Can Artificial Intelligence Transform Triple Helix? A Model Based on Comparative Experiences from Selected Countries

Akbar Mohammadi, University of Tehran, Iran

Abstract

The integration of artificial intelligence (AI) into the Triple Helix model, which involves collaboration between government, universities, and society, significantly impacts these relationships by enhancing capabilities, reshaping roles, and fostering innovation. AI technologies facilitate more dynamic interactions among these entities, leading to improved educational practices, governance, and social outcomes among them; however, no previous studies have thoroughly examined this influence. The aim of this study is to identify the complexities and mechanisms of this integration in strengthening relationships within the Triple Helix, based on an analysis of the experiences of leading countries, and is recognized as an innovation in research. The results of this study indicate that in East Asian countries, the government plays a crucial role in AI talent development by setting policies and providing support to universities, thereby facilitating this process. This activity has led to the rapid deployment of AI programs and increased student participation, demonstrating a model of government pull and university response. Additionally, AI technologies in these countries enable governments to enhance their data management capabilities, leading to more effective policy implementation and collaboration among the three actors of the Triple Helix. Moreover, in Western countries, universities collaborate with educational technology companies to improve product efficacy and create collective participation that drives innovation and enhances educational outcomes among the actors. Furthermore, the impact of AI on education in these countries includes social benefits, such as improved access to learning resources and personalized educational experiences, which could be of greater focus in future studies.

Keywords: Artificial Intelligence, Triple Helix, AI Integration, Benchmarking

Introduction

Artificial intelligence profoundly impacts diverse industries, enhancing research capabilities and addressing complex challenges with greater efficiency. Its evolution, guided by governance, introduces innovative technologies and strengthens market competitiveness (Mohammadi, 2024). Furthermore, it fosters collaboration between industry and academia, cultivating an environment conducive to innovation (Attarpour et al, 2024). The progression of artificial intelligence under sound governance equips universities and industries with essential tools, expediting technology advancement and transfer to drive effective growth and development (Khe, 2024).

Artificial intelligence is a concept with varied interpretations (Crawford, 2021) that often encompasses technologies like machine learning, neural networks, and various automated systems. It is occasionally presented as a versatile technology (European Commission, 2021) due to its increasingly widespread use across different domains. This extensive application results in practical uncertainties, particularly in the realms of policymaking and regulation (Ulnicane et al., 2022). Nations such as the United States, China, and Russia aim to exploit artificial intelligence to shift the power dynamics in their favor (Mirani & Thornton, 2020), while other global actors may employ artificial intelligence differently based on their own interests, objectives, and domains.

The swift expansion of artificial intelligence technologies and their transformative influence on a wide array of issues have presented fresh challenges for policymakers and other stakeholders on a global scale. Many endeavors associated with the advancement of artificial intelligence technologies are overseen by governments, yet international bodies have exhibited a notable capacity in addressing policies related to artificial intelligence. Despite artificial intelligence being an innovative technology that falls outside the scope of current legal or regulatory frameworks, there is a trend towards addressing new obstacles within existing structures.

Countries across the globe have implemented a variety of strategies to facilitate the advancement of artificial intelligence technologies (Mohammadi & Mohammadi, 2021). These strategies exhibit a range of objectives and methodologies. For instance, certain nations, particularly those in East Asia, place a strong emphasis on "development" by involving the government significantly in fostering artificial intelligence innovation. Conversely, countries within the European Union concentrate on "control," emphasizing the implementation of regulations governing

artificial intelligence. In contrast, nations like the United Kingdom, the United States, and Ireland prioritize "promotion" policies with intricate governance structures and a predominant role assigned to the private sector (Papyshev & Yarime, 2023). The primary aim of these strategies is to modernize societies and integrate artificial intelligence technologies into various aspects of human life. Recognizing the significance of contemporary information and communication technologies, including artificial intelligence, these strategies necessitate comprehensive approaches that encompass experts, technological capabilities, financial resources, and legal frameworks. In essence, these strategies demonstrate an acknowledgment of the significance of artificial intelligence and the necessity for targeted integration of resources (Woszczyna & Mania, 2023).

