A COMPARATIVE ANALYSIS OF INNOVATION SYSTEMS AT THE COUNTRY LEVEL FOR ROMANIA AND TURKIYE

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This study is a comparative framework for evaluating the national innovation system through assessing global innovation indicators. In an open world where information is one click away, less developed countries try to catch up with the ones that develop and apply the latest technologies. This paper aims to discuss the methodology of measuring the national innovation system and why it is relevant to measure and compare it to other nations. The methodology is structured in secondary data analyzing several global indicators defining innovation for a nation and applying the ROMPEDET method (Romanian Model of Performance Determination) to assess global innovation indicators for two countries.

Keywords: national innovation system, comparative framework, comparative analysis, innovation indicators

1. Introduction

This paper aims to shape a comparison framework emphasizing the importance of technological advancements, enriching the literature review with an indicator analysis and comparison. The paper discusses national innovation systems for Romania (RO) and Türkiye (TR), analyzes global indicators from 2022 and 2023, and proposes a calculation framework for comparison.

The national innovation systems (NIS) across countries change depending on the type of economy and policies imposed by the government. More mature nations show more effective systems, and nations in an embryonic state require improvement. NIS is widely analyzed in recent decades, including many study cases on countries resulting in a rich sample of examples and results, however, there are still some ways to underline the importance of this concept.

Innovation is a key factor for competitiveness. Innovation policy plays an important part in a nation's competitiveness, using macro indicators to study the nation's competitive advantage. An important aspect of this research is the way the

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method is built, tackling the Quadruple Helix (QH) framework and the ROMPEDET method to calculate the Technical Level (TL) and make the comparison.

A comparative advantage at the national level can be acquired through an adequate pool of indicators. Identifying and exploring a simple yet relevant framework to classify the indicators, the QH tackles innovation complexly, covering important common components of the NIS. Nowadays, NIS offers a rationale to explain technological and economic performance disparities between countries and even regions. The National Innovation System emphasizes how entities behave and relate to each other [1,2].

This paper aims to add to the existing research a new point of view for calculating and comparing the NIS between RO and TR and shaping a knowledge framework using the ROMPEDET method. The following section includes the literature review of the NIS and the QH framework approach. The methodology employed uses secondary data from international reports regarding global innovation indicators. The findings and conclusions show a perspective on NIS comparison using selected indicators to enrich components that contribute to innovation performance.

2. Literature Review

The concept of innovation has undergone multiple transformations due to society's changes, especially in recent years. In essence, innovation is a nonlinear process involving many iterations of knowledge supported by tools and frameworks. This nonlinear creative process builds interaction between relations of different actors using a systemic framework to keep the goals on track.

While the world is shifting, populations transform cities, markets engage in dynamics not encountered in past studies, and the battle against climate change influences how businesses interact. Overall, there has been a transformation of the paradigm regarding innovation [3]. An innovation system represents a framework facilitating the creation, diffusion, and utilization of innovation within an economic or industrial context.

A national innovation system represents a framework of actors facilitating the creation, diffusion, and utilization of innovation within the national economy. The NIS impacts both the public and private sectors, influencing knowledge flows within industries [1,2].

National Innovation System characteristics

A National System Innovation (NIS) can be defined as a multifaceted cluster of organizations which contribute to the development and diffusion of innovation, providing a framework of application. This framework of application involves policy-making and government power decisions to influence the innovation process and performance [4].

Within the literature, several frameworks are used to measure the performance of organizations, which deriving into the importance and performance of innovation systems. For example, in the Triple Helix (TH) of innovation, the interactions between universities, industry, and government show the system's state. The smooth operation of innovation systems depends on the fluidity of knowledge flows within the Triple Helix.

The innovation performance of an economy depends on how organizations perform in isolation and how they perform when interacting as elements of the same system. Hence, the NIS relies on understanding and deepening the linkages among the actors involved in the innovation process. This framework can improve a country's innovation performance, encouraging better markets, technologies, sustainability actions, and fair competitiveness. Within the current paper the analysis focuses on analyzing the possibility of joining the helix framework to the NIS comparison.

According to the Organization for Economic Cooperation and Development (OECD), the concept of NIS has no static definition. Thanks to the literature review, the main characteristics and features framing a general view of the system were identified. Three main characteristics constantly emerge and repeat themselves: human capital, R&D activities, and stakeholders involved in innovation [5].

