DOI: https://doi.org/10.30525/2256-0742/2026-12-1-256-264

THE TRIPLE HELIX MODEL OF INNOVATION: THE ROLES OF POLITICAL STABILITY, UNIVERSITIES AND CLUSTERS IN DEVELOPING A SMART ECONOMY

Iryna Kalenyuk[1], Oleksandr Umanskyi[2], Marina Celika[3]

Abstract. The necessity to strengthen institutions within the knowledge triad (Triple Helix) and to intensify their interactions is a pressing issue in contemporary scientific research. The purpose of this article is to examine the mutual influence of institutions such as political and operational stability, university-generated knowledge, and the development of science and technology clusters in fostering the smart economy within the Triple Helix model of innovation. Accordingly, the primary objectives of the study are as follows: firstly, to analyse scholarly sources and factual data in order to define the theoretical framework of the research; and secondly, to use as a sample the countries that host the world's top 100 science and technology clusters (STCs), conducting an empirical investigation to identify the key factors influencing the development of science and technology clusters and to quantify their impact. The research methodology is grounded in a systemic approach that combines general scientific and specific research methods. The qualitative component of the study is dependent on the analysis of scientific literature and factual data on the topic. The quantitative component is based on the standardisation of statistical data, graphical analysis, correlation-regression analysis, and econometric modelling. The information base for the quantitative analysis consists of the Global Innovation Index (GII) pillars and indicators, examined for the countries that host the world's top 100 STCs. This enables a focus on economies that are already demonstrating success in developing a smart economy. The analysis confirms the relevance of the Triple Helix model, in which each actor plays a significant role both for the functioning of the model itself and for shaping the dynamics and character of societal development. The interpretation of the results confirms the systemic importance of factors such as institutional stability and the presence of highly ranked universities for the development of science and technology clusters and the smart economy. The positional map developed in the study enables the visualisation of the positions of key innovation-leading countries, and the design of a priority roadmap based on the identified asymmetries. The empirical model confirms the statistical significance of levers such as political and operational stability and the level of cluster development. Moreover, the impact of political and operational stability is somewhat stronger than that of the university ranking indicator (QS university ranking, top 3). The consolidation of these positions facilitates the establishment of robust cluster ecosystems, and their synergistic integration becomes an effective catalyst for accelerated science-and-technology and economic development at the national level. General recommendations for countries seeking to develop a smart economy include achieving institutional predictability and stable business regulation, building a robust intellectual property protection system, ensuring transparent public–private research and development (R&D), fostering the entrepreneurial functions of universities, managing professional clusters, and strategically focusing on creating powerful cluster ecosystems capable of shaping national development.

Keywords: science and technology clusters, entrepreneurial universities, cluster ecosystems, knowledge ecosystem, knowledge chain.

JEL Classification: I25, I28, O31, O38

[1] Kyiv National Economic University named after Vadym Hetman, Ukraine *(corresponding author)*
E-mail: kalenuk@ukr.net
ORCID: https://orcid.org/0000-0003-1807-2849
[2] Kyiv National Economic University named after Vadym Hetman, Ukraine
E-mail: oleksandr.umanskyi@kneu.ua
ORCID: https://orcid.org/0009-0003-9013-1871
[3] Riga Nordic University, Latvia
E-mail: marina.celika@isma.lv
ORCID: https://orcid.org/0009-0008-7588-0539

1. Introduction

A pressing issue for contemporary science is the study of the factors that enable countries to influence their own development, build strong competitive advantages and transform innovation into a genuine driver of societal progress. The crucial role of knowledge and all factors related to its creation and use has long been widely recognised. However, the impact of knowledge is heavily dependent on the institutional conditions that shape the processes of its creation, diffusion and use. Understanding the importance of the knowledge triad (Triple Helix) is therefore essential. Yet the question remains: how can its real impact be ensured, and which institutional mechanisms can promote the transformation of knowledge into a driver of national development? These issues continue to attract considerable scholarly attention, given that the problem has many dimensions. How can institutions responsible for generating and disseminating knowledge be strengthened? How can the chains of knowledge creation, diffusion and use be shortened? What institutional mechanisms are necessary to build effective knowledge ecosystems? Which instruments are the most effective within knowledge chains? These and many other questions are of interest to numerous researchers.

In the context of new trends in societal development emerging under the powerful influence of digital transformation, these scientific problems become particularly important. The widespread adoption of information and communication technologies (ICT) in all areas of social life is fundamentally changing processes, accelerating their dynamics and altering their nature. One manifestation of this is the emergence of smart cities and the smart economy. The spread of ICT creates new ways to ensure comfortable, environmentally sustainable, inclusive and safe living and functioning. Digital technologies connect different sectors and parts of society into a single ecosystem that must operate according to smart principles, i.e., intelligent governance. ICT is also transforming knowledge ecosystems themselves, as well as the ways in which they function and interact with the external environment.

