange rates). Prior research has looked at these elements separately, but no comprehensive studies examine the combined effects of these factors in the Southeastern European context. This research aims to fill this gap by comprehensively analyzing these indicators and their relationships in driving sustainable entrepreneurial development in SEE countries.

Conceptual Framework

Based on the theoretical background and literature review, this study analyses the influence of technological innovations and institutional quality on entrepreneurial development in Southeastern European countries. Given this, there seems to be a dearth of empirical research on SEE countries, and this study fills that gap while promoting entrepreneurial development. Figure 1 demonstrates the relationship between entrepreneurial development and the explanatory variables.

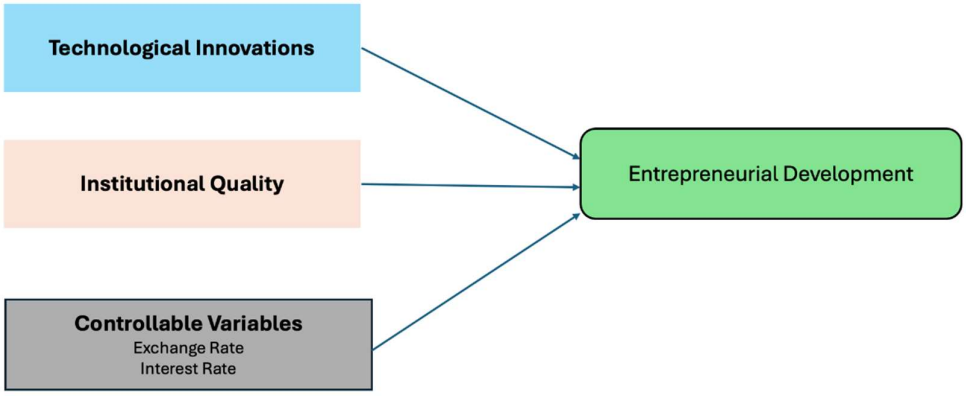

Figure 1. Conceptual framework.

3. Methodology

3.1. Data

This study empirically analyzes the impact of technological innovations and institutional quality on entrepreneurial development in Southeastern Europe. The research uses annual time-series data from the World Bank's databases covering 2014–2021. The study period was selected based on data available for our panel on technological innovation, institutional quality, and entrepreneurial development indicators. The controllable variables are interest and exchange rates (see Table 1 for data sources and description). The selected countries are Bulgaria, Bosnia and Herzegovina, Croatia, North Macedonia, Montenegro, Serbia, and Romania. Ref. [74] classifies these countries as SEE countries. However, Albania, Kosovo, and Turkey (East Thrace) were not included in the survey because of the unavailability of data.

Table 1. Data Sources and Description.

Variables	Abbreviation	Measurement	Sources
Entrepreneurial development	ED	The number of newly registered corporations per 1000 working-age people (those aged 15–64)	[75] https://www.enterprisesurveys.org/en/data (accessed on 3 August 2024)
Technological innovations	TI	Measured with intellectual property protection, education, and research and development	[76]
Institutional quality	INSQ	Measured with six broad dimensions: rule of law, regulatory quality, political stability, government effectiveness, voice and accountability, and control of corruption.	[51] www.govindicators.org (accessed on 4 August 2024)
Interest rate	INT	The cost of borrowing money	[77]
Exchange rate	EXR	The relative price of one currency expressed in terms of another currency	[77]

Source: Author's compilation (2024).

3.2. Variables, Definitions, and Relationships

The dependent variable in this study is entrepreneurial development (ED) in Southeastern Europe. Entrepreneurial development's ability to create new businesses and wealth

generates job opportunities and contemporary economic development for nations, and it is a significant factor in economic growth. Economic growth is known to be fueled by entrepreneurship [78]. Countries with greater levels of entrepreneurship typically experience faster rates of economic growth. The variables are sourced from Global Entrepreneurship Monitor, which measures the percentage of adults (aged 15 to 64) engaged in entrepreneurial activity. A higher score on this metric indicates an increased rate of entrepreneurial activity [75].