Human capital represents all human resources involved in the innovation process at any level. Human capital must be trained and educated to cultivate an innovative spirit, combining traits, habits, skills, experience, and knowledge. R&D activities are relevant for any entity keen to discover or work on new solutions and become more competitive. The stakeholders represent any entity that is part of the innovation process, within or outside the system, claiming any contribution to it. They also influence the system outputs [5, 19].

One important dimension of the innovation system is technological advancement, which plays a role in responding to globalization and market competition. Each nation ensures that its outputs support its industries and markets. Each country has built its own system; hence, innovation performance must be adapted to local and regional systems, building knowledge [5, 19].

NIS is characterized through different angles, from the economic development point of view, competitiveness, production, and nowadays more present sustainability and inclusiveness. The narrow definition of NIS focuses on science-based learning and codified knowledge, pointing out radical innovations and emerging technologies. On the other hand, the broad definition focuses on experience-based learning and tacit knowledge, pointing out incremental innovation, diffusion, and new technologies, interactive learning across organizational borders, as seen in Table 1. Another characteristic is the transnational flows which challenge the national institutions and governance [6].

Table 1

Defining NIS: Broad versus Narrow [6]

Definition	Characteristics
Broad	Focus on incremental innovation and diffusion Science based learning and codified knowledge Learning processes and establishing frameworks (procedures) Shaping human resources and learning.
Narrow	Focus on radical innovation and emerging technologies Experience based knowledge and Tacit knowledge Emphasis on processes of search and exploration Research and development (R&D)

Historically speaking, NIS has been a contested concept that relates to the political economy. This is why a better understanding is needed when discussing the measurement of innovation systems and their indicators. Innovation is a process characterized by uncertainty and disequilibrium; therefore, innovation will continually adapt and transform to the environmental influences and components of the system. In literature, several concepts overlap with NIS emphasizing comprehensive coverage. Each one of the concepts is briefly analyzed in Table 2 [6].

Table 2

National Innovation Systems overlapping over different concepts [6]

Concept overlapping and Author	Broad	Narrow	Characteristics
National Learning System (Viotti, 2022)	x	x	Process of technical change
National Entrepreneurial System (Acs et al., 2014)	x		Interaction between entrepreneurial attitudes, activities, and aspirations by individuals
Triple and Quadruple Helix (Etzkowitz and Leydesdorff, 2000)	x	x	Systemic process inspired by molecular biology University-Industry-government relations Applied at sectoral, regional, national and transnational levels
National Business System (Whitley, 1994)		x	Relations between social institutions and how firms and markets interact

Concept overlapping and Author	Broad	Narrow	Characteristics
Innovation Ecosystem (Moore, 1993)	x	x	Producers and users contributing to the innovation's performance As focal center is the form, the suppliers and the customers forming a value chain.

The wide number of concepts intertwining show a diversity of interventions over innovation and its performance indicators. In one way or another the systems pointed out in Table 2 cover the innovation system concept emphasizing different characteristics defining global innovation relevant for this paper's analysis and comparison [6].

Since the 90's literature review evolution, quantitative analysis has been instrumental regarding NIS, metrics and indicators being a critical point for the design and implementation of policies. To focus on the modality of measurement regarding the information and indicators prevailing for the applied concept of NIS is essential for the present paper. Understanding the source and methodology, as seen in Table 3, framing the NIS indicators through time, shows why and how nations participate in a worldwide innovation performance.

Table 3

Historical types of indicators for NIS [2,6]

Period	Indicator objective	Brief description	Database type
60'- 80'	Science and Technology	Linear model of innovation Focus on R&D, expenditure and personnel Narrow and limited Directed toward firms and processes	Locally in research institutes, universities, R&D departments
90'	Innovation	Innovation surveys, R&D Growth in productivity Learning and non-technological innovations	OECD, UNESCO, World Bank
2000 - 2010	Rankings of NIS scoreboards	Learning by comparing Benchmarking University-Industry linkages	OECD, UNESCO, CIS (Community Innovation Survey), EU
2010 - nowadays	Higher variety of indicators	Everything Clustering Infrastructure	GII, OECD, EIS (European Innovation Scorecard),

NIS and implications of TH

Since the concept of innovation has been studied, researchers have developed different frameworks to measure it from different angles and its performance because even though innovation is not immediately profitable, its outputs show a positive impact on the long term. The question is how NIS's performance is measured [6].