The governance strategies pertaining to the advancement of artificial intelligence technologies within the context of the industry-academia relationship involve a diverse array of stakeholders, including private enterprises, industry associations, universities, professional bodies, governments, international entities, and civil society. These stakeholders advocate for distinct norms and mechanisms for overseeing artificial intelligence, such as ethical guidelines, national policies, and formal regulations (Pandey et al., 2022). While private companies play a pivotal role in steering artificial intelligence initiatives, their primary focus on profitability and market demands may not always align with the broader public interest. Consequently, there exists a necessity for external government supervision to ensure that the wider implications are duly considered (Almeida et al., 2022). This scholarly investigation delves into the experiences of diverse countries in implementing artificial intelligence within the industry-academia dynamic and reflects on the outcomes of these endeavors.

Theoretical Foundations of Research

Industry-University-Government (Triple Helix) Cooperation

Artificial Intelligence (AI) has become a catalyst for significant transformations across various sectors of society, empowering mankind to approach management in a more methodical and strategic manner. The pivotal role of AI is evident in its ability to serve as a vital link between the realms of academia and industry, facilitating knowledge exchange and collaboration. The ascendancy of the industry in AI research is steadily increasing, primarily due to its command over computational capabilities, vast pools of data, and a talent pool rich in skilled

researchers. This transition towards industry dominance is manifested in the generation of impactful research outcomes, including scholarly publications, cutting-edge models, and essential performance indicators that shape the landscape of artificial intelligence.

The realm of artificial intelligence is now acknowledged within the sphere of international relations as a domain characterized by competition and potential conflict, fueled by uncertainties surrounding the relinquishment of control over technology and the oversight of human intervention. The words of Russian President Vladimir Putin in 2017 reverberate the sentiment prevalent in global discourse, as he boldly proclaimed, "Whoever becomes the leader in artificial intelligence will rule the world" (RT, 2017). Subsequently, a plethora of governmental and private entities have articulated their perspectives on the implications of artificial intelligence for society, particularly from a governance standpoint, emphasizing on critical areas such as infrastructural advancements, military applications, and the ramifications on employment and human interactions. While some of these perspectives have outlined comprehensive strategies to tackle the challenges posed by artificial intelligence, the majority have adopted principled positions aimed at mitigating the risks associated with disruptive AI technologies. By the year 2020, more than 30 nations worldwide had commenced dialogues on formulating national strategies for AI development, with 17 countries already implementing these strategies (Chen, 2022).

The exploration and discussion of national strategies for artificial intelligence governance within the Triple Helix domain originated during a pivotal research session held at a Dartmouth workshop in 1956, marking the inception of a groundbreaking field of study. Since that momentous occasion, the realm of AI development has transitioned into the hands of the private sector, embarking on a transformative journey across diverse sectors such as industrial robotics, data mining, and the integration of AI-driven leadership roles. This evolution witnessed a pattern where these innovations first gained traction within the tech industry, gradually earning societal approval through early triumphs and practical applications. Over the course of subsequent years, a new wave of sophisticated AI technologies emerged, encompassing advanced AI systems, deep learning algorithms, cutting-edge voice and image recognition software, as well as state-of-the-art data analytics tools. These technological marvels have found widespread application in sectors such as banking, e-learning platforms, medical diagnostics,

smart transportation systems, and beyond, revolutionizing the way we interact with and harness the power of AI in our daily lives (Robles & Mallinson, 2023).

In the contemporary landscape, nations at the forefront of technological innovation and home to the most prominent industrial players in the AI sector have assumed a leading role in shaping the trajectory of global AI development for the coming decade. Meanwhile, numerous other countries, particularly those in the developing world, are engaged in ongoing deliberations and knowledge-sharing initiatives to define their respective national priorities and chart a course for future AI frameworks that align with their unique socio-economic landscapes and aspirations (Mbangula, 2022).

Triple Helix Governance Based on Artificial Intelligence

The European Union, recognizing its internal disparities, holds the belief that artificial intelligence has the potential to support the green deal (European Commission, 2021) and is committed to promoting "human-centric artificial intelligence". Consequently, artificial intelligence is seen as a means to advance social justice and reduce inequality, empowering even the most marginalized individuals. The European Union endorses the principles of "ethics by design" and "security by design" in research and technology development (European Commission, 2021). A specific category of "high-risk artificial intelligence" has been established by the European Union, subject to special regulatory and oversight measures (European Commission, 2021).

