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THE PROSPECTS OF FORMING

INNOVATION INFRASTRUCTURE IN THE ECONOMY OF THE NAKHCHIVAN AUTONOMOUS REPUBLIC

PERSPECTIVAS DE CREACIÓN DE INFRAESTRUCTURA INNOVADORA EN LA ECONOMÍA DE LA REPÚBLICA AUTÓNOMA DE NAJICHEVÁN

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ABSTRACT

The development of innovation infrastructure is crucial to the economy of Nakhchivan Autonomous Republic for diversification and long-term growth. The paper examines the current state of affairs in Nakhchivan Autonomous Republic, focusing primarily on sectors such as renewable energy, agriculture, and technology-based firms. Although there are significant obstacles, such as a lack of finance, poor technological capacity, and geographical isolation, there are also positive opportunities. The article presents policy recommendations on how to enhance investment, build partnerships, and improve education efficiency, along with an in-depth analysis of current programs, such as government-supported technology parks and incubators. The comparative case studies of Israel and Estonia demonstrate how remote and small regions can overcome similar challenges. The findings emphasize the importance of international collaboration, targeted government support, and business sector involvement in developing innovation in Nakhchivan Autonomous Republic. This article also outlines future research needed to expand the innovation infrastructure of Nakhchivan Autonomous Republic.

Keywords: Innovation Infrastructure, Nakhchivan Autonomous Republic, Renewable Energy, Agri-tech, Economic Development.

RESUMEN

El desarrollo de la infraestructura de innovación es crucial para la economía de la República Autónoma de Najicheván, con vistas a la diversificación y el crecimiento a largo plazo. El artículo examina la situación actual de la República Autónoma de Najicheván, centrándose principalmente en sectores como la energía renovable, la agricultura y las empresas basadas en la tecnología. Aunque existen obstáculos importantes, como la falta de financiación, la escasa capacidad tecnológica y el aislamiento geográfico, también existen oportunidades positivas. El artículo presenta recomendaciones de políticas sobre cómo mejorar la inversión, crear asociaciones y mejorar la eficiencia de la

educación, junto con un análisis en profundidad de los programas actuales, como los parques tecnológicos y las incubadoras respaldados por el gobierno. Los estudios de caso comparativos de Israel y Estonia demuestran cómo las regiones remotas y pequeñas pueden superar desafíos similares. Los hallazgos destacan la importancia de la colaboración internacional, el apoyo gubernamental específico y la participación del sector empresarial en el desarrollo de la innovación en la República Autónoma de Najicheván. Este artículo también describe la investigación futura necesaria para ampliar la infraestructura de innovación de la República Autónoma de Najicheván.

Palabras clave: Infraestructura de innovación, República Autónoma de Najicheván, Energía renovable, Tecnología agrícola, Desarrollo económico.

INTRODUCTION

Innovation infrastructure is among the most crucial components of contemporary economic development strategy, especially among small or emergent economies that aim to increase their competitiveness in the global economy (Xiao et al., 2022). The theoretical models of innovation infrastructure explain the dynamics of technological advancement and entrepreneurship combined with economic growth. In this scenario, the innovation ecosystem refers to a network of institutions, policies, resources, and stakeholders who interact in the elaboration and diffusion of new technologies and business models (Autio & Thomas, 2021). For the majority of scholars, an effective innovation ecosystem should encapsulate both public and private institutions, culminating in R&D facilities, technology parks, incubators, and access to capital (Chang & Cheng, 2022). In smaller economies, innovation ecosystems tend to be highly dependent on effective collaboration between government, academia, and industry. Success stories drawn from smaller regions, such as Estonia's high-tech success or Israel's startup culture, demonstrate that geographically and resource-isolated regions can build highly competitive innovation ecosystems when strategic investments and adequate policies are in place.

On the other hand, innovation policy can be described as the governmental approach that aims to develop research, development, and technological enhancement within the economy. Effective innovation policies are vital in facilitating collaboration between universities and businesses, as well as among government agencies. Typically, innovation policies comprise tax incentives for research and development activities, support for small and medium-sized enterprises, and education and training funds allocated to science and technology fields. In the case of small economies, innovation policy needs to be tailored according to local conditions and must respond to specific challenges, including access to capital, workforce skills, and geographical constraints (Howoldt, 2024).

Regarding the above, economic modernization is understood as the process by which traditional sectors in a national economy, such as agriculture or manufacturing, are transformed through new technologies, business models, and practices (Sadik-Zada, 2021). This concept particularly applies to Nakhchivan Autonomous Republic (NAR), whose economy is mainly based on traditional industries like agriculture. The modernization process for these regions consists of integrating technological innovation, digitization, and industrial diversification. Countries like Singapore demonstrate this transformation, having evolved from a rural economy to a technological global hub through well-placed investments in innovation infrastructure.

These theoretical approaches emphasize that developing innovation infrastructure support is particularly important for economic growth in small or growing economies, as exemplified by the Nakhchivan Autonomous Republic. Thus, it is expected that a properly targeted innovation policy will yield a strong innovation ecosystem, leading to economic modernization, increased productivity, and sustainable growth. It can be said that particular academic and governmental research on the economy of the Nakhchivan Autonomous Republic has been carried out, focusing primarily on its strategic significance, geographical isolation, and economic structure. Traditionally, the backbone of the national economy of NAR has been agriculture, followed by light manufacturing and tourism. But with the modern transformation of the world economy into one based on knowledge and innovation, awareness is growing that Nakhchivan needs to transform toward a more diversified knowledge-based economy.