The classical Triple Helix model describes the interactions between universities, businesses and the government. In this model, universities educate specialists, conduct scientific research and apply new knowledge. Businesses commercialise this knowledge, develop the production of new goods and services, and create new jobs. In turn, they also invest in research. The state plays a pivotal role in shaping the overarching legal and regulatory framework governing these activities. It is expected to foster collaboration between academic institutions and the business and financial sectors, thereby promoting innovation. The present paper sets out the hypothesis that institutional arrangements such as innovation platforms, incubators, technology parks, clusters, and similar structures have the capacity to accelerate the collaboration between universities and business. It is a general rule that such entities function within the remit of specific legal and tax regimes. The practical and theoretical experience of such institutional arrangements is of interest.

2. Analysis of Research and Publicatio ns

The Triple Helix model was originally conceptualised by H. Etzkowitz (2000) and was subsequently extended to the Quadruple Helix (Carayannis, 2009) and Quintuple Helix (Carayannis, 2010) by E. G. Carayannis and D. F. J. Campbell. In these models, additional active actors are introduced: civil society (Quadruple Helix) and the natural environment (Quintuple Helix). In the context of establishing effective interaction among the key actors, universities, as centres for the production and dissemination of knowledge, occupy a particularly important place. The expansion of the entrepreneurial functions of universities, otherwise termed the third mission of universities, has become an object of research in the works of B. Clark (2008), C. Forliano (2020), O. Romanovski (2012), S. Slaughter (1997), P. Schulte (2004), and R. Florida (Education, 2010), among others.

The establishment of an effective knowledge helix is predicated on the active involvement of other actors, including those from the business and government sectors. In order to consolidate their position within knowledge chains, specific mechanisms must be implemented, including science and technology clusters, accelerators, incubators, and analogous initiatives. M. Caccamo et al. develop the concept of "knowledge communities", distinguishing three archetypes of accelerators based on the boundary space (Caccamo, 2022). The essence and forms of manifestation of knowledge ecosystems are examined by I. Kalenyuk (2024), while A. I. Vodă, S. Bortoş, and D. T. Şoitu (2023) and G. Jucevičius (2022) emphasise the key function of knowledge ecosystems as the creation of new knowledge. K. Järvi (2018) systematises the ways of organising knowledge ecosystems. S. Mian (2016) considers science parks, incubators and accelerators to be mechanisms for supporting innovation and technology-oriented entrepreneurial growth under the umbrella of Technology Business Incubation (TBI). The effectiveness of different models of science parks, accelerators, and incubators has been explored by I. Díez-Vial (2016), D. Soetanto (2016), M. Ryabokon (2018), Gao Q., Cui L., Lew Y. K., Li Z., and Khan Z. (2021), among many others. The impact of science and technology structures on the formation of the foundations of the circular economy is the subject of the study by S. Millette, C. E. Hull, and E. Williams (2020), while the role of universities as drivers of regional development through the formation of innovation clusters and technology transfer centres is analysed by Benneworth & Sanderson (Benneworth, 2009; Reichert, 2019; Tijssen, 2021; Umanskyi, 2025).

Even in his early classic work, The Competitive Advantage of Nations (1990), M. Porter paid particular attention to clusters as drivers of competitiveness, rather than to firms or governments (Porter, 1990). This idea runs through all his subsequent works on competition and competitiveness. Notably, in 1998 he published a separate work entitled Clusters and Competition, in which he observed that 'paradoxically, the most sustainable competitive advantages in a global economy are often local' (Porter, 1998). In the field of economic analysis, M. Porter's contributions are widely acknowledged for their innovation. A particular focus of his research lies in the study of corporate and industrial resilience in the context of global recessions. In their joint work with M. Delgado, it was demonstrated that industries located within stronger or broader clusters exhibited relatively higher annual growth during the period from 2003 to 2011, especially during the crisis. This phenomenon, as posited by Delgado (2021), is not merely attributed to the heightened vulnerability of weaker clusters, but rather, to the resilience exhibited by stronger ones.

Consequently, the study of knowledge ecosystems and their impact on societal development remains a highly pertinent topic of academic inquiry. It is imperative to acknowledge the significance of identifying the institutional mechanisms that augment the efficacy of knowledge ecosystems. Such mechanisms are pivotal in fostering enhanced interaction among universities, business entities, and governmental bodies. This, in turn, serves to amplify the impact of knowledge ecosystems on the innovation-driven development of a nation.

The **objective** of this article is to examine the mutual influence of such institutional factors as political and operational stability, university-generated knowledge, and the state of science and technology clusters on the development of the smart economy within the Triple Helix innovation model. The primary objectives of the study are as follows: firstly, to analyse scholarly sources and factual data in order to define the theoretical framework of the research; and secondly, to conduct an empirical study using as a sample the countries that host the world's top 100 science and technology clusters (STCs). The aim of this second objective is to identify the key factors influencing the development of science and technology clusters worldwide, and to quantify their impact.