The United Nations, the European Union, and the World Economic Forum concur that governance frameworks must be adaptable to keep pace with innovation and harmonize regulations across various stakeholders. Regulatory sandboxes are referred to by the European Union and the United Nations. A comprehensive governance framework is essential to mitigate the risks of artificial intelligence technologies and ensure their safe and ethical use, safeguarding privacy, fundamental rights, and benefiting the most vulnerable individuals.

Furthermore, the United Nations, the European Union, and the World Economic Forum advocate for interdisciplinary research to guide the applications of artificial intelligence towards sustainable and socially just foundations (Executive Coordination Commission, 2020). Collaboration among diverse stakeholders, including universities, civil society, citizens, and the private sector, is deemed necessary to harness artificial intelligence effectively and ensure its sustainability. This collaboration is essential for enhancing understanding of artificial intelligence,

reducing discrimination and biases (European Commission, 2021), and ensuring that the impact of artificial intelligence is positive for the majority while facilitating data access. Private companies and universities contribute skills and expertise, while the public sector provides appropriate legislation, funding, and support. Citizens and users should engage in acquiring digital and technical skills. Transparency and explainability are crucial to ensure informed consent and trust.

The United Nations promotes the concept of data altruism for justice in Triple Helix governance, emphasizing data sharing by the private sector to complement public sector data for the benefit of disadvantaged individuals. Gender-disaggregated information and improved data accessibility in developing countries are also endorsed by the United Nations to be more beneficial for vulnerable populations. Computational capacities should be enhanced to facilitate artificial intelligence training (World Economic Forum, 2021).

Ethics and justice are crucial in the development of tripartite relationships among academia, industry, and government for several reasons (Mohammadi, 2021; Mohammadi et al, 2021). Firstly, ethical considerations ensure the responsible and sustainable use of resources and technologies, promoting transparency and accountability in decision-making processes (Attarpour et al, 2023). Secondly, a focus on justice helps to address power differentials and ensure fair and equitable distribution of benefits and opportunities among stakeholders. Lastly, an ethical and just approach fosters trust and collaboration among academia, industry, and government, leading to more effective and impactful partnerships that contribute to societal well-being and progress.

Research Background

Triple Helix Governance Based on AI in China

China's approach to advancing artificial intelligence (AI) technologies is diverse. The nation is in the process of modernizing its military systems, increasingly integrating AI and associated technologies into areas such as information, command and control, logistics, and weapon systems. Efforts are underway to establish a regulatory framework for AI, including laws, ethical standards, and policy guidelines by 2025. China has emerged as a global frontrunner in AI research, innovation, and implementation, demonstrating significant progress in these areas. Moreover, the country has witnessed substantial growth in AI patent citations,

particularly in key regions like the Yangtze River Delta, Pearl River Delta, and Bohai Rim. These developments underscore China's dedication to AI advancement and its commitment to fostering an environment conducive to innovation and technological progress.

Triple Helix Governance Based on AI in Netherlands

Artificial Intelligence (AI) is a rapidly growing technology field that can have a significant impact on Dutch society and all its economic elements. To strengthen the Netherlands' position and maximize opportunities, a long-term program called AiNed has been designed by the Dutch AI Coalition and a consortium of over 400 public and private organizations. The development and utilization of AI aim to enable the Netherlands to benefit from the economic and social advantages of AI and synchronize with other leading countries.

According to the Dutch government's governance forecast, this approach could potentially generate a 1.6% growth in the country's Gross Domestic Product (GDP) based on the development of AI technologies. This serves as a catalyst for strong growth in the number of companies investing in and utilizing AI. The Netherlands also promotes the beneficial social impacts of AI by employing responsible and human-centric AI programs that align fully with European objectives. The National Growth Fund has allocated 204.5 million euros for the initial phase of the AiNed program.

Examples of AI applications currently employed and supported under these approaches in the Netherlands include: improving medical diagnoses and treatments, reducing pesticide use, energy savings, personalized education, more effective crime fighting, cost-effective repair and maintenance of roads, bridges, and railways, more efficient production and transportation of goods, long-term customer relationships in the service and retail sectors, as well as autonomous robots, vehicles, and unmanned aircraft.

