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New AI Technology Integration for Industry-University Cooperation

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Abstract: Governance plays a vital role in promoting Industry 4.0 technologies by fostering effective partnerships between industry and academia. This collaboration significantly accelerates the development of artificial intelligence (AI) technologies, improves research quality, strengthens scientific and technical capabilities, and enhances the impact of AI across various sectors. The main goal of this research is to investigate how the advancement of AI technologies contributes to strengthening the ties between industries and universities. This study undertakes a qualitative analysis of governance practices in technology development across various countries, aiming to gain a deeper understanding of the dynamics involved in this relationship. The results of this study indicate that AI technology can play a crucial role in enhancing capabilities for research, introducing new and innovative products and technologies, strengthening technological collaborations, facilitating technology transfer, and fostering competition and sustainable growth across various industries. Furthermore, this research emphasizes governance strategies regarding AI in the interaction and collaboration between industry and academia, providing new insights. These strategies include the establishment of joint committees between the parties, the initiation of joint research centers and projects, the promotion of knowledge and technology transfer, and the creation of shared platforms for education and research in AI. The findings of this study, with a focus on the growth of a knowledge-based economy, outline appropriate strategies for maximizing collaboration between industry and academia and offer insights in this regard.

Keywords: AI technology, technology integration, industry-university cooperation

1. Introduction

Artificial intelligence (AI) technology has a history of just under 60 years, yet its emergence has led to applications that profoundly affect our lives. Its focus lies in replicating and refining human intelligence through artificial technologies to invent intelligent machines. Some research argues that AI possesses the ability to think and act logically, while others hold a different perspective regarding its capability to behave and think like humans. According to various experts, in the coming decades, the diverse capabilities of AI will manifest, thereby radically transforming the existing dynamics of power, wealth, and prosperity – changes that can be compared in scope to the Industrial Revolution [1]. This technology can also enhance collaboration between industry and academia, creating an environment conducive to the development of innovations. The advancement of AI, building on these characteristics, can equip universities and industries with modern tools and accelerate the transfer of knowledge and technology between the two parties [2].

The swift expansion of AI 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 AI technologies are overseen by governments, yet international bodies have exhibited a notable capacity in addressing policies related to AI.

Despite AI being an innovative technology that falls outside the scope of current legal or regulatory frameworks, there is a trend toward addressing new obstacles within existing structures. This evolution reflects a growing recognition of the need for adaptive policies that can effectively manage the challenges posed by AI advancements [2].

Countries across the globe have implemented a variety of strategies to facilitate the advancement of AI technologies. 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 AI innovation. Conversely, countries within the European Union concentrate on "control," emphasizing the implementation of regulations governing AI. 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 [3]. The primary aim of these strategies is to modernize societies and integrate AI technologies into various aspects of human life. Recognizing the significance of contemporary information and communication technologies, including AI, 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 AI and the necessity for targeted integration of resources [1, 4].

The integration of new technologies in the current industry-university scenario is recognized as a challenge. This challenge can be mitigated through the cohesion of industry-university relationships

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and the co-creation of these two entities. Organizations that have established better connections with universities and strengthened their ambidextrous capabilities have been more successful in this domain [2, 5]. This is the most important reason why such research is necessary, and the research gap in identifying new insights for the integration of AI in the industry-university relationship needs to be addressed.

The strategies for governance related to the advancement of AI technologies in the context of the collaboration between industry and academia encompass a wide range of stakeholders. This includes private businesses, industry associations, universities, professional organizations, government entities, international organizations, and civil society. Each of these stakeholders promotes various standards and mechanisms for overseeing AI, such as ethical frameworks, national policies, and formal regulations [6]. While private companies are instrumental in leading AI initiatives, their strong emphasis on profitability and market demands may not always coincide with the broader public interest. As a result, there is a critical need for external governmental oversight to ensure that the wider implications are adequately addressed [7]. This research explores the experiences of different countries in integrating AI within the industry-academia relationship and reflects on the outcomes of these efforts.