The concept of "Quadruple Helix" (QH) for Innovation, shares a complex system involving scientific and technological disciplines, public and private sector, industry, media and culture-based knowledge by framing the innovation system and using a knowledge framework, understanding of the knowledge-based and knowledge-driven indicators of NIS. Research has shown that the TH and QH frameworks play a significant role in NIS [7].

Innovation systems differ from traditional clusters by exploitation of the Triple Helix, by the organization around opportunity and discovery, by knowledge exchanged horizontally and vertically, stimulating innovation and developing industrial clusters and interaction between stakeholders [8,10].

The QH (academia, industry, government, and society) is playing a crucial role as the end user of innovation is essential in framing innovation processes. The TH is presented as an evolutionary process towards interactive collaboration for long-term strategic goals. It highlights enablers and barriers in implementing the framework, emphasizing collaborative relationships between academia, industry, and government [8,10].

The innovation system results from interactions and relationships between actors producing, distributing, and applying types of knowledge, tangible and intangible. NIS's focus is to offer a different understanding of competitiveness based on knowledge and learning, and furthermore reflecting that non-price factors [6].

NIS significantly impacts economic growth, and efforts to improve it through innovation policies are justified. According to the Global Innovation Index (GII) reports, government intervention is essential in keeping the NIS closer to a high level of innovation.

The literature states that "successful performance of the developed and developing economies, societies and democracies increasingly depends on knowledge." This powerful statement has been proved by time, national economies, and worldwide indicators that show the evolution from developing countries to developed countries only if there is a desire to evolve, resources, and the right mix between industry, government, and academia [7].

Indicators of NIS

Using the QH a framework, a selected number of relevant innovation performance indicators were identified for the Romania and Turkiye comparison. After extensive research of the literature review, was considered a list of innovation performance indicators built in a previous research (1) Global Innovation Index (GII), (2) Global Entrepreneurship Monitor (GEM), (3) OECD, (4) Sustainable

Development Goals Index (SDGI), (5) CISCO Digital Readiness Index (CISCO DRI), (6) Frontier Technologies Readiness Index (FTRI), and (7) World Digital Competitiveness (WDC) ranking [19]. The above-mentioned sets of indicators are relevant for measuring innovation performance in a broad manner.

Innovation performance at the national level is measured using various methodologies and methods. Some existing approaches to measuring are composite indices, data development analysis (DEA), and evaluation of specific indicators that reflect the innovation capabilities of a country. The Global Innovation Index is a tool for measuring innovation performance to rank countries; another example is the European Innovation Scoreboard (EIS). However, the latter one is used to rank member states of the EU. DEA measures NIS with a focus on resources and results, allowing it to reveal disparities in performance among OECD nations. Other specific indicators, such as the ones mentioned previously, are SDGI, FTRI, and others. Reliance solely on one type of indices can dim the knowledge regarding the complexity of innovation systems [20,21].

ROMPEDET method originates from the Romanian management school, highlighting several strengths in decision-making processes because it is based on multi-evaluation criteria. Then, it aims to minimize the influence of personal biases in evaluating alternatives and encourages the use of quantitative data, emphasizing the reliability of the decision-making process [18].

For building the comparison and calculating the technical level, not all indicators were used and applied using ROMPEDET method [19]. This method was chosen for comparison mathematical comparison purposes. It was identified as helpful in this context because it shows a direct and understandable way to compare indicators. ROMPEDET method facilitates multiple criteria assessment, in this context was tailored for a different purpose [26]. Another point would be experimentation purposes, introducing the analysis in a future doctoral thesis.

3. Methodology

Following the literature analysis, the present research develops a comparative framework, having as a starting point the QH framework and the selected NIS innovation performance indicators. Besides the industry, government, and academia components, was included the “Digital Environment” - component enhancing competitiveness and performance. Digital Environment is added to the TH framework showing the importance of technological advancement in recent years and how connected is with society today.