Several studies identify the following as the major challenges of the Nakhchivan economy: its geographical isolation, lack of access to modern technologies, and low investment in infrastructure. For instance, Ahmadova (2019) indicates that isolation from the Azerbaijani mainland creates huge logistical problems and significantly restricts trade exchange and the flow of goods and services. This condition has been further exacerbated by the underdeveloped transport network in the region, which makes doing business cumbersome and closes off most avenues to international markets. Another crucial challenge is the lack of access to technology and digital infrastructure. Works by Ibrahimov and Nagiyev (2020) demonstrate a technological lag behind the rest of Azerbaijan, let alone Baku,

due to very low investment in R&D and limited interaction between local businesses and research institutions.

Despite these challenges, Nakhchivan possesses several strengths and opportunities that could support building innovation infrastructure in the region. With its strategic position bordering Turkey, Iran, and Armenia, the region has potential for regional cooperation in various initiatives focused on infrastructure and transportation corridors, fostering economic cooperation in the Eurasian region, such as the Zangazur Corridor, as Gulahmadov and Huseyn (2023) present. The Nakhchivan government actively promotes economic development through targeted policies aimed at fostering entrepreneurship and technological innovation. The small technology hubs and business incubators that exist in embryonic form represent steps toward building an innovation ecosystem in this region. This development creates opportunities for integrating new technologies, from smart farming to digital platforms for tourism services, as the state supports agricultural modernization and establishes conditions for tourism growth.

Various publications on the development of innovation infrastructure in other small or isolated regions provide insights that are relevant to Nakhchivan. For instance, Novruzov (2023) discusses the development of innovation infrastructure in other parts of Azerbaijan, particularly in recently liberated areas; regional collaboration appears especially important, with government acting as a facilitator of innovation through focused investments in both technology and education. In this line, Ibadoghlu (2022) discusses Azerbaijan's socio-economic development strategy for the years 2022-2026 and how innovation drives the development trail in an economy of an isolated or underdeveloped region. Results indicate government-emphasized initiatives that have to go hand in glove with international collaboration in the surmounting of unilateral obstacles to innovation in regions such as Nakhchivan.

However, while there is a substantial amount of research available on the economic challenges and opportunities in the Nakhchivan Autonomous Republic, few studies have specifically focused on this region's innovation infrastructure. The existing literature tends to concentrate on traditional sectors such as agriculture, manufacturing, and tourism, omitting detailed information concerning technological innovation and modernization potential in these areas. Moreover, although several studies have examined innovation infrastructure in other parts of Azerbaijan, the unique geographic and economic context of Nakhchivan requires special consideration. One significant gap in the literature is the lack of research on the role that digital infrastructure and technology could play in driving innovation in the Nakhchivan economy. As the global economy gradually digitizes, regions that lack access to sophisticated means of communication are likely to fall further behind others in terms of competitiveness and productivity. Few researchers have explored how Nakhchivan can embrace digital technologies, e-commerce, smart agriculture, or digital tourism to modernize its economy.

Furthermore, there is an apparent lack of research regarding the role of education and training in stimulating innovation processes in Nakhchivan. Innovation ecosystems across other regions have been observed to rely heavily on skilled labor with strong educational backgrounds in mathematics, technology, engineering, and science. However, there is little research examining how educational institutions within Nakhchivan are preparing students for participation in an innovation-driven economy. Against this background, this article aims to fill these gaps by providing a detailed analysis of the current state of innovation infrastructure in Nakhchivan, its potential for development, and recommendations for overcoming the region's unique challenges. Through this research, the article will contribute to the broader literature on innovation in small or isolated economies while providing practical policy suggestions for the government of Nakhchivan.

MATERIALS AND METHODS

Problem statement

Geographically and economically speaking, the Nakhchivan Autonomous Republic (NAR) occupies a unique position within Azerbaijan. Nakhchivan, an exclave surrounded by Turkey, Iran, and Armenia, is essential to the geopolitical and economic policies of the region. Despite its separation from Azerbaijan's mainland, Nakhchivan has proven resilient by focusing on key sectors including tourism, light industry, and agriculture (Allahverdi, 2024). However, the region's continued reliance on conventional sectors may hinder its long-term economic growth in an era increasingly driven by globalization and technological advancement.

A region's ability to attract investment depends on its innovation infrastructure, which includes digital networks, technology parks, research institutes, and startup ecosystems. Globally, regions that have effectively promoted innovation have reaped significant economic rewards, such as higher productivity, more diverse economic activity, and increased foreign investment. Building strong innovation infrastructure in Nakhchivan is particularly crucial as it has the potential to transform the region's local economy and integrate it into broader national and global economic frameworks. Through embracing innovation, Nakhchivan can ensure sustainable development in an increasingly

competitive global market, diversify its economy, and reduce its dependence on conventional sectors.

Given the strategic importance of the Nakhchivan region, several obstacles impede the development of an innovation-driven economy. The main challenge is the technological lag behind other economically developed regions, particularly the capital, Baku. Limited access to advanced technologies, combined with poor R&D infrastructure and a shortage of human resources in high-tech industries, forms the foundation of this gap. Moreover, inadequate investment in innovation from both government and private sectors further hampers the potential for economic modernization.

Geographical isolation presents another challenge for Nakhchivan. Transportation and communication limitations constrain trade and exchange, both essential components of a well-functioning innovation ecosystem. Additionally, while local government initiatives support entrepreneurship and technology, these programs remain fragmented and under-resourced. The lack of a strategic plan for developing innovation infrastructure puts the region at further risk of falling behind in the rapidly changing global economy.