Maximizing participation and seizing major opportunities for the Netherlands, the availability of extensive data, affordable computing power, and new generations of AI methods are rapidly advancing artificial intelligence. Despite a strong starting position in terms of AI knowledge, digital infrastructure, and overall use of digital technology in the Netherlands, there is a need for stronger development and a risk of falling behind (Benjamins et al., 2019).

The Dutch experience in supporting the development of AI technologies includes aligning Dutch business goals and policies in AI development. The Dutch government has established a new research consortium called CVON-AI to facilitate the development and use of AI solutions in medical research. The goal of this consortium is to create a cloud-based platform accessible to researchers, demonstrate the clinical applications of AI, optimize analytical methods, and enhance AI awareness through education (Vergeer, 2020).

Triple Helix Governance Based on AI in Canada

Canada is actively promoting the advancement of artificial intelligence (AI) technologies. In 2017, the Canadian government introduced the "National Strategy for Artificial Intelligence," aiming to position Canada as a global frontrunner in AI innovation. The government sponsors workshops on AI and its societal impacts, convening experts, influencers, and community representatives to explore the ethical and social dimensions of AI across various sectors like healthcare, education, and the workplace. However, there are concerns regarding the inclusiveness of these workshops, potentially excluding ordinary citizens and average consumers from engaging with the technology. Gender diversity in AI-related activities in Canada remains understudied, highlighting the need for legislative measures to support women in the AI industry and ensure equity and gender parity. In summary, Canada's efforts to advance AI technologies encompass strategic planning, educational initiatives, and a call for greater gender inclusivity and representation.

Triple Helix Governance Based on AI in United Kingdom

The United Kingdom is actively promoting the advancement of artificial intelligence (AI) technologies. The National Health Service (NHS) is striving to establish itself as a global leader in AI applications in healthcare and is dedicated to training and involving medical professionals in AI initiatives. The integration of AI into healthcare presents regulatory challenges and necessitates a delicate balance between the advantages of ongoing enhancements and the assurance of safety protocols (Banerjee et al., 2022). Within the field of dermatology, there is growing interest in utilizing AI for evaluating the risk associated with skin lesions; however, there is a notable absence of ethical guidelines and standardized regulations in this area. Recent legal competitions in the UK have underscored the imperative need for robust AI policies and the significance of incorporating legal considerations into AI governance and decision-making processes (Drake et al., 2022). Aspiring physicians in the UK acknowledge the positive influence of AI technologies on their clinical

training, yet they express apprehensions regarding the potential impact on clinical judgment and practical competencies.

Research Methodology

The current research methodology utilized in this study employs a meta-study approach known as Systematic Literature Review (SLR), focusing on analyzing the policies and developmental materials of chosen nations in the realm of artificial intelligence technology advancement. Systematic literature review involves the systematic exploration, assessment, synthesis, and interpretation of quantitative or qualitative research within a specific field (Catalano, 2013). Following the methodology proposed by Sandelowski and Barroso (2006), the research process in this study unfolded through seven distinct stages, encompassing: articulating the research objectives and formulating research inquiries, systematically scrutinizing texts and research backgrounds, identifying and selecting pertinent documents, extracting relevant data, analyzing and synthesizing study outcomes, ensuring quality control, and presenting the research findings. The tasks undertaken at each stage are detailed as follows:

Stage 1 - Clarifying research objectives and inquiries. The primary aim of this study is to address the following queries through a comprehensive review of literature, documents, and policy frameworks concerning artificial intelligence technology development in selected countries: 1- To what degree is the advancement of artificial intelligence technologies prioritized in the governance strategies of chosen nations with regards to industry-academic partnerships? 2- What key initiatives and tactics are adopted by selected countries in fostering the growth of artificial intelligence technologies? 3- How do the primary strategies of selected countries in advancing artificial intelligence technologies align with industry-academic governance dimensions?

Stage 2 - Thorough review of background information. This segment involves conducting library research and meticulously examining reputable documents and articles to identify the initiatives and policies of selected countries in the realm of artificial intelligence technology development.

Stage 3 - Criteria for selecting study subjects. The choice of countries for analyzing developmental documents was based on three key factors: 1- availability of information, 2- global rankings and achievements in artificial intelligence, and 3-

alignment with the unique context of Iran's ecosystem. Following rigorous evaluation and assessment by researchers, the countries selected for examination were China, England, Canada and the Netherlands. Subsequently, the primary industry-academic governance policies and developmental materials from these nations were reviewed and assessed.

