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International Science and Technology Interactions: Pathways for the National Comprehensive Scientific Map towards the 1414 Horizon

Seyed Morteza Mortazavi
Ph.D. of Futures Studies, Imam Khomeini International University, Qazvin, Iran.
s.m.mortazavi@edu.ikiu.ac.ir
Moslem Shirvani Naghani*
Assistant Professor, Department of Futures Studies, Imam Khomeini International University, Qazvin, Iran.: Shirvani@soc.ikiu.ac.ir

Abstract

Objective: The globalization of the economy and the intensification of technological competition have transformed international science and technology interactions into a strategic imperative. Consequently, this research aimed to design a foresight-oriented framework for formulating potential pathways of international science and technology interactions within Iran's Comprehensive Scientific Map towards the 1414 horizon.

Method: This study employed a multipol mixed-methods approach, involving the participation of twelve experts comprising policymakers from the Ministry of Science, international researchers, and managers of universities and science and technology parks. In this regard, contributors were selected through purposive sampling. Accordingly, the qualitative phase involved conducting a structured nominal group session where independent ideas were recorded and prioritized. The quantitative phase entailed distributing three validated standard questionnaires (assessing measures, policies, and future images according to evaluation criteria), confirmed for validity and reliability.

Findings: This study identified eleven evaluation criteria and designed three future images: scientific networking, an educational empowerment system, and integrated science diplomacy. It formulated overarching policies including the integration of research programs, proficiency assessment for Persian language education, and joint technological investment. For operationalization, fourteen supportive measures were proposed. The top five measures in order of priority are: international collaboration among knowledge-based companies; establishing a joint fund for technological research; allocating research grants to priority projects; developing a regional research problem bank; and concluding technology transfer agreements. Findings further revealed that each future image, such as scientific networking, is realized through the combination of relevant policies and measures. This framework elucidates the strategic linkage between policies, future images, and operational actions.

Conclusion: This research demonstrates that identifying optimal pathways for international science and technology collaborations establishes dynamic mechanisms for adapting to environmental changes and enables the targeted allocation of resources to strategic domains in this field.

Keywords: International science and technology interactions, national comprehensive scientific map, future images, multipol, resource allocation

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Publisher: Imam Khomeini International University

Corresponding Author/ E-mail: Moslem Shirvani Naghani: Shirvani@soc.ikiu.ac.i

Introduction

The growing trend of technological complexity and economic globalization has intensified international research interactions, encompassing research collaborations and the global distribution of research activities (Stek & Geenhuizen, 2016). This trend has persisted and been reinforced, aligning with the new orientation towards international scientific cooperation, the centrality of science in addressing environmental challenges, and the increasing willingness of various countries to participate in this arena (Gui et al., 2019). Consequently, it has created a necessity for knowledge-based actors such as companies and universities to achieve international access to knowledge and a presence in various international locations (Stek & Geenhuizen, 2016). In this context, with an understanding of the imperative for technological advancement and the realization of sustainable development goals, international science and technology cooperation plays an irreplaceable role in enhancing the technological capabilities of nations, generating innovative solutions, and increasing global influence. These partnerships facilitate the development and deployment of advanced technologies in areas such as infrastructure modernization and industrial innovation (Peng et al., 2025). However, cultural, social, and legal differences, along with factors such as financial resource shortages, constraints on data sharing, and disparities in global academic standards, pose significant challenges to realizing effective international science and technology collaboration (Momtazmanesh et al., 2021). Iran, too, faces challenges in its international science and technology interactions, including cultural, social, economic, scientific, and political factors, as well as international sanctions (Tarassoli et al., 2022), which can constrain the development of capabilities, including emerging technologies. Therefore, despite the existing challenges, international science and technology cooperation is considered a fundamental strategy for ensuring the continuous development of national innovation systems (Wang et al., 2023). Although these collaborations are formed with the aim of efficiently integrating diverse resources and enhancing scientific, technological, and economic levels, the structural differences among countries mean that the choice of cooperation model and the combination of resources have a decisive impact on the success of projects (Wang et al., 2023). Hence, the design of intelligent strategies for the country's comprehensive scientific roadmap, aimed at identifying optimal patterns of international cooperation aligned with national advantages, is presented as a critical necessity for enhancing Iran's strategic position in this field.