Overcoming these barriers and prioritizing innovation infrastructure development is crucial for Nakhchivan's long-term economic growth. This focus will foster an ecosystem for technological advancement, innovation, and entrepreneurship, positioning Nakhchivan to create new employment opportunities, attract foreign investment, and substantially contribute to Azerbaijan's broader economic goals. This paper will further examine these challenges and outline strategies for overcoming them to establish the foundation for a sustainable innovation-driven economy in the Nakhchivan Autonomous Republic.

Research Objectives

As stated before, this paper aims to examine the possibilities for innovation infrastructure development in the Nakhchivan Autonomous Republic. The study will assess the current economic, technological, and institutional environment as a foundation for determining innovation infrastructure development in the region. The article seeks to demonstrate how NAR's innovation capability can be improved by identifying strengths, weaknesses, opportunities, and threats. It also encompasses an investigation of government policy, private investment, and international cooperation, all crucial elements in ensuring a sustainable innovation ecosystem. The ultimate objective is to provide strategic directions that may guide policymakers, business leaders, and educators in effectively fostering innovation infrastructure development so that NAR is well-positioned for future economic growth.

The following research questions have guided the elaboration of the research:

1. What is the current state of innovation infrastructure in the Nakhchivan Autonomous Republic?

To answer this question, it is examined the available resources, institutions, and initiatives supporting innovation in NAR. It was investigated the current technological level, the presence of educational institutions, and the existence of innovation centers such as technology parks or incubators.

2. What are the prospects for developing innovation infrastructure in the near and long-term future?

This question explores the potential for further development of innovation infrastructure in NAR. It examines recent trends in technology and entrepreneurship, and investigates potential investment opportunities, partnerships, and collaborations both locally and internationally.

3. What mechanisms should be employed to accelerate innovation in the NAR economy?

This question identifies specific policies, investments, and collaborative efforts that can stimulate innovation in NAR. It particularly focuses on providing actionable recommendations for government, private sector, and academia to work cooperatively in building a robust ecosystem that can foster innovation, ultimately leading to sustainable economic growth in the long term.

Methodology

This section outlines the key characteristics of the research methodology applied in this study to analyze the development of innovation infrastructure in the Nakhchivan Autonomous Republic. Both qualitative and quantitative data are discussed in detail, providing a comprehensive understanding of the current status of innovation infrastructure in NAR and its future development prospects.

Research Design

This paper employs a mixed-methods research design that combines both qualitative and quantitative approaches for a more holistic analysis of innovation infrastructure in NAR. The mixed-methods approach is particularly suitable for this study, as it integrates numerical data, such as economic indicators and innovation indices, with contextual insights from expert opinions and policy reviews. The major elements of the research design include:

SWOT Analysis: The SWOT analysis examines the current state of innovation infrastructure in NAR by identifying

its relative strengths, weaknesses, opportunities, and threats. This framework assists in evaluating internal strengths and weaknesses within the region, along with external opportunities and threats that may affect innovation infrastructure development. Strengths may include government initiatives, while weaknesses might center on technological limitations. Opportunities could encompass regional collaborations, and threats might involve geopolitical constraints or insufficient investment.

Comparative Assessment: The study employs a comparative assessment to evaluate NAR's innovation infrastructure against other similar small or peripheral regions that have successfully developed their innovation ecosystems. The analysis compares NAR with regions such as Estonia or Israel, which, despite their small size, have made significant progress in innovation development through strategic investment in policies and frameworks. This comparison provides a benchmark for identifying potential pathways for NAR's innovation-driven development.

Data Collection

Data collection involves both primary and secondary information necessary for understanding the economic and innovation landscape in NAR.

Primary Data:

Interviews: Semi-structured interviews will be conducted with key stakeholders in NAR, including economic experts, government officials, business leaders, and academics. These interviews will capture the challenges and opportunities related to developing innovation infrastructure in NAR. The respondents will provide insights on current policies, initiatives, and future strategies for fostering innovation.

Focus Groups: Focus group discussions with entrepreneurs and small business owners in the region will help understand the practical challenges they face when adopting new technologies or launching innovation-driven enterprises. These discussions will also highlight gaps in government support, access to finance, education, and other barriers to innovation in NAR.

Secondary Data:

Government Reports: Content analysis of official government publications, including economic reports, innovation policy documents, and development plans related to Nakhchivan, will serve as a methodological tool for understanding the regional government's priorities and strategies concerning innovation infrastructure.

Regional Statistics: Economic and demographic statistics provided by the State Statistical Committee of the Nakhchivan Autonomous Republic will quantify NAR's economic performance through GDP growth, employment rates, and sectoral contributions. Innovation-specific statistics, when available, will include R&D expenditure, number of startups, and patent applications filed.

Academic and Policy Research: The literature review and policy research will focus on innovation in small economies and developing regions, including specific case studies of regions facing challenges similar to NAR. Examples of successful innovation policies and initiatives will provide comprehensive understanding.

Comparative Regional Data: Data from other regions with successful innovation infrastructures will serve as benchmarks. Key indicators for comparison will include government investment in innovation, R&D spending, number of technology parks, and innovation-related employment.

Data Analysis

Data analysis will be conducted using both qualitative and quantitative techniques to ensure a comprehensive interpretation of the data collected in this study.