Methodology. The research methodology employed is founded upon a systems approach, integrating both general scientific methods and specific research methodologies. The qualitative component of this study is predicated on the analysis of scholarly sources and factual data on the topic.

The quantitative component is based on the standardisation of statistical data, graphical analysis, correlation-regression analysis, and econometric modelling. The information base for the quantitative analysis consists of the Global Innovation Index (GII) pillars and indicators, which are examined for the countries that host the world's top 100 science and technology clusters (STCs). This approach enables a focus on countries that have already demonstrated success in developing a smart economy. The selection of STCs for the GII ranking has been carried out since 2016 using a special bottom-up approach that does not take administrative or political borders into account, but instead focuses on the actual geographical concentration of innovation activity. Clusters are identified on the basis of hard data using three main quantitative indicators of innovation activity (the number of Patent Co-operation Treaty (PCT) patent applications; scientific publications from the Web of Science's Science Citation Index Expanded (SCIE), with a focus on science and technology fields), as specified in GII 2024 (pp. 304-306). In this study, ranking indicators are not utilised.

The dataset under consideration consists of 27 observations, covering data for 28 countries in which the world's most powerful STCs are located. The observations are defined by the criterion that "a country has at least one S&T cluster in the GII top 100 during 2016-2024 in the respective annual GII reports". The number of observations is fewer than the number of countries because three international clusters are treated as follows: Singapore (Singapore/Malaysia), Shenzhen-Hong Kong-Guangzhou (China/Hong Kong), and Basel (Switzerland/Germany/France). In this case, the arithmetic mean of the indicators for the respective countries is used. Notably, there is no Malaysian national STC on the list of the world's 100 most powerful clusters, but Malaysia's data is included in the international cluster "Singapore". Conversely, Egypt is excluded from the calculations since the Cairo cluster was the first to enter the top 100 STCs in 2024.

In the empirical section of the study, the classical Triple Helix framework (university-business-government) is applied, with a corresponding GII indicator selected for each helix. Universities are represented by indicator 2.3.4, entitled "QS university ranking, top 3" (index value rather than rank). This indicator is designed to capture the number of universities in a country that are ranked among the top three in one of the world's most influential and widely used annual university rankings. The rankings in question are the QS World University

Rankings, which are compiled by the British company Quacquarelli Symonds (QS). QS specialises in global higher education analytics. "Business" is represented by indicator 5.2.3, "State of cluster development", which reflects respondents' perceptions of the effectiveness of innovation and industrial clusters in the country. "Government" is represented by indicator 1.3.1, "Policy stability for doing business", which reflects the business community's perception of the extent to which the government ensures a predictable and stable policy environment for entrepreneurship, including in areas such as taxation, regulation and law enforcement. This is particularly important for innovation activity.

Therefore, by employing representative data from GII reports, the present study analyses the relationship between institutions, universities and business (clusters) in the synergistic context of the Triple Helix, as a manifestation of the development of the smart economy.

3. Results

The annual Global Innovation Index (GII) ranks the world's leading economies based on their innovation capabilities. The presence of strong science and technology (S&T) clusters is one of the various parameters that is particularly important. Since 2016, the GII has compiled a list of the world's 100 best S&T clusters. These clusters are not determined by administrative or political borders, but by two metrics: the presence of inventors, according to WIPO data, and the affiliation of authors of scientific publications. Well-known S&T clusters, such as Silicon Valley in the San Francisco Bay Area, Cambridge, Munich and Paris in Europe, and Bangalore, Seoul, Shenzhen and Tokyo in Asia, are centres for renowned universities, scientists and companies engaged in research and development. Mature science and technology clusters demonstrate the advantages of the smart economy, attracting the attention of technology giants, start-ups, and venture companies. In Silicon Valley, for example, world-class universities such as Stanford and Berkeley conduct fundamental research in collaboration with powerful multinational corporations (MNCs), such as Apple, Google/Alphabet, Meta, Microsoft and Amazon. Together, they create breakthrough technologies that underpin smart industries (Umanskyi, 2025).

The developers of the GII assume that co-operation between these entities leads to groundbreaking scientific achievements and inventions that drive countries' innovative development (Global, 2024).

In order to identify the impact of the level of development of clusters and institutions on the innovative development of countries, data on the 100 best science and technology clusters in the world and the countries in which they are located was summarised. In particular, over the last three years, the number of S&T clusters has increased only in China (see Figure 1).

In order to visualise the state of institutions and clusters in the countries that host the world's 100 most powerful science and technology clusters, a quadrant analysis was carried out in line with the GII methodology, distinguishing four quadrants: high-high, high-low, low-high, and low-low. The resulting quadrant map is based on standardised data (z-scores) for 28 countries from the WIPO report, with the cut-off points set at zero, where X denotes the *Institutions* pillar and Y denotes the indicator *State of cluster development* (Figure 2).