Stage 4 - Data extraction. During this phase, comprehensive examination and supplementary research were conducted, leading to the initial (open) and axial coding of the documents.

Stage 5 - Information analysis and synthesis. This stage involved breaking down and analyzing the coded data to identify key concepts and themes using the content analysis technique. Systematic Literature Review (SLR) offers a range of methodologies for synthesizing data, including content analysis, theory-driven analysis, thematic synthesis, qualitative comparative analysis, and framework analysis (Dixon-Woods et al., 2005). The inductive content analysis approach was utilized to develop a central theory, model, or conceptual framework. Thus, the research employed open coding, axial coding, and selective coding techniques to achieve its objectives.

Findings

The incorporation of artificial intelligence technology into collaborations between universities and industries enhances educational innovation by seamlessly integrating specialized environments, educational content, teaching methodologies, and learning platforms with industry requirements and practices. As academia moves towards a digitally immersive era driven by artificial intelligence, the adaptation of researchers and professors to effectively interact with AI will be pivotal for the future of education. In essence, artificial intelligence is transforming the dynamics between academia and industry, with the industry playing a significant role in AI research and its diverse applications across sectors. This study delves into the facets of Triple Helix governance in the advancement of artificial intelligence technologies and examines the experiences of selected nations. The innovations and strategies proposed in the four primary AI applications are outlined as follows: (1) Enhanced data collection and analysis to facilitate knowledge acquisition, scientific breakthroughs, industrial advancements, and informed decision-making. (2) Increased automation across sectors such as transportation and industry. (3) Improved productivity in individual consumption, energy utilization, and resource

management. (4) Promotion of equality and alleviation of poverty through AI interventions. Enhanced data gathering and analysis capabilities offered by artificial intelligence are evident in studies showcasing its ability to uncover insights and correlations within vast datasets, fostering scientific discoveries and a deeper comprehension of the world. AI technologies enable swifter and more informed decision-making processes. Applications like machine learning, smart sensors, remote sensing, Internet of Things, computer vision, and drones are instrumental in data analysis. These tools are utilized for monitoring various phenomena such as weather patterns, species migration, forest health, water systems, public transportation efficiency, and energy consumption. Studies also highlight the efficacy of AI technologies in predictive analytics, such as forecasting future energy consumption, carbon emissions, and climate change impacts. The United Nations Digital Cooperation Roadmap underscores the importance of leveraging big data and AI to generate actionable insights that can address public health challenges, including disease outbreaks and their impact on vulnerable populations (United Nations, 2020, p. 8).

The World Economic Forum, along with the United Nations and the European Union, advocates for the utilization of artificial intelligence technologies to tackle challenges posed by climate change and environmental shifts. These technologies leverage big data to identify patterns that enhance decision-making processes and improve forecasting accuracy (World Economic Forum, 2018). Within the realm of Triple Helix governance centered on artificial intelligence, it is anticipated that advancements in democratic systems and responsible economic models will be fostered. This will be achieved through improved information accessibility, enhanced communication channels, and more efficient monitoring of inefficiencies (Attarpour et al, 2023). Artificial intelligence plays a crucial role in bolstering cybersecurity measures, enabling the tracking and analysis of intricate criminal networks, and streamlining migration and asylum procedures. The growing adoption of automation (Attarpour et al, 2024) is another key aspect highlighted in studies on Triple Helix governance driven by artificial intelligence. Automation, facilitated by technologies like robotics and autonomous vehicles (Mohammadi & Babaei, 2023), liberates individuals from mundane tasks, allowing them to focus on more creative endeavors. This shift not only enhances human well-being by freeing up time for innovation but also contributes to more effective Triple Helix governance by redirecting attention towards creative and impactful tasks. In work environments, automation enhances operational efficiency and organizational performance by

minimizing errors and production fluctuations on assembly lines. The implementation of autonomous vehicles and intelligent systems through automation aids in reducing accidents and improving overall road safety. By integrating automation and artificial intelligence technologies, individuals can allocate more time to strategic and creative pursuits, alleviating them from repetitive and exhausting tasks. This transition ultimately leads to the enhancement of Triple Helix governance and the promotion of human welfare.