The two explanatory variables are technological innovation (TI) and institutional quality (INSQ). The World Bank's Global Innovation Index measures technological innovation. This index evaluates a nation's capacity for innovation based on elements like intellectual property protection and research and development. Technological quality has been recognized as a key force behind business innovation and productivity; hence, it can boost enterprises' competitiveness and efficiency, in turn boosting economic growth [79]. A higher score indicates more innovation [76]. Institutional quality is important in determining the business environment and encouraging entrepreneurship [80]. Strong legal and regulatory frameworks and efficient governance are examples of high-quality institutions that offer a stable and predictable environment for businesses to operate and expand [81]. The quality of a nation's business environment is reflected in its institutional quality (rule of law, regulatory quality, political stability, government effectiveness, voice and accountability, and control of corruption). The quality of institutions can be assessed using various indicators offered by the World Bank's governance indices [51].

The study considers two control variables. An interest rate is (INT) the cost of borrowing money, shown as a percentage of the borrowed amount. It is employed to determine how much interest will be paid for a loan. The exchange rate (EXR) is the relative value of one currency in terms of another or a group of currencies [77]. Like other factors influencing entrepreneurial development, these two control variables are critical. The monetary policy interest rate and real exchange rate deepen the economic integration process of SEE countries, sustaining entrepreneurial development and economic growth at large [82].

Therefore, previous studies, such as [83–85], have been inconclusive regarding the relationship between the dependent variable ED and the explanatory variables; this study aims to assess the influence of technological innovations and institutional quality on entrepreneurial development, with special attention to SEE countries for practical policy implications.

3.3. Model Specification

Inspired by the theoretical framework and empirical review studied by [24,53,84] and in achieving the objective, Equation (1) presents the empirical model specification that captures the variables (exogenous factors).

$$\mathrm{ED} = f\ (\mathrm{TI}, \mathrm{INSQ}, \mathrm{INT}, \mathrm{EXR}) \tag{1}$$

Econometrically, the model is presented as

$$\mathrm{ED}_t = \beta_0 + \beta_1 \mathrm{TI}_t + \beta_2 \mathrm{INSQ}_t + \beta_3 \mathrm{INT}_t + \beta_4 \mathrm{EXR}_t + \varepsilon_t \tag{2}$$

where ED_t is the entrepreneurial development (proxy with the number of newly registered corporations per 1000 working-age people (those aged 15–64)) at time t, TI_t is technological innovation, and INSQ_t represents the institutional quality. INT_t is the interest rate, and EXR_t is the exchange rate, while β_0 is the constant term, β_1, β_2, β_3, . . ., β_5 are the coefficients to be estimated, and ε_t represents the error term.

3.4. Estimation Methods

The process commenced with initial tests with descriptive statistics, correlation analysis for multicollinearity, and unit root (stationarity) tests. The data were analyzed for the selected SEE countries using the cross-sectional auto regressive distributed lag model (CS-ARDL). Consequently, to access the short and long-term correlation effects between technological innovations, institutional quality, and entrepreneurial development in Southeastern Europe, the CS-ARDL) approach was employed. Ref. [86] assert that the CS-ARDL model improves the ARDL model by incorporating a linear combination of the average cross-sectional values of both the dependent and independent variables to address cross-sectional correlation in the error term. Refs. [86,87] affirmed that the method to address CD is by employing cross-sectional averages. More so, the CS-ARDL framework considers the one-year lag of the dependent variable as a weakly exogenous regressor in the error correction mechanism [88]. Furthermore, the CS-ARDL methodology facilitates substantial control over unobservable variables employed to assess long-term effects within the regression model. The CS-ARDL methodology effectively addresses the cross-sectional dependence and heterogeneity challenges by integrating the dynamic common correlated impact predictor and to avoid the problems of bias and inconsistency [89–92]. The CS-ARDL model for study indicators is specified below:

$$\mathrm{ED}_{it} = \beta_0 + \sum_{j=1}^{p} \alpha_{it} \Delta \mathrm{ED}_{it-j} + \sum_{j=0}^{q} \varphi_{it} X_{it-j} + \sum_{j=0}^{n} \delta_{it} \bar{\mathrm{A}}_{t-j} + \epsilon it \tag{3}$$

where β_0 is constant term, α_{it} is a scalar vector for the lagged response variable, φ_{it} symbolizes the $k \times 1$ vector containing estimates of independent indicators, p and q represent the average lags for the response, while the vector of independent indicators is presumed to be equal in all cross-sections $\bar{\mathrm{A}}_{t-j}$ for cross-sectional averages of regressors specified as $\bar{\mathrm{A}}_{t-j} = \Delta \mathrm{ED}_{it-j}$; X_{it} is the vector for independent explanatory indicators expressed as follows:

$$\mathrm{ED}_{it} = (\mathrm{TI}_{it} + \mathrm{INSQ}_{it} + \mathrm{INT}_{it}\ \mathrm{EXR}_{it}), \text{ and } \varepsilon_{tt} \text{ is the error term} \tag{4}$$

The model of ARDL stated by [93] is as follows:

$$Yit = \sum_{j=1}^{p} \varphi ij Yi, t - j + \vartheta i + \epsilon it \tag{5}$$

N stands for the countries; X_{it} stands for the determinants of entrepreneurial development; T stands for time; j is the lag; and #i is stated as the fixed effect of the countries. Equation (5) is adjusted to take into account the modification coefficient and its long-term dynamics:

$$\Delta Yit = øi(Yi, t - 1 - \theta i Xi, t) + \sum_{j=1}^{p-1} \varphi ij \Delta Yi, t - j + \sum_{j=0}^{q-1} \delta ij \Delta Xi, t - j + \vartheta i + \epsilon it \tag{6}$$

The study examined the structure of heterogeneity in the variance. The OLS analysis might not be able to accurately and consistently predict the B vector [94]. Considering this situation, the variation structure and quantile structure of the data are taken into account in quantile regression models [95,96]. The predictions from quantitative regression models are more flexible and reliable than those from the OLS model because they do not make any assumptions about how the error term will be distributed [97]. Based on the conditional mean (estimated mean value) of how the dependent variable responds to the independent

variable(s), the OLS method makes predictions. In estimating the conditional median or other numbers, thus, the quantile regression is used for all the quantiles within the range of the entrepreneurial development distribution. Ref. [98] offered a PMG estimator that allows the averaging of coefficients over cross-sectional observations. However, the PMG estimator enables the evaluation of the unit separately and then averages the projected coefficient over the cross-sectional observations. It is also suitable when the variables are ordered at I(0) and I(1). This technique is also appropriate when the sample size is small. In this situation, the study considered seven countries over 8 years. This study's seven cross-sections (seven countries) and 8-year time series are smaller than those in most panel studies, which ARDL models can adequately handle. This study also used quantile regression because it is appropriate for analyzing various dimensions of issues over several periods. Furthermore, a dynamic panel generalized method of moments (GMM) estimator was also applied to perform a robust analysis. The two-step GMM addresses the endogeneity issue, incorporates lagged variables to account for autocorrelation and heteroscedasticity commonly found in panel data, and simultaneously estimates a system of equations to capture the interdependencies among the variables [99,100].