- Qualitative Analysis: Qualitative data will include interview transcripts, focus group discussions, and content from policy documents, all subjected to thematic analysis. This approach will facilitate the identification of major themes and patterns related to strengths, weaknesses, opportunities, and threats concerning NAR's innovation infrastructure. Key themes will include government policy support, investment barriers, and opportunities for international collaboration. The thematic analysis will also aim to uncover recurring challenges highlighted in stakeholder interviews, such as funding issues, infrastructure gaps, and talent shortages. Additionally, content analysis of policy documents and government reports will be conducted to assess the alignment between official innovation strategies and the practical challenges reported by stakeholders. This will help pinpoint gaps between policy intentions and their implementation.
- Quantitative Analysis: Quantitative data, including economic performance indicators and innovation metrics, will be analyzed using descriptive and inferential statistical methods. Descriptive statistics will summarize the economic conditions of NAR, such as GDP growth, unemployment rates, and sectoral contributions to the economy. Innovation-specific metrics, including R&D investment levels, the number of startups, and patents filed, will provide insights into the current state of innovation in NAR. A comparative analysis will benchmark NAR's economic and innovation performance

against similar regions using statistical methods. Key indicators, such as R&D expenditure as a percentage of GDP, the number of innovation hubs or technoparks, and the growth of innovative sectors, will be compared with regions like Estonia or Israel. This analysis will highlight potential areas for improvement and suggest strategies that NAR could adopt from other regions.

The study will also employ a SWOT matrix analysis to quantify the influence of these factors on NAR's innovation environment. This will provide a clearer indication of the factors that present the greatest opportunities or threats to the region's innovative development.

RESULTS AND DISCUSSION

Current State of Economy and Innovation Infrastructure in NAR

Because of its exiled position, the Nakhchivan Autonomous Republic occupies a particular place in the general economic structure of Azerbaijan. The leading sectors of the economy—agriculture, manufacturing, tourism, and trade—form the backbone of the region's GDP. Agriculture has conventionally been considered the leading sector, with heavy emphasis on cereal production, fruits, vegetables, and livestock. Moreover, rich soils, supported by government agrarian reforms, have allowed Nakhchivan to maintain stable production of agricultural products, providing employment for a large proportion of the population. Other significant areas of production include food processing, textiles, and building materials. Manufacturing in Nakhchivan is somewhat underdeveloped compared to other regions in Azerbaijan; however, the government has provided some grounds for industrialization, such as the establishment of free trade zones and tax incentives for companies operating in this field. These efforts have resulted in modest growth in this sector, particularly in the manufacture of products exported to neighboring countries such as Turkey and Iran.

Tourism is a relatively new sector in NAR, favored by the cultural heritage, historical monuments, and breathtaking natural landscapes of the region. The government has recognized the potential of tourism as one of the main drivers of economic development and has invested in infrastructure projects aimed at improving infrastructure and tourist services. The sector remains underdeveloped in relation to its general potential, and many more investments will be required to position the Nakhchivan Autonomous Republic among the top attractions.

Being at the border of Armenia, Iran, and Turkey, trade is an essential aspect of the NAR economy. Such a geopolitical position provides a number of opportunities for international trade; however, several problems are evident within the region, particularly related to transportation and logistics. Eventually, the opening of the Zangazur Corridor may finally connect Nakhchivan with the rest of Azerbaijan, thereby stimulating trade and economic development in the region in the near future. Notwithstanding these positive developments, the NAR remains an enclave economy with a high level of state involvement. Its economic structure, dominated by more traditional industries, makes full participation in the world economy difficult and underscores the need for innovation-driven development to diversify its economic base.

The innovation infrastructure within the Nakhchivan Autonomous Republic is literally at its very beginning, with only a few initiatives implemented so far for the development of technological entrepreneurship. While in other parts of Azerbaijan, such as in Baku, innovation ecosystems have attained relatively more advanced levels of development, only recently has NAR begun to prioritize establishing institutions and policies supportive of innovation. The development of technology parks and business incubators in this regard is one of the flagship initiatives aimed at supporting startups and small enterprises. Although still in their infancy, these initiatives represent necessary building blocks for the creation of an innovation ecosystem in NAR. Government funding has flowed into the construction of infrastructure that may support the growth of high-tech industries, but large-scale impact has yet to be seen.

Additionally, research institutions and universities in Nakhchivan have started to interact with the private sector in promoting R&D activities, though the number of such collaborations has been very limited and underfunded. On the government side, policies for innovation are mostly focused on tax incentives for technology-based enterprises and grants for research and development projects. Although these policies are welcome moves, no significant impacts have been observed so far due to the absence of higher-level strategic planning and coordination at various levels. International collaboration and partnerships—essential for accessing advanced technologies and expertise—are also relatively few. More serious efforts should be made to attract foreign investment and develop stronger interactions with international research centers and businesses to accelerate the growth of the innovation infrastructure in Nakhchivan.

With its small market size and the high levels of risk associated with investments required by new technologies, private sector innovative activity is not very active in Nakhchivan. While the government remains the main driver of innovation-related initiatives, building a more

sustainable innovation ecosystem will require increased private sector participation—particularly in industries with high potential for technological innovation, such as agricultural technology and digital tourism.