Enhanced efficiency and environmental sustainability. Automation plays a pivotal role in reducing redundancy, energy wastage, and unnecessary emissions. Research indicates that artificial intelligence contributes significantly to advancing sustainable production practices, particularly in the realm of agricultural progress. Within agriculture, the integration of artificial intelligence technologies aids in minimizing pesticide and fertilizer usage, optimizing water resources, controlling weed proliferation, promoting animal well-being, and swiftly identifying crop diseases. Furthermore, applications extend to streamlining transportation systems, managing energy distribution effectively, optimizing waste disposal methods, and implementing energy-efficient solutions like smart homes that align with residents' daily routines. Smart grids further enhance energy management by integrating various renewable energy sources. The European Union highlights the potential of "smart thermostats, which analyze user behavior and adjust temperatures accordingly, leading to potential energy savings of up to 25%" (European Commission, 2021).

Advancement in social equity and poverty alleviation. In the discourse surrounding sustainable development, artificial intelligence is anticipated to play a crucial role in fostering gender equality. Emphasis is placed on creating new employment opportunities, particularly for women, through artificial intelligence interventions. Given the competitive edge in artificial intelligence development held by major economies like China, the United States, and the European Union, the United Nations has devised an "internal strategy to bolster AI-driven empowerment, with a specific focus on supporting developing nations and millions of vulnerable individuals" (Executive Board for Coordination, 2019, p. 1). Reports from the Global Pulse initiative underscore the positive impact of artificial intelligence technologies in aiding populations in developing countries, particularly in areas such as women's workforce participation, monitoring gender-based violence, mapping unsafe regions, and more.

Conclusion and Implications

The collaboration among academia, industry, and society forms the foundation of Artificial Intelligence (AI) governance. Active involvement from AI developers, professional bodies, and educational institutions shapes the norms governing AI development and deployment. Despite technology companies espousing ethical standards for AI utilization, the pursuit of financial gains and market pressures can sometimes impede their alignment with public interests. Reflecting on the broader spectrum of intelligence encompassing both artificial and natural information flows is essential to understanding the societal and environmental impacts of AI. The deployment of AI systems presents unique legal complexities, necessitating global harmonization of laws and regulations. While AI has revolutionized the public relations domain and offers avenues for enhancement, it also raises pertinent concerns that demand attention from researchers and experts.

The formulation of policies governing the collaboration between academia and industry in the domain of artificial intelligence holds significant importance due to the myriad benefits it offers to nations. Given the swift evolution of AI technologies, countries must adapt their policies promptly to keep pace with advancements and leverage the opportunities presented by these technologies. The provided table delineates key strategies for managing industry-academia relationships in the development of AI technology in five specific countries. These strategies, derived from a comprehensive document review, are segmented into four categories: data-driven decision-making, automation-centric industry-academia governance, productivity-oriented industry-academia governance, and proactive industry-academia governance aimed at fostering greater equality and reducing poverty.

Table 1. Key Strategies for Triple Helix Cooperation in the Development of AI Technology in Selected Countries

	China	United Kingdom	Netherlands	Canada
Enhanced decision-making through data analytics	Enhancing decision-making in smart industries, public services, and urban management through data analysis, fostering data exchange networks, China's focus on AI and machine learning for data-driven	• Development of intelligent data centers that provide the possibility of collecting and analyzing various data and information. • Encouraging research and development in the field of artificial intelligence and big data • The use of artificial intelligence in public services in various fields	• Promoting research and development in the field of artificial intelligence and big data • Policymaking in the area of privacy protection in the use of data and information	• Development of training programs and workforce preparation in the field of artificial intelligence • Encourage research and development in the field of artificial intelligence and big data