The data used for this research is purely secondary. All the data used to build the knowledge framework is extracted from international databases and resources, free to access by anyone. The analyzed data is as much as possible up to date because the analysis was made for the year 2023, and the comparison for the

Technical Level 2022-2023, a period when the COVID-19 pandemic started to fade, however international regional conflicts were lively and influencing the worldwide context. One of the main secondary sources used was GII report which provided precious data for the comparison. During 2020-2022, both Romania and Türkiye were adopted new national strategic policies toward innovation. Hence, this was another argument to create a focus on this period.

Firstly, a list of international indicators representative for both countries extracted from secondary sources was elaborated. GII and OECD are two organizations measuring performance innovation globally, nationally and locally. The selected indicators were researched and brainstormed to complement each other. Within this context, a methodology was built. The second step was to match the indicators to the QH components, as seen in Table 4. The final step of the methodology was to apply the ROMPEDET method for each component of the QH.

Table 4

Selected NIS performance Indicators [11,12,13,14,15,16,17,19]

Performance Indicators	Quadruple Helix Components				Source
	Government	Industry	Academia	Digital Environment	
Business Environment	x	x		x	GII
Creative goods and services		x		x	GII
Credit	x	x			GII
Employment Rate	x		x		OECD
General Infrastructure	x				GII
Gross expenditure on R&D, % GDP	x	x	x		GII
ICTs	x			x	GII
Industrial production		x			OECD
Innovation linkages		x	x	x	GII
Investment		x			GII
Knowledge creation		x	x	x	GII
Knowledge diffusion	x	x		x	GII
Knowledge impact			x	x	GII
Labour productivity and utilization Index	x	x			OECD
Tertiary education			x		GII
Trade, diversification, and market scale	x	x			GII
Triadic patent families Index	x		x		OECD

As a result, only 17 indicators (as shown in Table 4) out of the 25 selected initially could be used to calculate the Technical Level after a trial-and-error calculus. In the first iteration of the method measurement, some of the indicators could not fit the technical-level calculations.

The 17 performance indicators show the comparison for both countries and the correlation between NIS indicators and QH. The ROMPEDET method measures a global performance indicator named Qualitative Technical Level (QTL), which evaluates variables such as a product's specifications or indicators. The ROMPEDET method is derived from the Technical Level methodology [18]. Calculus is made for each QH component to better understand the TL comparison. The TL can be measured using the below formula:

$$H_i = a \prod_{j\in S_1} \left(\frac{x_{ij}}{x_{kj}}\right)^{\gamma_j} \times \prod_{j\in S_2} \left(\frac{x_{kj}}{x_{ij}}\right)^{\gamma_j} \quad (1)$$

Where: H = eta, the absolute technical level of the GH component; a = 1000 is a proportionality constant calibrating the Technical Level; γ_j = gamma, the weight of each indicator, x_{ij} is the value measured for the year 2023 and x_{kj} is the value measured for the year 2022, for the same indicator. The formula comprises two products of ratios between the characteristics x_{ij} and x_{kj}; S_1 = the subset of characteristics whose value is directly proportional to the performance indicator H_i; S_2 = the subset of characteristics whose value is inversely proportional to the performance indicator H_i. All characteristics are directly proportional to the performance indicator H_i.

The following methodology has been used to calculate the QTL, by determining the technical level of each NIS:

- Identifying the indicators of each nation (in this analysis, Romania and Türkiye), considering the performance indicators related to the Quadruple Helix Components analysed in Table 4.
- Determining the weight of each indicator by comparing 2 by 2, following a comparison scale (4,2,1,0); Determining how strong is the connection between the compared indicators and calculation of the weight of indicators as presented in Tables 5, 6, 7, and 8.
- Calculation of the technical level;
- Comparison, of the technical level obtained with the technical level of other nations.

For determining the weight of each QH component for both countries, it should be noted that a comparison 2 by 2 should be made utilizing a scale as follows: 4 if the indicator compared is much more important than the other one; 2 if the indicator compared is more important than the other one; 1 if the indicator is as important as the other one, and 0 if the indicator is less important. After comparing the indicators, the weight is calculated using the following formula: $\gamma j = \sum nj \,/\, \sum \sum nji$.