In the Autonomous Republic of Nakhchivan, there are several serious obstacles to developing innovation infrastructure. One of the main barriers is a lack of finance. There is underinvestment in the public-private sector for research and development, and while a few government grants or incentives may exist, these are generally not sufficient to spur large-scale innovation activity. The lack of investment by venture capital and private equity in the region further significantly curtails the appetite for progressive start-ups and small enterprises seeking to scale and innovate. Another significant challenge is the lack of sufficient technical skills within the local workforce. As educational institutions in Nakhchivan advance in educating students in science and technology, they are clearly not yet producing a workforce advanced enough for an innovation-driven economy. Businesses can seldom find the required talent to adopt new technologies and implement them in business without specialized training courses in engineering, information technology, and data science. This issue is compounded by the limited collaboration opportunities between academia and industry, making innovation even more stunted.

The second important barrier is geographical isolation. The exclave position of Nakhchivan restricts transportation and logistical links with the rest of Azerbaijan and surrounding regions, thus limiting the flows of goods, services, and knowledge, which are crucial in driving innovation. While the planned Zangazur Corridor is expected to ease some of these issues, for the time being, this situation limits the opportunities that firms and institutions throughout NAR could exploit through cross-border collaborations, attracting foreign investment, and accessing international markets.

Last but not least, the minimal level of collaboration between academia and industry is one of the major problems in building a strong innovation ecosystem in Nakhchivan. While research institutes and universities are becoming more active in R&D, there is still a significant gap between academic research and its application in the private sector. This gap would again impede the commercialization of new technologies and reduce the overall impact that research activities could have on the economic advancement of the region.

These challenges can only be resolved through dedicated efforts by the government and private sector of the country, accompanied by international cooperation. Nakhchivan would begin to overcome many of these obstacles toward the creation of a sustainable, innovation-driven economy through significant investment in education, research, and physical infrastructure, combined with stronger academia-industry links.

Perspectives of Innovation Infrastructure Development

The infrastructure of innovation in Nakhchivan opens crucial perspectives for economic transformation and modernization. Since NAR is considered to be in a strategic location and with the respective government initiatives and sectoral innovation, it has all the potential to establish an innovative ecosystem that could serve the needs of both the economic challenges facing the country and increase the global demand for technological development. In this section, sectors with good potential for innovation are discussed, some policy recommendations are reviewed, and opportunities for international collaboration are considered.

Strategic Opportunities

High potential for innovation and growth can be identified in several sectors of NAR: renewable energy, agriculture, and technology-based startups.

Renewable Energy:

NAR is situated in a region that holds immense potential for renewable sources of energy, namely thermal, wind, and solar. Given the arid climate and high levels of sunlight in this region, investments in basic infrastructure for capturing solar energy could provide a sustainable solution for local needs, as well as being a component of a broader effort to reduce carbon emissions. It is worth noting that wind energy projects can be developed in areas with good wind conditions. Subsidizing renewable energy projects with government support through tax incentives will attract foreign investors in such projects, opening up new avenues for public-private participation. The focus on renewable energy would reduce NAR's dependence on imported fossil fuels and make it a regional leader in clean energy production.

Agriculture:

Agriculture is still one of the major economic sectors of NAR, with much potential for innovation through agri-tech solutions. In smart farm technologies, precision agriculture, drone monitoring, and automated irrigation systems can be adopted in the form of farmyards for higher productivity and sustainability. The NAR government could also encourage the application of such technologies by providing subsidies to farmers who utilize innovation-driven methods of farming. Partnerships with agri-tech

companies from other countries may also bring highly advanced technologies and expertise into the region for greater efficiency and increased production.

Technology-based Startups:

Although the technology sector is relatively new in NAR, there seems to be significant interest in promoting a wave of startups and entrepreneurship. It could also be a way for the region to create technology hubs and incubators that nurture a vibrant startup ecosystem in industries such as software development, e-commerce, and digital services. What would further spur growth is government policies that offer seed funding, mentorship programs, and access to international markets. Standalone partnerships with venture capital firms, both local and international, may also offer financial support to budding entrepreneurs for scaling innovative businesses.

Policy Recommendations

To foster a climate conducive to innovation, the NAR government must pursue various policy measures to encourage investment, education, and collaboration.

Tax Incentives:

Targeted tax incentives have proven to be one of the best ways to attract investment in innovation. The government of NAR could offer tax breaks or reduced corporate tax rates for those investing in R&D, technology adoption, and the incubation of startups. This would lower the cost burden for companies and encourage more local and international firms to invest in innovative activities (Ibrahimov and Nagiyev, 2020). Additionally, the government could consider extending tax incentives to the agriculture and renewable energy sectors in pursuit of sustainability and technological advancement.

Education and Workforce Development:

One of the most crucial elements in ensuring that the innovation infrastructure provides necessary technical skills to the local workforce is education. Investments in education, particularly in STEM fields, will be vital for producing the next wave of innovators. This area calls for prioritization, with the government supporting the creation of specialized training programs in academic institutions focused on technology, engineering, and entrepreneurship. Partnerships with international universities and research institutions could also improve the quality of education and provide students with exposure to global trends and practices.

Private Sector and Academia:

Successful innovation requires collaboration at three levels: government, the private sector, and academic institutions. Public-private partnerships could be formed to facilitate the sharing of resources, expertise, and funding for innovative projects. The government could also encourage universities to collaborate with businesses on research projects, particularly in applied sciences and engineering. Promoting this spirit of cooperation would help NAR accelerate the commercialization of its new technologies and solutions.

Chances of International Cooperation

International collaboration is crucial for creating an innovation infrastructure in NAR by facilitating access to advanced technologies, capital, and expertise. There are various ways through which NAR can be internationalized (Gulahmadov and Huseyn, 2023).