Quadrant: High/High.

This quadrant includes 14 countries, most of which (13) are advanced economies: Australia, Austria, the United Kingdom, Denmark, Canada, the Netherlands, the United States, Germany, France, Finland, Switzerland and Sweden. By region, European countries predominate (10 countries): Austria, the United Kingdom, Denmark, the Netherlands, Germany, France, Finland, Switzerland, and Sweden; there are two North American countries (the United States and Canada), one Asian country (China), and Australia. The highest values for both indicators (X – Institutions; Y – State of cluster development) are observed in Switzerland (1.18; 1.30), while the lowest are in France (0.18; 0.16). The most balanced country is the Netherlands (0.87; 0.86). The least balanced country is Finland (1.07; 0.22). This quadrant illustrates the complementarity of strong institutions and well-developed clusters. This is driven by policies that aim to maintain regulatory stability, as well as by high-quality cluster management.

Quadrant: High/Low.

This particular quadrant encompasses four countries, all of which are classified as high-income economies: Israel, Belgium, the Republic of Korea, and Japan. From a regional perspective, it comprises one European country, one Middle Eastern country, and two countries of East/South-East Asia and Oceania. Three countries – Korea, Belgium and Japan – have relatively close and high values in this quadrant. Korea (0.36; -0.08) is the most balanced in this group, while Israel (0.08; -0.54) is an outlier. In the High/Low quadrant, it can be seen that a high-quality institutional base does not necessarily lead to strong clusters. Whether the cluster subsystem needs strengthening through joint R&D, technology roadmaps or supply chains does not always have a clear answer, given the specificities of national innovation systems.

Quadrant: Low/High.

This quadrant contains two countries: China, an upper-middle-income economy in East and South-East Asia; and Italy, a high-income European country. China is the leader, with institutions that are less developed than average (-0.31), but a very high level

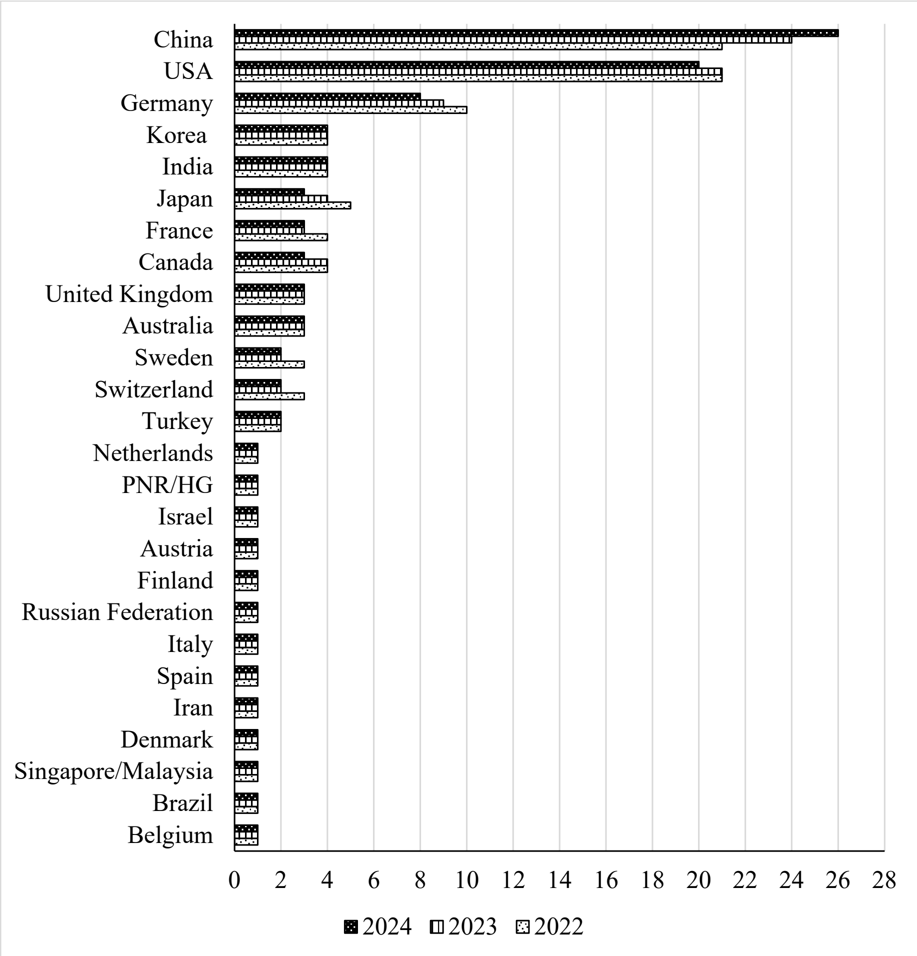

Figure 1. Number of S&T clusters in countries hosting the top 100 S&T clusters, 2022–2024

Source: compiled on the basis of standardised GII data (Global, 2022-2024)

of cluster development (1.44). This small quadrant shows that cluster strength can compensate for institutional constraints. This implies that the main regulatory recommendations are to reduce regulatory risks, strengthen intellectual property protection and standardise procedures.