2. Literature Review

2.1. Industry-university-government cooperation

AI is a concept with varied interpretations [8] that often encompasses technologies like machine learning, neural networks, and various automated systems. It is occasionally presented as a versatile technology [9] due to its increasingly widespread use across different domains. This extensive application results in practical uncertainties, particularly in the realms of policymaking and regulation [10]. Nations such as the United States, China, and Russia aim to exploit AI to shift the power dynamics in their favor, while other global actors may employ AI differently based on their own interests, objectives, and domains [11].

AI is currently assisting various sectors of industries and society in two forms: generative and hybrid. This area of AI enables the management of processes, products, and technologies to be conducted in a more structured and organized manner. Through this approach, technology can strengthen the relationship between academia and industry, enhancing the vital link between them by facilitating the knowledge exchange processes [2].

The field of AI has now become a significant aspect of international relations, marked by competition and the potential for conflict. This tension arises from uncertainties related to control over technology and the impact of human intervention. In 2017, Russian President Vladimir Putin captured a widely held view during this discourse when he stated, "Whoever becomes the leader in artificial intelligence will rule the world." Following this declaration, numerous government bodies and private organizations have shared their insights on the societal implications of AI, especially regarding governance. They focus on essential areas including infrastructure development, military use, and the effects on jobs and human relationships [12]. Although some have proposed detailed strategies to address the challenges presented by AI, many have instead taken a more principled approach aimed at reducing the risks tied to emerging AI technologies. By 2020, discussions on creating national AI development strategies had begun in over 30 countries, with 17 nations already putting these plans into action [13].

The exploration and discussion of national strategies for AI governance within the industry-university domain originated during a pivotal research session held at a Dartmouth workshop in 1956, marking the inception of a groundbreaking field of study [14]. 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 [15].

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 socioeconomic landscapes and aspirations [16].

2.2. Industry-university governance based on artificial intelligence based on justice and ethics

The European Union, recognizing its internal disparities, holds the belief that AI has the potential to support the green deal [9] and is committed to promoting "human-centric artificial intelligence." Consequently, AI 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 [9]. A specific category of "high-risk artificial intelligence" has been established by the European Union, subject to special regulatory and oversight measures [9].

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 AI 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 AI toward sustainable and socially just foundations [9]. Collaboration among diverse stakeholders, including universities, civil society, citizens, and the private sector, is deemed necessary to harness AI effectively and ensure its sustainability. This collaboration is essential for enhancing understanding of artificial intelligence, reducing discrimination and biases [9], and ensuring that the impact of AI 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 industry-university 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 AI training [9].

Ethics and justice are crucial in the development of tripartite relationships among academia, industry, and government for several reasons [11, 17]. First, ethical considerations ensure the responsible and sustainable use of resources and technologies, promoting transparency and accountability in decision-making processes (Attarpour et al., 2023). Second, 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.

3. Research Background

3.1. Industry-university governance based on AI in China

China is taking a multifaceted approach to the development of AI technologies. The country is actively modernizing its military, incorporating AI and related technologies into various sectors, including information systems, command and control, logistics, and weaponry. There are ongoing efforts to create a regulatory framework for AI, which aims to outline laws, ethical standards, and policy guidelines by 2025 [18, 2]. As a result, China has become a leader in AI research, innovation, and implementation, showing notable advancements in these fields. Additionally, there has been a significant increase in AI patent citations, especially in critical regions such as the Yangtze River Delta, Pearl River Delta, and Bohai Rim. These trends highlight China's commitment to advancing AI and creating a supportive environment for technological innovation [11].

3.2. Industry-university governance based on AI in the Netherlands

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 [19].

According to the Dutch government's governance forecast, this approach could potentially generate a 1.6% growth in the country's gross domestic product 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 [19].

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; and 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 AI. 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 [20].

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 [21].