Table 5

The comparison matrix for weighing the indicators of *Government* component

Indicators	BE	Credit	ER	GI	GERD	ICTs	KD	LPUI	TDMS	TPFI	Σnj	Total weight
BE	0	1	1	2	1	0	1	1	1	1	9	0.089
Credit	1	0	2	1	1	2	1	4	2	4	18	0.178
ER	1	0	0	1	2	1	2	2	1	4	14	0.138
GI	0	1	1	0	1	1	1	2	1	4	12	0.118
GERD	1	1	0	1	0	0	1	0	1	1	6	0.059
ICTs	2	0	1	1	2	0	0	4	2	2	14	0.138
KD	1	1	0	1	1	2	0	4	1	1	12	0.118
LPUI	1	0	0	0	1	0	0	0	0	1	3	0.029
TDMS	1	0	1	1	1	0	1	2	0	1	8	0.079
TPFI	1	0	0	0	1	0	1	1	1	0	5	0.049

Table 5 provides a comparative analysis of the *Government* component, emphasizing the weighting scores and calculus methodology. The comparison was made by considering purely the statistical differences between 2023 and 2022. The indicators that weighed the most in the case of the Government component were Credit, Employment Rate, and information technologies.

Table 6

The comparison matrix for weighing the indicators of *Industry* component

Indicators	BE	CGS	Credit	GERD	IP	IL	Invest	KC	KD	LPUI	TDMS	Σnj	Total weight
BE	0	2	1	2	2	1	1	1	1	2	1	12	0.131
CGS	0	0	0	0	2	0	1	1	1	0	1	6	0.065
Credit	1	2	0	0	1	2	1	1	2	1	1	9	0.098
GERD	0	2	2	0	2	1	1	0	0	0	1	7	0.076
IP	1	0	1	0	0	1	0	1	1	1	0	5	0.054
IL	1	2	0	1	1	0	1	1	1	2	1	8	0.087
Invest	1	1	1	1	2	1	0	1	2	2	1	11	0.120
KC	1	1	1	2	1	1	1	0	1	2	1	10	0.109
KD	1	1	0	2	1	1	0	1	0	2	2	9	0.098
LPUI	0	2	1	2	1	1	0	0	0	0	0	5	0.054
TDMS	1	1	1	1	2	1	1	1	0	2	0	9	0.098

Table 6 provides a comparative analysis of the *Industry* component. The indicators that weighted the most in this component's case were the Business Environment, the Investments, and the Knowledge Creation to sustain innovation capabilities.

Table 7

The comparison matrix for weighing the indicators of *Academia* component

Indicators	ER	GERD	IL	KC	KI	TE	TPFI	Σnj	Total weight
ER	0	2	1	2	1	1	2	9	0.187
GERD	0	0	1	1	2	2	1	7	0.145
IL	1	1	0	2	1	0	2	7	0.145
KC	0	1	0	0	1	2	1	5	0.104
KI	1	0	1	1	0	1	1	5	0.104
TE	1	2	2	0	1	0	4	10	0.208
TPFI	1	1	0	1	1	1	0	5	0.104

Table 7 provides a comparative analysis of the *Academia* component. The indicators that weighted the most in this component's case were the importance of Tertiary Education and the Employment Rate.

Table 8

The comparison matrix for weighing the indicators of *Digital Environment* component

Indicators	BE	CGS	ICTs	IL	KC	KD	KI	Σnj	Total weight
BE	0	1	2	1	2	1	1	7	0.218
CGS	1	0	2	1	2	1	1	6	0.187
ICTs	0	0	0	2	1	1	1	4	0.125
IL	1	1	4	0	2	4	1	11	0.343
KC	0	0	1	0	0	1	1	2	0.062
KD	1	1	1	1	1	0	1	4	0.125
KI	1	1	1	1	1	1	0	5	0.156

Table 8 provides a comparative analysis of the *Digital Environment* component. The indicators that weighted the most in this component's case were the Innovation Linkages and the Business Environment.

Table 9 provides a general view of the weights of each indicator.