Quadrant: Low/Low.

This quadrant includes eight countries, most of which are upper-middle-income economies, such as Brazil, Turkey and the Russian Federation. The Asian countries represented are Turkey, Iran, India and Singapore/Malaysia, while the European countries are Spain and the Russian Federation, and the South American country is Brazil. Spain demonstrates the highest values for this quadrant (-0.38; -0.32), while Iran is an outlier. Spain is regarded as the most balanced country in this quadrant. The country with the least balanced score is India (X = -0.61; Y = -1.80). For the countries that fall into the Low/Low quadrant, basic institutional reforms are required, along with the development of competencies and pilot cluster-management projects with international mentoring.

Consequently, the presence of institutions and the advancement of science and technology clusters function as reciprocal catalysts. It is evident that imbalances in the relationship between these parameters serve to delineate clear policy priorities.

Within the largest cluster scientific and technological ecosystems as institutional drivers of scaling the smart economy in the global space, the influence of two indicators, namely "Political stability for doing business" and "University ranking" (index assessment of this indicator) on the "State of development of clusters" was revealed. The econometric model of two-factor linear regression (1) is calculated on index data (rating indicators were not used in this study) of 28 countries worldwide from the WIPO report (n=27 observations).

A two-factor linear regression model (1) was constructed based on the regression equation of the form:

$$Y = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2, \quad (1)$$

where Y is the effective characteristic (State of cluster development);

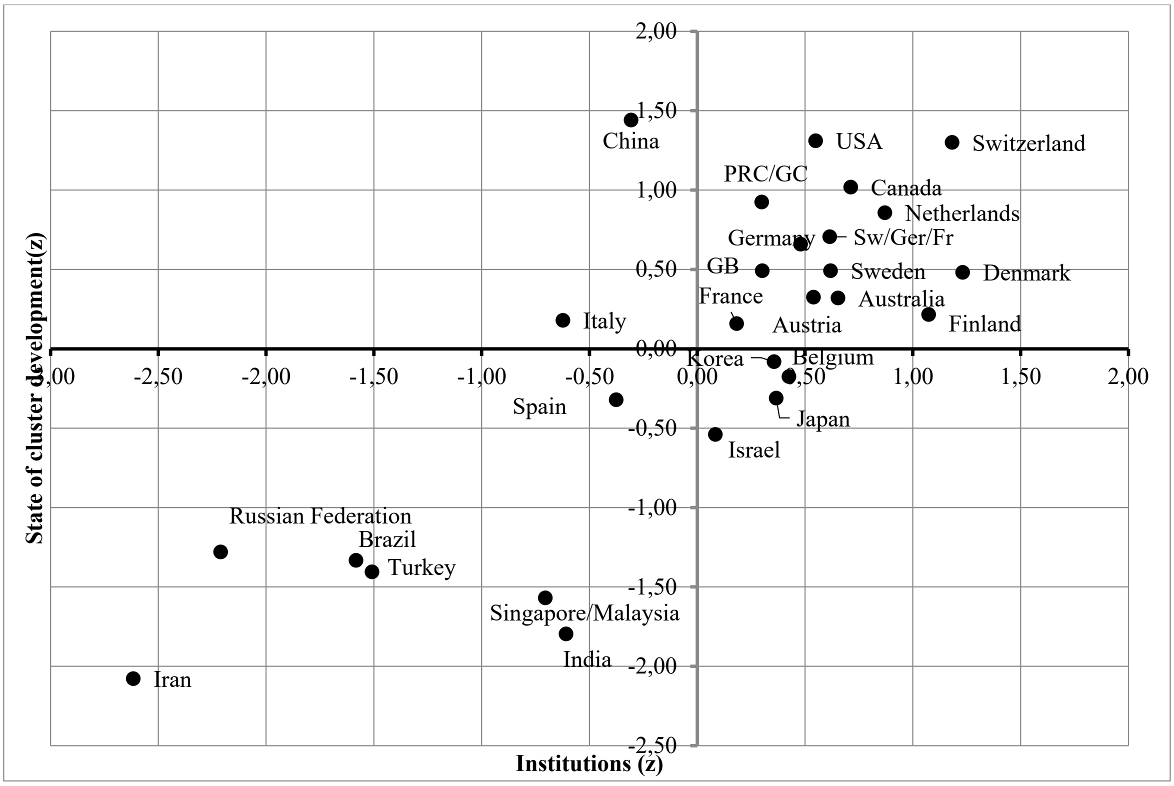

Figure 2. Positional quadrant map "Institutions vs State of cluster development"
(X – Institutions; Y – State of cluster development)

Source: compiled on the basis of standardised GII data (Global, 2024)

two factor characteristics x1 – (Political stability for doing business); x2 – University ranking;

b_1 and b_2 –coefficients at factors and b_0 is the free term of the regression equation (intercept coefficient).