Panel causality tests establish the causal relationship among the variables [101]. The suggested methods for estimation only give elasticity inference. To find out which variables are causally related, we use the D-H test from [101], which is a heterogeneous cross-country causality tool. The D-H test of causation is an improvement on the [102] original causality test. It considers both different types of group data and residual cross-sectional correlations. In particular, this method is different from others because, under the null hypothesis, all of the Granger causation factors are equal to zero, making them all the same. So, the D-H test is calculated using a panel model, which can be written as follows:

$$Y_{it} = \sum_{i=1}^{n} \alpha_{11i} X_{t-i} + \sum_{j=1}^{n} \beta_{11i} Y_{t-j} + \mu_{11t} \quad (7)$$

$$X_{it} = \sum_{i=1}^{n} \alpha_{21i} Y_{t-i} + \sum_{j=1}^{n} \beta_{21i} X_{t-j} + \mu_{21t} \quad (8)$$

Equations (7) and (8) show the two primary Granger causality models for this analysis. Y stands for entrepreneurial development, while X stands for technological innovations, institutional quality, interest rate, and exchange rate. Additionally, this study uniquely created an institutional quality index utilizing the rule of law, regulatory quality, political stability, government effectiveness, voice and accountability, and control of corruption. This index was created using principal component analysis (PCA). In addition, with the aid of PCA, we created an index for technological innovation using variables such as research and development expenditure and trademark application for residents. This study also distinctively controlled for exchange and interest rates because these variables affect the development of entrepreneurial activities [103,104].

4. Empirical Outcomes and Deliberations

4.1. Descriptive Statistics

The summary data for the variables are presented in Table 2.

Table 2 presents the descriptive statistics of the variables used. The average values of ED, TI, INSQ, INT, and EXR are 804.172, –1.794, –3.576, 24.424, and 0.935, respectively, while the standard deviations for the variables are 1980.161, 1.000, 1.000, 36.951, and 5.545, respectively. However, the minimum value for ED is 0.877. The maximum value is 6454. The minimum and maximum values for TI are –0.834 and 2.115, respectively. The minimum value for INSQ is –1.672, while the maximum is 1.956. The minimum and maximum values

for INT are 0.755 and 111.271, respectively. Finally, EXR has a minimum value of –25.678 and a maximum of 8.422. The huge differences in the minimum and maximum values show substantial variations in the chosen variables; therefore, it is worth investigating.

Table 2. Descriptive Statistics.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
ED	56	804.172	1980.161	0.0877	6454
TI	56	−1.794	1.000	−0.834	2.115
INSQ	56	−3.576	1.000	−1.672	1.956
INT	56	24.424	36.951	0.755	111.271
EXR	56	0.935	5.540	−25.670	8.420

Source: Author's Compilation (2024).

4.2. Multicollinearity Test Results

The multicollinearity problem is a fundamental issue in regression. Therefore, a correlation matrix and variance inflation factor were used in the study to check for multicollinearity. In Table 3, the outcomes revealed that variables in the correlation matrix do not correlate with each other because the variables have values of less than 0.80 [105]. In addition, the VIF result shows that all the variables have values of less than the required 5.0, thereby showing that the variables do not suffer from multicollinearity problems.

Table 3. Correlation Matrix of Panel Analysis Variables.

Variables	**TI**	**INSQ**	**INT**	**EXR**	**VIF**
TI	1.0000				1.28
INSQ	0.3869	1.0000			1.23
INT	0.0210	−0.0644	1.0000		1.92
EXR	−0.2902	−0.1967	−0.6536	1.0000	2.10

Source: Author's Compilation (2024).

4.3. Unit Root (Stationarity) Test Results

A unit root test is essential to determine the degree of integration in the series. The unit root tests by [106,107] were the unit root tests conducted in this investigation. Table 4 displays the outcomes of these investigations. The IPS and LLC tests show that all the variables except interest rate and exchange rate are integrated at order one I(1). Therefore, this indicates that INT and EXR are integrated at order zero I(0), while ED, TI and INSQ are integrated at order one I(1). Therefore, the variables I(0) and I(1) are integrated; hence, there is a need to adopt panel ARDL as the regression technique.

Table 4. Results of Unit Root (Stationarity) Test.