Methodology

The present study adopts a mixed-methods (qualitative-quantitative) design due to its utilization of the Multipol approach. Accordingly, in the first phase of this research, future images, policies, actions, and a set of criteria were proposed by experts using the Nominal Group Technique. In this phase, participants adhered to established protocols for the systematic conduct and management of the interview session to prevent bias and ensure the validity of the results (reliability and validity). In the second phase, the quantitative analysis of the data obtained from distributing evaluation questionnaires (an assessment matrix based on the criteria, actions, policies, and future images) within the Multipol method was conducted. Multipol is a multi-criteria decision-making tool that, with the participation of experts, simultaneously evaluates actions against policies and policies against future images to provide comprehensive solutions (Hadizadeh et al., 2024). It is noteworthy that the structure of these questionnaires is standardized, and their indicators are derived from the data obtained in the first phase; thus, their validity and reliability are confirmed. Consequently, these questionnaires were distributed among the experts, who were asked to complete them collaboratively, reaching a consensus. The theoretical population of this study consists of all qualified individuals with expertise, experience, or responsibility in the field of international science and technology interactions. Thus, through purposive sampling, 12 experts were selected based on specific criteria to form the nominal group and complete the questionnaires.

Results

Findings indicate that the necessary actions for the Policy of Integrating Research Programs include: allocating joint research grants to priority projects, holding an annual summit for research members from neighboring countries, developing a regional shared database of research problems, publishing an annual of joint strategic research, fostering international collaboration between knowledge-based companies, and concluding technology transfer agreements. These measures can facilitate access to the scientific networking image . It is noteworthy that within the framework of this policy assessed as a high-success-probability policy most of its essential actions were also classified as having the highest chance of success. Furthermore, the necessary actions for the Policy of Competency Assessment in Persian Language Education include: organizing an annual olympiad for innovative teaching methods, dispatching evaluator trainers to target centers for performance assessment, awarding annual "Distinguished Professor of Persian Language Teaching" prizes, and establishing a virtual academy for training international instructors of Persian language. These actions can facilitate access to the educational empowerment system image. Finally, the necessary actions for the Policy of Joint

Technological Investment include: establishing joint research institutes with target countries, allocating joint research grants to priority projects, developing a regional shared database of research problems, creating a joint fund for technological research, implementing pilot projects on clean energy, fostering international collaboration between knowledge-based companies, holding a permanent exhibition of joint technological achievements, and concluding technology transfer agreements. These measures can facilitate access to the integrated science diplomacy image.

Conclusions

The present study addressed the question of identifying science and technology international interaction strategies for the country's comprehensive scientific map towards the 1414 horizon, proceeding from the premise that science and technology function as a mutually reinforcing engine for economic growth and strategic advancements. In this context, and considering barriers such as structural differences and resource constraints which impact the success of these interactions, the formulation of targeted policies and actions for optimal resource allocation and enhanced productivity facilitates successful interactions and the achievement of strategic objectives. Consequently, to achieve the study's primary goal, expert opinions and the resulting questionnaires and feedback were utilized in two fundamental phases. To this end, first, 11 evaluation criteria were established to assess potential outcomes. Subsequently, three potential future images were proposed: Scientific Networking, Educational Empowerment System, and Integrated Science Diplomacy. Based on these future images, policies aimed at enhancing international science and technology interactions were formulated, taking into account social, technological, economic, environmental, and political dimensions. To operationalize these policies, fourteen supporting actions were proposed. Among these fourteen actions, five are of higher priority, listed in order as follows: International collaboration of knowledge-based companies to foster practical engagement with global innovation actors. Establishing a joint fund for technological research to create sustainable financing for strategic projects. Allocating joint research grants to priority projects to support applied research. Developing a regional shared database of research problems to identify common priorities and allocate resources effectively. Concluding technology transfer agreements to facilitate access to advanced technologies. These policies, actions, and images possess specific interrelationships. For instance, the Policy of Integrating Research Programs, identified as the most critical policy, along with supporting and priority actions of allocating joint research grants to priority projects, holding an annual summit for research members from neighboring countries, developing a regional shared database of research problems, fostering international collaboration of knowledge-based

companies, and concluding technology transfer agreements can serve as a potential pathway for achieving the Scientific Networking image. Similar relational logic applies to the other images.

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