The calculated model (2) has the form:

$$\underset{}{CLUST} = \underset{0.015}{13.593} + \underset{0.000}{0.584} \cdot POLITLSTAB + \underset{0.000}{0.374} \cdot RANKUNIVER, \quad (2)$$

where CLUST is a performance attribute (Cluster Development Status);

two factor attributes POLITLSTAB is a factor attribute (Political Stability for Doing Business);

RANKUNIVER is a factor attribute (University Ranking) and 13.593 is a free member (constant).

The statistical characteristics of the model indicate that it is adequate, qualitative and well-specified according to all the main diagnostic criteria (see Table 1, Table 2 and Table 3). Quality and diagnostics: R^2=0.855; Adj.R^2=0.843 (the difference between them is small – 0.012, i.e., the selected predictors of the model really contribute to the explanation of the hypothesis, and the model is not overloaded with predictors); all three variables originate from the same composite GII index, but the model specification tests indicate that multicollinearity is absent. $F(2,24)$=70.79, F critical (α = 0.05) =3.400, 70.79> 3.400, F critical (α = 0.01) =5.610, 70.79> 5.610, p=0.0000, p<0.0001 (the significance of the model is high); DW=1.71 in the "zone of acceptable absence of autocorrelation" 1.5<DW<2.5. For α=0.05 (n=27, k=2): d1=1.22, d2=1.56/

Acceptance of H_0 (without autocorrelation): d1 < DW, d2 < DW < 4 – d2 (1.22< 1.71, 1.56 < 1.71< < 2.44). For α = 0.01: d1= 1.09, d2= 1.23, so 1.09 < 1.71, 1.23<1.71<4-1.23. Information criteria (calculated with SSE): AIC = 188.9729; BIC = 192.8604 (close, i.e., the model is balanced, not too complex). Additional tests (JB, BP, RESET) show no problems. Normality of residuals JB p=0.64; homoscedasticity BP p=0.66; the RESET test does not reject the linear specification at the 5% significance level (RESET p = 0.85). Diagnostics of residuals and collinearity: standardised residuals: [-15.856; 11.475], sd ≈ 7.303; no outliers |z|>3 are observed. Collinearity is low: VIF≈1.66 for both predictors (Tolerance/VIF – POLITLSTAB: 0.602/1.661; RANKUNIVER: 0.602/1.661 - below critical thresholds 5–10. T-test: for both predictors |t| are large, t-critical (α = 0.01) 2.797, t-critical (α = 0.05) 2.064. POLITLSTAB t-actual 6.139, 6.139>2.797, 6.139>2.064, RANKUNIVER: t-actual 4.036, 4.036>2.797, 4.036>2.064. p < 0.001 → H_0: B=0 is rejected; each predictor is significant.

Table 1
Coefficients (unstandardised/standardised) with 95% confidence interval

Variable	B	SE (B)	β	t	p	95% CI (lower)	95% CI (upper)	Tol/VIF
CLUST	13.593	5.190	—	2.619	.015	2.882	24.303	—
POLITLSTAB	0.584	0.095	0.615	6.139	.000	0.388	0.781	0.602/1.661
RANKUNIVER	0.374	0.093	0.404	4.036	.000	0.183	0.566	0.602/1.661

Source: calculated based on GII data (Global, 2024)

Table 2
Goodness of fit and ANOVA

Indicator	Value	SS	df	MS	Note
R / R^2 / Adj.R^2 / SEE	0.925 / 0.855 / 0.843 / 7.60145	—	—	—	
ANOVA (F, p)	F(2,24) = 70.786; p = .000	SSR=8180.364; SSE=1386.771; SST=9567.135	2 / 24 / 26	MSR=4090.182; MSE=57.782	The model is generally significant

Source: calculated based on GII data (Global, 2024)

Table 3
Critical values (along with observed ones)

Test	Observed	df	α	Critical	Conclusion
t (POLITLSTAB)	6.139	df=24	0.05	2.064	Significant
		df=24	0.01	2.797	Significant
t (RANKUNIVER)	4.036	df=24	0.05	2.064	Significant
		df=24	0.01	2.797	Significant
F (model)	70.786	df1=2, df2=24	0.05	3.400	Significant
		df1=2, df2=24	0.01	5.610	Significant

Source: calculated based on GII data (Global, 2024)

The modelling results can be interpreted as follows: an increase in policy stability for doing business by 1 point leads to an increase in state of cluster development by 0.584 points. An increase in the QS university ranking, top 3 index value by 1 point leads to an increase in state of cluster development by 0.374 points. Therefore, the impact of policy stability for doing business is somewhat stronger than that of the QS university ranking indicator. The predicted value of the dependent variable when both explanatory variables equal zero is 13.593.