	IPS		**LLC**	
Statistics	**I(0)**	**I(1)**	**I(0)**	**I(1)**
ED	−0.114 (0.454)	−12.492 (0.000)	−0.877 (0.190)	−6.724 (0.020)
TI	−1.211 (0.880)	−9.243 (0.000)	−1.027 (0.152)	−6.529 (0.000)
INSQ	0.366 (0.642)	−8.576 (0.007)	−1.835 (0.133)	−8.413 (0.000)
INT	−8.406 (0.029)	−21.895 (0.000)	−6.588 (0.000)	−12.592 (0.000)
EXR	−9.6203 (0.032)	−21.590 (0.000)	5.549 (0.001)	−9.027 (0.000)

Note: 5% is considered statistically significant. The null hypothesis is rejected (*p*-value 5%). Source: Author's Compilation (2024).

5. Results and Discussion

5.1. Panel Regression Results

Hausman's test helps to choose the most appropriate model between the pooled mean group (PMG) and mean group (MG), as well as between the PMG and the dynamic fixed effect (DFE). The most appropriate technique is the pooled mean group because the Hausman test results were not statistically significant; therefore, our interpretation is based on the pooled mean group estimator, as shown in Table 5. From the long-term results, technology and institutional quality have a positive and significant relationship with entrepreneurial development, which is in agreement with the study of [26,63,84,108].

Table 5. Panel Regression Results for Entrepreneurial Development.

	Dependent Variable: Entrepreneurial Development			
Independent Variables	**Mean Group**	**Pooled Mean Group**	**Dynamic CCE (CS-ARDL)**	**GMM**
EDL1 (0.024)				**1.008 ****
TI	6.778 ** (2.898)	0.088 *** (0.013)	0.092 *** (0.0283)	0.046 *** (0.011)
INSQ	−0.257 (0.403)	5.912 ** (0.004)	1.873 *** (0.609)	0.376 *** (0.062)
INT	−2.020 (1.544)	−2.291 (2.187)	−1.944 (2.670)	−2.2695 (2.419)
EXR	−0.016 (0.021)	−1.338 *** (0.041)	0.0687 ** (0.028)	−0.019 (0.026)
Hausman Test Wald chi2 statistic Sargan test statistic Hansen Test	−18.940 (0.425) 1171.411 (0.000) 99.825 (0.321) 22.000 (1.000)	−64.90 (0.5890) Autocorrelation test (Arellano-Bond test) AR(2)	0.980 (0.328)	
Short-run Coefficients				
Error correction	−1.3521 *** (0.3834)	1.371 *** (0.239)	0.934 *** (0.117)	
TI	1.0726 *** (0.274)	0.388 (0.684)	0.767 (0.553)	
INSQ	13.552 ** (6.610)	6.490 *** (1.848)	2.927 (2.340)	
INT	10.183 ** (4.154)	2.543 *** (0.283)	0.054 (1.868)	
EXR	8.038 *** (2.560)	−2.385 (2.940)	1.025 (1.262)	
Cons	27.354 ** (11.664)	5.035 ** (2.438)	21.689 *** (5.670)	

Note: Standard errors in parentheses. ***, **, denote 1%, and 5%, level of significance, respectively. **Source:** Author's Compilation (2024).

Entrepreneurial development increases by 0.088 for every unit increase in technological innovation. This suggests that sound and advanced technology stimulates entrepreneurial development in SEE economies. Similarly, with a coefficient value of 5.912, institutional quality considerably impacts entrepreneurial development at the 5% significance level. This indicates that entrepreneurial activities develop by 5.912 per unit increases in institutional quality.

Moreover, the exchange rate shows a negative and significant effect on entrepreneurial development, a finding supported by [109]. With the coefficient value of −1.338 at the 1% significance level, the exchange rate shows a negative significant link with entrepreneurial development. It indicates that entrepreneurial development increased by 1.338 for every unit decrease in the exchange rate, signifying that a reduction in the exchange rate plays a crucial role in fostering entrepreneurial development. Similar findings were shared by other studies [82,110]. However, the interest rate reveals a negative correlation with entrepreneurial development, but it was statistically insignificant. This suggests an inverse relationship between interest rates and entrepreneurial development in SEE countries. This was not concordant with the findings of [111].