	China	United Kingdom	Netherlands	Canada
	decisions, and investments in IoT, 5G, and robotics.			
Automation-driven Triple Helix cooperation	Enhancing decision-making in smart industries, public services, and urban management through data analysis, fostering data exchange networks, China's focus on AI and machine learning for data-driven decisions, and investments in IoT, 5G, and robotics.	• Development of intelligent data centers that provide the possibility of collecting and analyzing various data and information. • Encouraging research and development in the field of artificial intelligence and big data • The use of artificial intelligence in public services in various fields	• Promoting research and development in the field of artificial intelligence and big data • Policymaking in the area of privacy protection in the use of data and information	• Development of training programs and workforce preparation in the field of artificial intelligence • Encourage research and development in the field of artificial intelligence and big data
Productivity-focused Triple Helix partnership	Enhancing decision-making in smart industries, public services, and urban management through data analysis, fostering data exchange networks, China's focus on AI and machine learning for data-driven decisions, and investments in IoT, 5G, and robotics.	• Development of intelligent data centers that provide the possibility of collecting and analyzing various data and information. • Encouraging research and development in the field of artificial intelligence and big data • The use of artificial intelligence in public services in various fields	• Promoting research and development in the field of artificial intelligence and big data • Policymaking in the area of privacy protection in the use of data and information	• Development of training programs and workforce preparation in the field of artificial intelligence • Encourage research and development in the field of artificial intelligence and big data
Promoting equity and poverty alleviation through Triple Helix cooperation	Enhancing decision-making in smart industries, public services, and urban management through data analysis, fostering data exchange networks, China's focus on AI and machine learning for data-driven decisions, and investments in IoT, 5G, and robotics.	• Development of intelligent data centers that provide the possibility of collecting and analyzing various data and information. • Encouraging research and development in the field of artificial intelligence and big data • The use of artificial intelligence in public services in various fields	• Promoting research and development in the field of artificial intelligence and big data • Policymaking in the area of privacy protection in the use of data and information	• Development of training programs and workforce preparation in the field of artificial intelligence • Encourage research and development in the field of artificial intelligence and big data

The utilization of AI in policymaking presents governments with valuable prospects. For instance, AI enables governments to prioritize issues according to public preferences and formulate evidence-based policies. Moreover, it facilitates real-time policy assessment and feedback on their efficacy. Additionally, the integration of AI technologies in industry-academia governance promotes collaboration between stakeholders and policymakers, enhancing legitimacy. As indicated in the literature, AI can streamline policy decisions, resulting in greater efficiency, enhanced service delivery, and the generation of public value. Nevertheless, the implementation of AI policies in policymaking encounters a range of challenges that necessitate scrutiny. Key challenges encompass data management, ethical considerations, organizational structure, accountability, and ethical responsibilities. Addressing ethical concerns such as data privacy and equitable AI usage is crucial in industry-academia governance and policy development.

Hence, nations must incorporate AI development policies into their overarching strategies to capitalize on the benefits AI offers in policymaking. These policies should address pertinent challenges and factors to maximize the advantages of AI in enhancing governmental performance and public services. Governments should have confidence in AI's ability to optimize operations and services. Many countries have already harnessed AI, some employing it in policy formulation. Iran should similarly embrace AI across all facets of industry-academia governance, particularly within government institutions, to unlock unprecedented opportunities and narrow the technological gap with other nations. This objective is also articulated in Iran's strategic vision for AI development, aiming to position the country among the top 10 global leaders in AI by 2031, fostering economic prosperity and societal well-being. Therefore, comparative analyses of successful nations' experiences and developing countries sharing similarities with Iran can offer valuable insights for policymakers to leverage.

Limitations and Future Research

In conducting this study, researchers encountered several limitations, particularly concerning the reluctance of some governments to foster collaboration within the Triple Helix model. This hesitance may stem from a lack of interest in developing partnerships among academia, industry, and government, which is crucial for advancing AI initiatives. Additionally, the uneven development of AI capabilities across different nations has led to resistance in some governments against the widespread adoption and integration of AI technologies. Moreover, the influence of

universities varies significantly across different governance structures. In certain contexts, universities possess considerable power to effect change and drive innovation, while in others, their impact is diminished due to insufficient emphasis on knowledge and technology. To address these challenges, it is recommended that future research explore the proposed framework in both developed and developing countries separately. This comparative analysis could yield insights into the varying levels of engagement and collaboration in the Triple Helix model across different contexts. Furthermore, validating the developed framework in diverse national settings could provide a deeper understanding of its applicability and effectiveness in enhancing AI governance. Such studies would contribute to a more nuanced understanding of the dynamics at play in the collaboration among academia, industry, and government, ultimately informing better policy decisions and fostering more robust AI ecosystems globally.

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