This means that efforts to improve policy stability for doing business and enhance the competitiveness of universities will directly and positively impact the development of cluster ecosystems. In turn, this will foster the development and growth of the smart economy, strengthen international competitiveness and improve overall welfare.

4. Conclusions

The study, which is based on GII data, confirms the importance of the Triple Helix model. In this model, each actor plays a significant role in both the model's own functioning and its influence on key parameters of societal development. Interpreting the results highlights the systemic importance of factors such as institutional stability and the presence of highly ranked universities for developing science and technology clusters and a smart economy.

The positional map developed in the paper enables the locations of leading innovation countries to be visualised. Classifying countries into four quadrants provides a roadmap of priorities, as the identified asymmetries clearly indicate the need to strengthen either institutions or clusters.

The empirical model confirms the statistical significance of the two policy levers defined as the study's focus. Strengthening factors such as policy stability for doing business and QS university ranking (top 3) makes it possible to build robust cluster ecosystems. Their synergistic combination becomes an effective driver of accelerated scientific and technological development, as well as economic development, at the national level.

General recommendations for countries seeking to develop a smart economy are as follows: achieving institutional predictability and regulatory stability for business; creating a robust intellectual property protection system; ensuring transparency in public-private research and development; promoting the entrepreneurial functions of universities; developing professional cluster management; and maintaining a strategic focus on creating robust cluster ecosystems capable of shaping national development.

References:

Benneworth, P., & Sanderson, A. (2009). The regional engagement of universities: Building capacity in a sparse innovation environment. *Higher Education Management and Policy,* 21(1), 131–148. DOI: https://doi.org/10.1787/hemp-v21-art2-en

Caccamo, M., &Beckman, S. (2022) Leveraging accelerator spaces to foster knowledge communities. *Technovation*, Volume 113, 102421. DOI: https://doi.org/10.1016/j.technovation.2021.102421

Carayannis, E. G., & Campbell, D. F. J. (2009). Mode 3 and Quadruple Helix: toward a 21st century fractal innovation ecosystem. *Journal of Technology Transfer*, 46(3/4). DOI: https://doi.org/10.1504/IJTM.2009.023374

Carayannis, E. G., & Campbell, D. F. J. (2010). Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? *International Journal of Social Ecology and Sustainable Development*, 1(1):41–69. DOI: https://doi.org/10.4018/jsesd.2010010105

Delgado, M., and Porter M. (2021). Clusters and the great recession. *Available at SSRN 3819293*. SSRN Electronic Journal. DOI: https://doi.org/10.2139/ssrn.3819293

Díez-Vial, I., & Montoro-Sánchez, A. (2016) How knowledge links with universities may foster innovation: The case of a science park. *Technovation*, Volumes 50–51, Pages 41–52. DOI: https://doi.org/10.1016/j.technovation.2015.09.001

Forliano, C., De Bernardi, P., & Yahiaoui, D. (2020). Entrepreneurial universities: A bibliometric analysis within the business and management domains. *Technological Forecasting and Social Change*, 165: 120522–120522. DOI: http://dx.doi.org/10.1016/j.techfore.2020.120522

Gao, Q., Cui, L., Lew, Y. K., Li, Z., & Khan, Z. (2021) Business incubators as international knowledge intermediaries: Exploring their role in the internationalization of start-ups from an emerging market. *Journal of International Management*, Volume 27, Issue 4, 100861. DOI: https://doi.org/10.1016/j.intman.2021.100861

Garcia, A. J. G., & Tuesta, Y. N. (2025) The third mission of universities towards knowledge transfer, innovation, entrepreneurship, and sustainable development: a systematic literature review. *Revista de Administração de Empresas.* DOI: https://doi.org/10.1590/S0034-759020250301x

Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship. 17th ed. Geneva: WIPO, 2024. DOI: https://doi.org/34667/tind.50062

Järvi, K., Almpanopoulou, F., & Ritala, P. (2018) Organization of knowledge ecosystems: Prefigurative and partial forms. *Research Policy.* Volume 47, Issue 8, October 2018, Pages 1523–1537. DOI: https://doi.org/10.1016/j.respol.2018.05.007

Jucevičius, G. (2022) Knowledge Ecosystem Approach to Addressing the Wicked Problems. Vol. 23 No. 1: Proceedings of the 23rd European Conference on Knowledge Management. DOI: https://doi.org/10.34190/eckm.23.1.810

Kalenyuk, I., Djakona, A., & Panchenko, Y. (2024). Understanding the knowledge ecosystem: core and forms. *Baltic Journal of Economic Studies, 10*(4), 229–244. DOI: https://doi.org/10.30525/2256-0742/2024-10-4-229-2445

Leitão, J., Pereira, D., & Gonçalves, Â. (2022). Business Incubators, Accelerators, and Performance of Technology-Based Ventures: A Systematic Literature Review. *Journal of Open Innovation: Technology, Market, and Complexity*, Volume 8, Issue 1, 46. DOI: https://doi.org/10.3390/joitmc8010046