Foreign Investment:

Above all, scaling innovation in NAR has significant implications for attracting foreign direct investment. NAR can target foreign investors by showcasing the potential already inherent in renewable energy and agriculture. Several governments, particularly from the European Union and the Middle East, have shown interest in investing in renewable energy projects. NAR should capitalize on this opportunity by seeking financing for its clean energy initiatives. Furthermore, collaborating with multilateral organizations such as the World Bank or the Asian Development Bank could provide additional funding for large-scale innovation projects.

Regional Cooperation:

NAR can also benefit from a regional cooperation approach with neighboring countries such as Turkey, Iran, and Armenia, particularly through the establishment of cross-border innovation projects. Recent developments, including the establishment of the Zangazur Corridor, have opened avenues for cooperation with infrastructure projects that will support trade, logistics, and technological exchange. Strong connections with these regions allow NAR to expand its innovation landscape and access emerging markets.

International Research Partnerships:

Enhancing the culture of innovation in NAR could also be achieved by partnering with international research institutions. Collaborations with leading universities and research institutions from various parts of the world would provide access to state-of-the-art technologies and methodologies. This could be further supported through exchange programs, joint research projects, and the establishment

of international innovation conferences or forums held in NAR, aimed at attracting global innovators and investors to the region for mutual benefit (Ibrahimov and Nagiyev, 2020).

Prospects for Developing Innovation Infrastructure

The establishment of innovation infrastructure in the Nakhchivan Autonomous Republic opens great perspectives for economic transformation and modernization. In this respect, it is possible to develop a complete innovation ecosystem in the NAR through the effective use of its strategic location, various government initiatives, and sectoral value creation potential that address both the economic challenges of the region itself and the world's need for technological advancement. Further sections discuss the most promising sectors for innovation, provide respective policy recommendations, and investigate possibilities for international collaboration.

Strategic Opportunities

The NAR has several fields with very high potential in terms of innovation and opportunities, among which the most outstanding are renewable energy, agriculture, and tech-based startups.

Renewable Energy: The NAR falls into a geographical area that has enormous potential regarding the development of renewable energy sources. Solar and wind are the main renewable sources of energy that could be developed in the region. Due to the arid region with high-intensity sunlight most of the time, investment in infrastructure for solar energy could achieve sustainability not only for local energy needs but also contribute to the general goal of reducing carbon emissions. Similarly, projects on wind energy can also be developed in areas with favorable wind conditions. With government support, subsidies, and tax incentives, foreign investors would be attracted to the development of renewable energy projects, opening new avenues for public-private partnerships in this area. The NAR would reduce its dependence on imported fossil fuels by making use of renewable energy sources and positioning itself as a regional leader in the production of clean energy.

Agriculture*:* Agriculture is among the main economic sectors in the NAR, and agri-tech solutions provide huge potential for innovation. Technologies provided by smart farming include Precision Agriculture, Drone Monitoring, and automated irrigation, which will greatly enhance productivity and sustainability. In this regard, the government may support such technologies by providing subsidies to farmers who adopt innovation-driven approaches to agriculture. Furthermore, cooperation with foreign agri-tech companies may guarantee the inflow of technologies and skills to the region, improving agricultural efficiency and output (Ibrahimov and Nagiyev, 2020).

Technology-based startups: Although the technology sector in NAR is still nascent, an uptick of interest can already be seen in the promotion of startups and entrepreneurship. With the establishment of technology hubs or incubators, the region can significantly support the emergence of a healthy and strong startup ecosystem that participates in software development, e-commerce, and digital operations. Such a sector would be further helped on its growth path by government policies that ensure seed funding, mentorship programs, and access to international markets. Venture capital partnerships on the local and international levels would also bring in the much-needed finance towards budding entrepreneurs, creating opportunities for scaling innovative businesses.

Policy Recommendations

Certain policy measures should be instituted by the government in the NAR to encourage investment, education, and collaboration, which will lead to a supportive environment for innovation.

Tax Incentives: Targeted tax incentives appear to be one of the best ways to attract investment in innovation. This may involve the provision of tax breaks or concessional corporate tax rates by the NAR government for firms that invest in R&D, technology adoption, and the incubation of start-ups. This will lower the financial barrier for businesses and encourage both local and foreign firms to engage in innovative activities. Furthermore, the extension of tax incentives to renewable energy and agriculture will promote sustainability and technological advancement.

Investment in Education and Training*:* The most important component of the innovation infrastructure is ensuring that the local workforce accelerates with the proper technical skills. In this regard, investment in education at all levels has been made to equip the next generation of innovators. Interactions among the government, academic institutions, and specialized training programs should focus on technology, engineering, and entrepreneurship. Additionally, partnerships with foreign universities and research institutions could enhance the quality of education and provide opportunities for global exposure for students.

Collaboration between Government, Private Sector, and Academia: Innovation flourishes through focused collaboration between the government, private sector, and academic institutions. The development of public-private partnerships would enable them to collaborate not only on

resources but also on expertise and funding for innovative projects. The government can offer certain incentives to universities involved in research projects with businesses, specifically in applied sciences and engineering. By developing a culture of coordination, the NAR would accelerate the commercialization of new technologies and their solutions.

International Collaboration Potential

Since international collaboration, in general, can provide access to advanced technologies, capital, and expertise, it is of paramount importance for the development of innovation infrastructure in the case of the NAR. There are various avenues for international engagement in the NAR.