Table 9

The weights of the indicator analysis

Government		**Industry**		**Academia**		**Digital Environment**	
Indicator	Weight	Indicator	Weight	Indicator	Weight	Indicator	Weight
BE	0.089	BE	0.131	ER	0.187	BE	0.218
Credit	0.178	CGS	0.065	GERD	0.145	CGS	0.187
ER	0.138	Credit	0.098	IL	0.145	ICTs	0.125
GI	0.118	GERD	0.076	KC	0.104	IL	0.343
GERD	0.059	IP	0.054	KI	0.104	KC	0.062
ICTs	0.138	IL	0.087	TE	0.208	KD	0.125
KD	0.118	Investments	0.120	TPFI	0.104	KI	0.156
LPUI	0.029	KC	0.109				
TDMS	0.079	KD	0.098				
TPFI	0.049	LPUI	0.054				
		TDMS	0.098				

Further steps include calculating the technical level for each QH component for both countries, comparing the two countries, and preparing the knowledge framework proposal based on the QH framework and the selected indicators.
The same analysis must be applied for determining the weight. Hence the only difference between the technical level of the two countries will be the gaps between the indicators. The extended formula for the TL for the QH government component is found below as an example for all four QH components. For the comparison:

$$H_{aGRo} = 1000 \text{ x } \left(\frac{22.9}{26.8}\right)^{0.089} \text{ x } \left(\frac{32.2}{30.5}\right)^{0.178} \text{ x } \left(\frac{63.1}{61.9}\right)^{0.138} \text{ x } \left(\frac{30.6}{33.3}\right)^{0,118} \text{ x } \left(\frac{0.5}{0.5}\right)^{0.059} \text{ x } \left(\frac{74}{78.9}\right)^{0.138} \text{ x } \left(\frac{46.9}{44.8}\right)^{0.118} \text{ x } \left(\frac{0.7}{4.4}\right)^{0.029} \text{ x } \left(\frac{57.8}{66.8}\right)^{0.079} \text{ x } \left(\frac{8}{8}\right)^{0.049} = 1135.3$$

The clusters and the researchers were taken out from the TL calculations.

$$H_{aGTr} = 1000 \text{ x } \left(\frac{27.2}{36.4}\right)^{0.089} \text{ x } \left(\frac{41.4}{34.9}\right)^{0.178} \text{ x } \left(\frac{52.8}{50.3}\right)^{0.138} \text{ x } \left(\frac{38.5}{39}\right)^{0,118} \text{ x } \left(\frac{1.1}{1.1}\right)^{0.059} \text{ x } \left(\frac{80.5}{80.5}\right)^{0.138} \text{ x } \left(\frac{22.4}{22.8}\right)^{0.118} \text{ x } \left(\frac{5.3}{0.7}\right)^{0.029} \text{ x } \left(\frac{84.1}{81.9}\right)^{0.079} \text{ x } \left(\frac{64.8}{64.8}\right)^{0.049} = 1280.9$$

Table 10

Comparison QTL for Romania and Türkiye [developed by the authors]

Calculated absolute QTL	**Romania**	**Türkiye**
Government (H_{aG})	1135,3	1280,9
Industry (H_{aInd})	NA	1610.3
Academia (H_{aA})	1026.5	1206.6
Digital Environment (H_{aDE})	2687,9	1187,5

The ROMPEDET method used to calculate the TL compares RO and TR. Each country has a different trajectory, yet both consider innovation as part of the national system. While neither country hosts emerging technology breakthroughs, it leads to different QH components.

The national systems' set-ups differ from the point of infrastructure and investment. Türkiye leads the TL for three out of four QH components, as seen in Table 6. Innovation performance relates to policymaking, economic performance, industry, and a coherent technological infrastructure. Both countries consider these components important for innovation performance.

6. Discussions

Each nation's innovation journey is unique and requires many iterations and work. In both cases, the two compared countries accept innovation as part of their regional and local measures towards innovation. Romania is still struggling with implementing innovation; from the policy point of view, there are many areas for improvement. Türkiye, however, has improved its position among the countries that innovate, one strength being the infrastructure developed in recent years [11,14].

There are several differences between the analyzed two countries. From the point of view of the Government criteria, both countries have implemented policies encouraging an innovation mindset approach and innovation practices. In 2022, the Romanian government developed a strategy for innovation, a concrete plan with four strategic goals to nurture innovation. On the other hand, Türkiye has implemented in 2020 a strategy plan involving seven national strategic goals [19].

From the industry's point of view, GII does not consider any city or region as Romania's innovation cluster; however, Turkiye has two.

From the point of view of academia, Romania does not sufficiently sustain the academic environment. The increase in innovation knowledge is low compared to Türkiye, and similarly, in the research and development activity, Romania's GERD is very low compared to Türkiye's. Romania has had lower success in patents compared with Türkiye.