At 1%, the value is statistically significant due to the error term of 1.371. Given that it is harmful and substantial, it is assumed that entrepreneurial development reacts to shocks from TI, INSQ, INT, and EXR. This indicates that entrepreneurial development is moving from a short-term state of disequilibrium to a long-term state of equilibrium at a rate of 1.371.

However, diagnostic tests were performed for the two-step GMM to verify the results' correctness, as shown in the lower section of Table 4. The Wald chi2 statistic of 1171.411 with a probability value of 0.000 shows that the model has a strong fit. Additionally, the Sargan test statistic has a probability value of 0.321; therefore, the test's null hypothesis, which states that overidentifying constraints are valid, cannot be rejected. This indicates that the instruments are valid.

Additionally, the Z-statistic of the second order (AR 2) is 22.000 with a probability value of 1.000 according to the Arellano-Bond test for zero autocorrelation in first-differenced errors. Therefore, the test's null hypothesis, "no autocorrelation", cannot be disproved. As a result, autocorrelation is not an issue in the model. Entrepreneurial development is the dependent variable in the GMM model, and the independent variables are lag of entrepreneurial development, technological innovation (TI), institutional quality (INSQ), interest rate (INT), and exchange rate (EXR). The findings showed that entrepreneurial development positively correlates with every variable except interest and exchange rates.

Also, in Table 5, the lag of entrepreneurial development, technological innovation (TI), and institutional quality (INSQ) are all positively correlated with entrepreneurial development, suggesting that the probability of the coefficient of entrepreneurial development will rise as the lag of entrepreneurial development, technological innovation (TI), and institutional quality (INSQ) increases. Nonetheless, the findings showed that, at the 1% and 5% levels of significance, lag of entrepreneurial development, technological innovation (TI), institutional quality (INSQ), and exchange rate are significant determinants of entrepreneurial development. This is because half of the values of these variables' coefficients are higher than their standard errors. This indicates that the lag of entrepreneurial development, technological innovation (TI), institutional quality (INSQ), and exchange rate all significantly influence entrepreneurial development in Southeastern Europe.

5.2. Robustness Check for Entrepreneurial Development

The study performed a robust check using quantile regression in Table 6, and entrepreneurial development was the model's dependent variable. In contrast, the independent variables were lag of entrepreneurial development, technological innovation (TI), institutional quality (INSQ), interest rate (INT), and exchange rate (EXR) in Table 6. The findings showed that entrepreneurial development is positively related to technological innovations and institutional quality across all the time dimensions, suggesting that the probability of the coefficient of entrepreneurial development will rise as technological

innovation (TI) and institutional quality (INSQ) increase at all times. This is consistent with the works of [26,60].

Table 6. Quantile Results for Entrepreneurial Development.

	(0.25)	(0.50)	(0.75)	(0.90)
TI	753.120 ***	1516.955 ***	1487.762 ***	1370.474 ***
	(212.334)	(201.511)	(132.704)	(60.705)
INSQ	162.729 ***	324.360 **	339.851 ***	76.051 ***
	(8.728)	(128.089)	(130.450)	(9.674)
INT	−35.761	−10.620	−0.144	−16.397
	(46.986)	(44.591)	(29.365)	(13.433)
EXR	−20.275 ***	−40.556 ***	−39.394 ***	37.953
	(7.370)	(6.994)	(4.606)	(22.107)
Cons	1256.165 ***	1573.136 ***	2099.091 ***	2415.828 ***
	(282.722)	(268.311)	(176.694)	(80.829)

Note: Standard errors in parentheses. ***, **, denote 1%, and 5%, level of significance, respectively. **Source:** Author's Compilation (2024).