Investment Abroad*:* Foreign direct investment in scaling innovations in the NAR would be crucial. The region may also target international investors, particularly those interested in its perceived potential in renewable energy and agriculture. Governments from other regions, especially the European Union and the Middle East, are looking to invest in renewable energy projects, which could benefit the NAR in securing funding for its Clean Energy Initiatives. Furthermore, cooperation with multilateral organizations like the World Bank or the Asian Development Bank could open additional financial resources for implementing large-scale innovative projects (Gulahmadov and Huseyn, 2023).

Regional Cooperation: The NAR could also benefit from regional cooperation, particularly with neighboring countries like Turkey, Iran, and Armenia, by developing cross-border innovation projects. The opening of the Zangazur Corridor provides an opportunity for the NAR to cooperate on infrastructure projects that will make trade, logistics, and technological exchange more efficient. With strong connections to these neighboring areas, access to the broader innovation ecosystem will allow the NAR to acquire new markets.

International Research Partnerships: Other ways of enhancing innovation in the NAR include collaboration with international research institutions. Partnerships with leading universities and research centers worldwide could provide access to the latest technologies and methodologies. This collaboration could further be facilitated through exchange programs, joint research projects, and the establishment of international innovation conferences or forums hosted in the NAR, which could attract global innovators and investors to the region (Ibrahimov and Nagiyev, 2020).

Case Studies

The next section spends some more light on the probable development of innovation infrastructure in the Nakhchivan Autonomous Republic through case studies of other regions in the world that develop innovation against similar challenges. Case studies benchmark the NAR on how strategic policies, government support, and collaboration with international partners can overcome bases to innovation.

Models of Successful Innovation in Other Regions

Scarcity and geographic isolation have not deterred several regions of the world from building successful innovation ecosystems. Notable examples include Estonia and Israel.

Estonia: A Forerunner of the Digital Economy

Probably the best example of how a small, geographically remote country can rise to global leadership in innovation, especially in terms of digital governance and technology, is Estonia. After emerging as an independent country in 1991, Estonia made it a priority to build a well-connected digital infrastructure. The Estonian government encouraged e-governance policies such as digital ID cards, e-residency, and electronic voting, thus earning a reputation as one of the leading countries in digital transformation. While developing a culture of innovation, Information and Communication Technology (ICT) education played an essential role in this success. Moreover, various public-private partnerships, coupled with international relationships—particularly with European Union countries—were crucial investments for the country as they sought funding and technical capabilities. The Estonian experience offers valuable lessons for the NAR, demonstrating that building an innovation ecosystem requires a focus on developing digital infrastructure and education. From there, further strategies could include investing in more e-government services and online platforms, as well as enhancing ICT education in schools and universities. Similarly, Estonia's reliance on international partnerships presents an opportunity for the NAR to seek technical and financial support from foreign governments, international organizations, and large multinational corporations.

Israel: The Nation of Startups

Israel, more recently referred to as the "Startup Nation," is another model worth considering for the NAR. Despite being a small and resource-poor country, Israel has built a world-class innovation ecosystem, especially in the high-tech sector. This success can be attributed to the focused strategic approach of its ecosystem, which includes venture capital, government support for R&D, and strong military-industry-academia linkages. A multi-agency

Israeli government fosters innovation through the Israel Innovation Authority, which provides subsidies and tax breaks to startups and firms engaged in research and development. The mandatory military service in Israel has also produced many extremely successful entrepreneurs and engineers, particularly from its elite technological units.

The NAR could look to Israel for guidance in supporting government programs that promote grants for R&D, tax incentives for startups, and fostering innovation by connecting military and academic interests. Additionally, promoting the development of the venture capital ecosystem will provide financing for scaling technology-based startups.

Local Initiatives

Although still in the early stages of developing its innovation infrastructure, NAR already has a number of local initiatives that could form the foundational blocks for further development:

Nakhchivan Technology Parks and Business Incubators:

The regional government has initiated the construction of technology parks and incubators to foster more venture and technological innovation. These facilities provide start-ups and small businesses with the resources, mentorship, and networking opportunities needed to scale their ventures. While these initiatives are still relatively new, they represent significant strides toward building an innovation ecosystem in NAR.

The success of these efforts will depend on continued government support and the involvement of private sector partners to ensure that the infrastructure and services provided by these technology parks meet the evolving needs of the business community.

Collaboration with Universities:

Some initiatives at NAR universities, such as Nakhchivan State University, have started to focus on building relationships with the local private sector to enhance R&D activities in fields like agriculture and manufacturing. These partnerships have led to the realization of relatively innovative approaches in farming and food production, thus modernizing traditional industries. Such collaborations will become even more crucial for the further development of innovation infrastructure in the region when extended to renewable energy and digital services (Ibrahimov and Nagiyev, 2020).

Final remarks

The current research findings provide insight into both the opportunities and challenges in developing innovation infrastructure in NAR, largely confirming the hypotheses initially presented in the introduction.

Actual Structure of Economy versus Potential for Innovation:

The analysis of the economy of NAR highlights the region's reliance on traditional sectors such as agriculture, manufacturing, and tourism. With construction at a low level, the innovation infrastructure of the economy is predictably underdeveloped—certainly more so than in regions like Baku. The limited presence of technology parks, research institutions, and startup ecosystems in NAR supports the assumption that the region lags behind in developing a robust innovation ecosystem. However, the study identifies a few promising areas for innovation in renewable energy and agriculture, where the impact could be significant, aligning with global trends in sustainable development and smart agriculture.