Mian, S., Lamine, W., & Fayolle, A. (2016). Technology Business Incubation: An overview of the state of knowledge. *Technovation*, Volumes 50-51, Pages 1–12. DOI: https://doi.org/10.1016/j.technovation.2016.02.005

Millette, S., Hull, C. E., & Williams, E. (2020). Business incubators as effective tools for driving circular economy. *Journal of Cleaner Production*, Volume 266, 121999. DOI: https://doi.org/10.1016/j.jclepro.2020.121999

Porter, M. E. (1998). Clusters and competition. On competition. T. 7. 54 p. Available at: https://static1.squarespace.com/static/54fe01fde4b068b128045b78/t/568a998c25981d3d913bba04/1451923852664/Clusters+and+the+economy.1998.pdf

Porter, M. E. (1990). *The Competitive Advantage of Nations.* New York: Free Press. Available at: https://economie.ens.psl.eu/IMG/pdf/porter_1990_-_the_competitive_advantage_of_nations.pdf

Reichert, S. (2019). The Role of Universities in Regional Innovation Ecosystems. Available at: https://www.eua.eu/images/pdf/eua_innovation_ecosystem_report.pdf

Romanovski, O. O. (2012). The Phenomenon of Entrepreneurship in Universities of the World: Monograph. Vinnitsa : Nova Kniga, 504 p. (in Ukrainian)

Rosli, A., & Rossi, F. (2016). Third-mission policy goals and incentives from performance-based funding: Are they aligned? *Research Evaluation*, 25: 427–441. DOI: http://dx.doi.org/10.1093/reseval/rvw012

Ryabokon, M., & Pikalov, Y. (2018). Innovative clusters of business accelerators in the sphere of science and technology entrepreneurship. *Baltic Journal of Economic Studies, 4*(5), 291–296. DOI: https://doi.org/10.30525/2256-0742/2018-4-5-291-296

Rybnicek, R., & Königsgruber, R. (2019) What makes industry-university collaboration succeed? A systematic review of the literature. *Journal of Business Economics*, 89: 221–250. DOI: http://dx.doi.org/10.1007/s11573-018-0916-6

Schulte, P. (2004). The Entrepreneurial University: a Strategy for Institutional Development. *Higher Education in Europe*, Vol. 29, no 2, P. 187–193.

Slaughter S. Academic Capitalism: Politics, Policies, and the Entrepreneurial University / S. Slaughter, L. Leslie. Baltimore; L.: John Hopkins University Press, 1997.

Soetanto, D., & Jack, S. (2016). The impact of university-based incubation support on the innovation strategy of academic spin-offs. *Technovation*, Volumes 50-51, 2016, Pages 25–40. DOI: https://doi.org/10.1016/j.technovation.2015.11.001

Tijssen, R., Edwards, J., & Jonkers, K. (2021). Regional Innovation Impact of Universities. Edward Elgar Publishing. DOI: https://doi.org/10.4337/9781839100536

Trencher, G., Yarime, M., McCormick, K., Doll, C., & Kraines, S. (2014). Beyond the third mission: Exploring the emerging university function of co-creation for sustainability. *Science and Public Policy*, 41: 151–179. DOI: http://dx.doi.org/10.1093/scipol/sct044

Umanskyi, O. (2025). Institutional framework for developing globally significant science and technology clusters: leading practices for Ukraine's smart economy. *Scientific Notes*, 40(3), p. 326–341. DOI: https://doi.org/10.33111/vz_kneu.40.25.03.28.192.198

Vidican, G. (2009). The role of universities in innovation and sustainable development. *WIT Transactions on Ecology and the Environment, Vol 120, Sustainable Development and Planning* IV, Vol. 1, 131–139. DOI: https://doi.org/10.2495/SDP090131

Vodă, A. I., Bortoş, S., & Şoitu, D. T. (2023). Knowledge Ecosystem: A Sustainable Theoretical Approach. *European Journal of Sustainable Development*, *12*(2), 47. DOI: https://doi.org/10.14207/ejsd.2023.v12n2p47

World Intellectual Property Organization (WIPO). *Global Innovation Index 2022: What is the future of innovation-driven growth?* 15th ed. Geneva: WIPO, 2022. DOI: https://doi.org/10.34667/tind.46596

World Intellectual Property Organization (WIPO). Global Innovation Index 2023: Innovation in the face of uncertainty. 16th ed. Geneva: WIPO, 2023. DOI: https://doi.org/10.34667/tind.48220

World Intellectual Property Organization (WIPO). *Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship*. 17th ed. Geneva: WIPO, 2024. DOI: https://doi.org/10.34667/tind.50062

Received on: 08th of January, 2026
Accepted on: 24th of February, 2026
Published on: 13th of March, 2026