From the point of view of the digital environment, Romania had a more open approach to technology adoption and implementation; even though Turkiye has a more powerful economy and markets, it could not implement large-scale technology.

This study highlights the importance of certain indicators measuring NIS's innovation performance for growth and development; however, it does not provide in-depth insights related to the mechanism linking different system elements.

Both Romania and Turkiye face unique challenges within the international context, and while aspiring to become important innovators, they struggle with some aspects related to technological advancement and economic development [11,14].

There are some key common aspects that both countries share and influence the innovative character, as geographically speaking the strategic location that impacts economic growth and innovation and the high instability. Another point would be brain drain; the skilled talent is rather heading to better opportunities in developed countries, as the number of tertiary level talent is migrating from Romania and Turkiye. The level of investment in research and development should be higher to foster durable innovation.

For Romania, being an EU member can be considered a blessing and a curse at the same time, providing access to EU funding and standards; however, the lack of alignment of the bureaucratic processes is a hurdle, or corruption is still alive within some industries [11,14].

While developing countries are focused more on traditional metrics, for example, GDP on R&D, investment sources, patent fillings, and so on. Romania and Turkiye may exhibit different innovation performance indicators and emerging technologies that are being implemented and may not reflect fully the official rankings because there is a lack of data and standardized metrics, innovation for development in digitalizing industries.

The main ideas regarding potential strategies for enhancing the performance of innovation systems can be pointed out, maintaining a policy that fosters innovation, for which both countries are prepared. Education and skilled talent, research and development – a better collaboration between academia and industry, facilitating technology transfer, increasing intellectual property protection, fostering international collaboration, supporting entrepreneurship, and building a start-up ecosystem.

Through this analysis, it can be argued that at the national and international levels, the number and quality of indicators can frame the innovation system of a certain region. Many indicators in the literature can give insights regarding the level of innovation, and solutions to improve the system can be found through trial and error of the applied methodology and method.

Regarding limitations, can be pointed out that the analysis used general indicators, modeling the inputs only for a comparison between countries. Even though the authors used a knowledge framework that has been discussed for the first time, the ROMPEDET method shares a general comparison analysis.

A future research direction could be directed towards a QH framework having as a fourth component Artificial Intelligence (AI) or sustainability, and mandatory having a more in-depth analysis regarding the performance indicators of innovation.

The NIS is when it comes to understanding why nations' growth rates are different and what characteristics develop innovation systems. It moves the focus from raw competitiveness to the perspective of interaction and networking. A knowledge framework built on the idea of learning by comparing, the NIS should inspire national policy strategies for economic development, competitiveness, and sustainability [6].

Existing methods of measuring NIS performance often count on singular metrics like R&D expenditure, patent filling, and number of scientific researchers. While these are valuable metrics and provide important insights, they might not capture the system's complexity. Our research proposes a novel framework for measuring NIS performance that incorporates a broader range of indicators that can be improved and a methodology to calculate and compare the different indicators fitting the QH model.

As key differences and originality, the framework proposed considers a broader range of innovation dimensions and recognizes the importance of the government, industry, academia, and digital environment. The research delves into qualitative factors such as policy changes, emerging technologies, and regional differences. Hence, the analysis can significantly vary across countries.

Of course, the proposed methodology is not perfect and can be perfected. Besides the holistic approach, there is the regional granularity; these disparities allow a more nuanced understanding of the innovation performance and implications of regional policy interventions.

7. Conclusions

The proposed method offers practical value by addressing shared challenges and opportunities in Romania and Turkey's innovation ecosystems. It highlights critical issues like brain drain, underinvestment in R&D, and the need for stronger academia-industry collaboration, emphasizing actionable strategies such as fostering entrepreneurship, enhancing intellectual property protection, and improving education systems. For Romania, the dual impact of EU membership—providing funding access while exposing bureaucratic inefficiencies—is particularly relevant. Additionally, the method critiques traditional innovation metrics, advocating for more inclusive indicators that capture emerging technologies and digital transformation. By identifying tailored solutions and promoting international collaboration, this approach provides a robust framework for enhancing innovation systems and driving sustainable economic growth in both countries.

This research can draw greater attention from policymakers, academics, and practitioners, promoting the adoption of the ROMPEDET method to support more informed decision-making and enhance innovation capabilities and economic growth.

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