Development Challenges of Innovation Infrastructure:

The primary issues identified—finance, lack of technical skills, and geographical isolation—align with the concerns discussed in the literature review. These factors are indeed expected to significantly limit the innovative capacity of NAR regarding foreign investment and collaboration between academia and industry. Geographical isolation remains a significant barrier to trade and international collaboration in NAR, a finding consistent with previous studies. However, promising areas were identified where challenges could be mitigated, either through improved connectivity or corridors, with the Zangazur Corridor offering hope for alleviating some logistical and connectivity challenges, potentially improving trade and innovation prospects in the future.

Alignment with Global Best Practices:

Compared to the successful examples of innovation-driven growth in small economies like Estonia and Israel, NAR is significantly behind in its current innovation ecosystem. However, several strategic opportunities in sectors such as renewable energy and agriculture suggest that NAR can adopt global best practices to catch up. For instance, Estonia has focused on digital governance, while Israel has emphasized technology start-ups. These examples provide potential models for NAR to build its niche in either renewable energy or agri-tech. In any case, this study confirms that although there are substantial barriers ahead, the region is not lacking in resources or potential to develop a successful innovation infrastructure.

Policy and Practice Implications of this research

The results of this study have wide-ranging implications for various stakeholders in NAR—including policymakers, business leaders, and academic researchers. If these stakeholders embrace the strategic opportunities presented by this research, NAR will be well on its way to developing a truly sustainable and competitive innovation ecosystem.

For Policymakers:

Investment in innovation infrastructure should be a central component of NAR's broader economic development strategy. The findings from this study suggest that government support will be crucial, particularly in the form of tax incentives, competitive grants, and direct investment in education, which are key to overcoming innovation barriers. Therefore, policymakers should consider extending the current tax incentives to a broader range of industries, especially renewable energy and technology-based startups, to stimulate local entrepreneurship and attract foreign direct investment. Additionally, public-private partnerships (PPPs) could be developed to bridge the gap between universities, industry, and government, making the innovation system more interactive.

Another significant recommendation for policymakers is the need to focus on regional cooperation. Given NAR's geographical location, the government should pursue international collaboration, particularly with neighboring countries such as Turkey and Iran, with an emphasis on cross-border innovation and technology transfer. The Zangazur Corridor presents a valuable opportunity to improve logistics and connectivity, significantly boosting the region's potential in international trade and innovation networks.

For Business Leaders:

The findings suggest that business leaders in NAR should take a more proactive role in supporting innovation-driven growth, particularly in high-potential sectors such as agriculture and renewable energy. Companies operating in these industries should invest in research on new technologies related to precision farming and renewable energy, as such initiatives can enhance productivity and sustainability. Business leaders should also advocate for increased interaction with academia to promote the commercialization of research and development. Indeed, businesses stand to gain access to new technologies, skilled talent, and funding sources through collaboration with universities and research centers.

Furthermore, business leaders should seek international partnerships to overcome the limitations of the local market. Engaging with foreign investors, venture capital firms, and international development organizations can provide the necessary financial and technical resources to scale innovative enterprises in NAR.

Researchers:

The impact of this research on academia is twofold. First, academia must take a more proactive role in stimulating innovation, with educational and research programs tailored to regional economic needs. The study highlights the considerable potential for research in agri-tech and renewable energy, which should be incorporated into university curricula and research agendas. Second, there is a need for closer collaboration between academia and industry, particularly on applied projects that address the current challenges in sectors such as agriculture and energy. This approach would help commercialize the solutions being developed and reduce the gap between academia and industry.

Additionally, researchers should establish international networks to exchange knowledge and expertise. Participation in international conferences will raise the profile of NAR's academic institutions, while research collaborations and academic exchange programs will provide access to cutting-edge technologies and methodologies that are crucial drivers of innovation in the region.

CONCLUSIONS

In this article, the current condition of the innovation infrastructure in the Nakhchivan Autonomous Republic—a potential driver of economic modernization and long-term growth—has been discussed. The findings underline the region's traditional reliance on agriculture, manufacturing, and tourism sectors, while strategic opportunities for innovation have been identified in areas such as renewable energy, agri-tech, and technology-based startups. The development of innovation parks, schemes, and government-backed programs are at least providing some hope for an innovation-driven future. But for the present, at least, many challenges persist—such as the limitations of funding, shortage of adequate technical skills, and geographical isolation. Against this backdrop, targeted government policies addressing these barriers, occasional investment in education, and international collaboration could likely provide NAR with a more sustained innovation environment.

A host of limitations beset this overall study and potentially impact the generalizability of the conclusions that can be made. First, detailed and updated data on innovation infrastructure in NAR were limited, especially on quantitative metrics such as R&D expenditure and startup activities.

Second, qualitative data from interviews and focus groups had small samples, and their representativeness may not carry over well to the wider business and academic communities relevant to NAR. Finally, the comparative analysis with other regions is solely based on secondary sources, which might not be representative of the full complexity of NAR's unique economic and geographic context.

Future research is needed regarding NAR's innovation infrastructure, which must be supported by a more robust gathering of quantitative data, especially on new sectors such as renewable energy, technology startups, and digital services. Longitudinal studies need to be conducted with the aim of charting developments over time for a more in-depth analysis of government policy and private sector efforts toward success. Moreover, it would be of equal interest to explore how the role of education and enhancement of skills for stimulating innovation can complement efforts, with particular attention to STEM fields, to help NAR build a more skilled workforce. In this respect, further investigation into the possibility of regional and international collaboration, especially with the perspective of the Zangazur Corridor, would provide further evidence on how NAR can position itself within global innovation networks to attract foreign investment.

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