Furthermore, the findings showed that, at the 1% and 5% levels of significance, technological innovation (TI) and institutional quality (INSQ) are significant determinants of entrepreneurial development at different dimensions of the regression. It was shown that the exchange rate is a significant but negative determinant over the time dimension, except for the 0.90 dimension. This is because half of the values of these variables' coefficients are higher than their standard errors. This indicates that technological innovation (TI), institutional quality (INSQ), and exchange rate significantly influence entrepreneurial development in Southeastern Europe.

5.3. Quantile Plot for Entrepreneurial Development

Figure 2 below depicts the marginal effects of technological innovation, institutional quality, interest rates, and exchange rates for all the quantiles within the range of the entrepreneurial development distribution. It can be seen from the plots of technological innovation, institutional quality, interest rates, and exchange rates that the magnitude of these variables increases compared with the lower thresholds, thereby depicting that the magnitude of the impact is high.

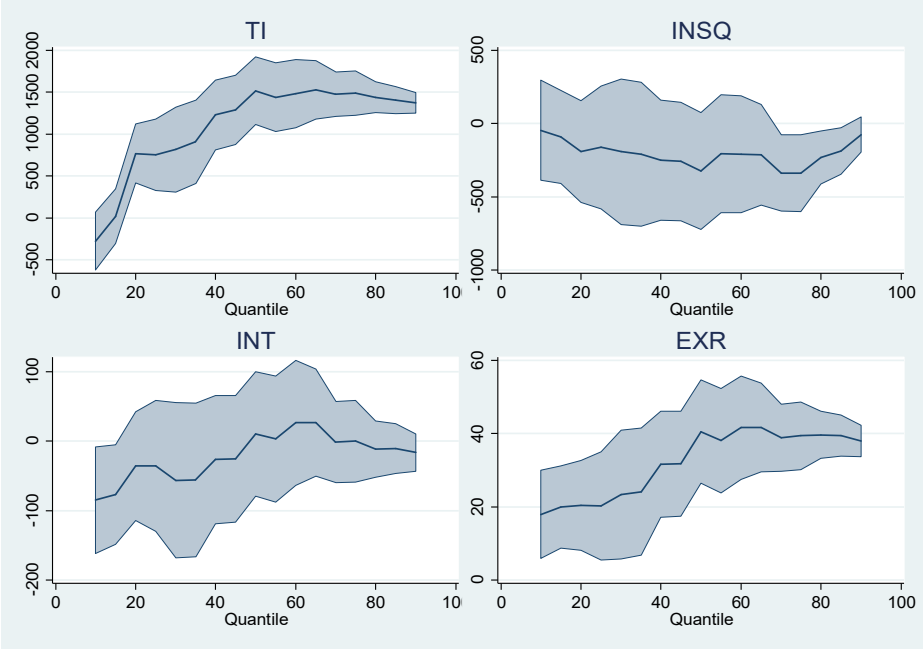

Figure 2. Conceptual Model for Entrepreneurial Development.

5.4. Dumitrescu and Hurlin (2012) Granger Causality Test Results

To evaluate the direction of causality between technological innovations, institutional quality, and entrepreneurial development in SEE economies, a [101] Granger causality test was conducted (See Table 7). It reveals that bi-directional causality existed between technological innovations and entrepreneurial development, while unidirectional causality existed between technological innovations and institutional quality, as well as from interest rate to exchange rate in southeastern Europe.

Table 7. Granger Causality Test.

Null Hypothesis:	Obs.	F-Statistic	Prob.
No Granger Causality between TI and ED	56	6.56476	0.0003
No Granger Causality between ED and TI		3.50102	0.0058
No Granger Causality between INSQ and ED	56	0.03087	0.9696
No Granger Causality between ED and INSQ		0.00422	0.9958
No Granger Causality between INT and ED	56	0.76101	0.4744
No Granger Causality between ED and INT		0.54713	0.5832
No Granger Causality between EXR and ED	56	0.13195	0.8768
No Granger Causality between ED and EXR		0.09910	0.9059
No Granger Causality between INSQ and TI	56	0.46149	0.6339
No Granger Causality between TI and INSQ		3.83378	0.0023
No Granger Causality between INT and TI	56	0.17206	0.8426
No Granger Causality between TI and INT		0.23889	0.7887
No Granger Causality between EXR and TI	56	0.36454	0.6970
No Granger Causality between TI and EXR		0.16174	0.8513
No Granger Causality between INT and INSQ	56	0.68939	0.5082
No Granger Causality between INSQ and INT		0.71336	0.4966
No Granger Causality between EXR and INSQ	56	0.72602	0.4906
No Granger Causality between INSQ and EXR		0.00925	0.9908
No Granger Causality between EXR and INT	56	0.62490	0.5409
No Granger Causality between INT and EXR		2.63428	0.0852

Source: Author's Conceptualization (2024).

6. Conclusions and Recommendations

6.1. Conclusions

Entrepreneurial development is crucial to economic transformation because it creates marginal workplaces that reduce unemployment, raise incomes, and enhance people's quality of life while encouraging innovation and economic growth. This study analyzed the effect of technological innovations and institutional quality on entrepreneurial development with annual data from 2014 to 2021. We employed panel data analysis of the cross-sectional auto regressive distributed lag model (CS-ARDL), quantile regression, and Granger causality [101] models. A dynamic panel generalized method of moments (GMM) estimator was also applied to perform a robust analysis. The study reveals that technological innovations and institutional quality positively influence entrepreneurial development in the long run in Southeastern Europe (SEE) countries. The finding suggests that strengthening the region's regulatory structures and institutional quality would improve sustainable entrepreneurial development.

However, the exchange rate has a negligible negative and significant impact on entrepreneurship development, while the interest rate has an insignificant and adverse effect. Furthermore, the study reveals the presence of a bidirectional causality correlation between technology innovations and entrepreneurial development. In contrast, the study established a unidirectional causality from technology innovations to institutional quality. Also, the causality relation only runs from the interest rate to the exchange rate. To sum up, it can be deduced that a relationship exists between technological innovations, institutional quality, and entrepreneurial development in SEE.

Based on the above premise, technological advancement (intellectual property protection, education, and research and development) and good institutional quality (legal

system, regulatory environment, and bureaucracy) yield numerous benefits and are the primary drivers of sustainable entrepreneurial development in SEE countries.

6.2. Recommendations

Based on the outcomes of this study, the following policy recommendations are suggested:

- Governments of Southeastern European countries should strengthen regulatory structures because sound institutions improve society's welfare through social and economic predictability, boost entrepreneurs' trust and investment, and facilitate easy business transactions.
- Sound policies like R&D investments, encouraging business–university partnerships, and establishing an atmosphere encouraging innovation will boost technical development and make the region more competitive.
- There is a need to improve the conditions for sustained entrepreneurial development; governments and institutions in Southeast European nations should take a holistic approach and prioritize strengthening the rule of law, reducing corruption, and improving governance systems.
- Finally, the governments of SEE countries should manage their monetary policies to enhance the development of entrepreneurial activities in their respective countries.

6.3. Limitations of the Study

This study did not consider other macroeconomic factors that may impact entrepreneurial development, such as economic growth, inflation, population size, foreign direct investment, endowment of natural resources, course curricula, and educational levels. Nonetheless, these variables can be considered for future research. Furthermore, modern forms of entrepreneurship, including green and social entrepreneurship, have not been included in this study, which mainly concentrated on traditional forms since countries are moving toward sustainable development. Future studies could address these constraints to gain a more thorough understanding of the intricate elements impacting entrepreneurial development, which could have repercussions for the economic growth and general well-being of the countries of Southeastern Europe. In addition, future studies should consider comparing at least two regional blocs of European countries.

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