3.3. Industry-university governance based on AI in Canada

Canada has made significant progress in developing the relationship between industry and academia focused on promoting and supporting AI (AI). In 2017, the Government of Canada introduced the "National Strategy for Artificial Intelligence," aimed at positioning the country as a global leader in AI innovation. Under this strategy, the country has organized various workshops and bootcamps to examine the implications of AI on society, where a community of stakeholders – including experts, policymakers, and leaders from both academia and industry – convene to explore the ethical and social dimensions of AI across various sectors, including healthcare, education, and the workforce [22].

Despite these efforts, there are concerns regarding the inclusivity of these workshops, as they may inadvertently exclude everyday citizens and consumers from the critical discussions surrounding AI technology. This lack of broader participation raises questions about the comprehensiveness of the dialogue and the potential for overlooking diverse perspectives that are essential for responsible AI development. Furthermore, the issue of gender diversity within AI initiatives in Canada has not been adequately addressed, highlighting the urgent need for legislative measures that encourage women's involvement in the AI sector and promote gender equality. Canadian initiatives to advance AI technologies are characterized by strategic planning, educational programs, and a commitment to enhancing gender inclusivity and representation [23]. However, to fully realize the potential of these initiatives, it is crucial to ensure that all stakeholders, including marginalized groups, are included in the conversation. By addressing these gaps, Canada can strengthen its position as a leader in AI while fostering a more equitable and inclusive technological landscape.

3.4. Industry-university governance based on AI in the United Kingdom

The United Kingdom is actively promoting the advancement of AI technologies. The National Health Service 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 [24]. 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 United Kingdom have underscored the imperative need for robust AI policies and the significance of incorporating legal considerations into AI governance and decision-making processes [25]. Aspiring physicians in the United Kingdom 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.

3.5. Industry-university governance based on AI in Brazil

Brazil has a rich history of formulating digital advancement strategies, encompassing endeavors in research and development, as well as the integration of AI-driven technologies across industry and governmental sectors. The government has prioritized enhancing criminal investigation techniques and public safety measures through the utilization of AI solutions. In light of the global health crisis caused by the COVID-19 pandemic, Brazil introduced a remote healthcare platform powered by AI to enhance the accessibility of medical services [26]. Recent research underscores the necessity of establishing a public policy framework to foster the acceptance of AI technologies in Brazil, as delays in this regard could exacerbate disparities among nations. In summary, Brazil's approach entails a diverse array of policies and programs designed to bolster the advancement and implementation of AI technologies in key domains such as digital innovation, law enforcement practices, and healthcare services [27].

4. Methodology

The current research methodology utilized in this study employs a meta-study approach known as a systematic literature review (SLR), focusing on analyzing the policies and developmental materials of chosen nations in the realm of AI technology advancement. SLR involves the systematic exploration, assessment, synthesis, and interpretation of quantitative or qualitative research within a specific field [28]. In this research, qualitative research and case studies of the policy experience of successful countries have been used.

Following the methodology proposed by Sandelowski and Barroso [29], 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 AI technology development in selected countries: (1) To what degree is the advancement of AI technologies prioritized in the governance strategies of chosen nations with regard to

industry-academic partnerships? (2) What key initiatives and tactics are adopted by selected countries in fostering the growth of AI technologies? (3) How do the primary strategies of selected countries in advancing AI 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 AI 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 AI, 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, Brazil, 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. SLR offers a range of methodologies for synthesizing data, including content analysis, theory-driven analysis, thematic synthesis, qualitative comparative analysis, and framework analysis [30]. 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.

5. Findings

The assimilation of AI technologies into the enhanced connectivity of collaborations between universities and industries fosters and develops technological innovations. Consequently, universities are facilitating greater adaptability among researchers and professors to effectively interact with the industry as they transition toward a digital revolution and a digitally immersive era driven by AI. Today, the development of e-commerce and the significance of data analytics represent a common concern for both industry and academia, with solutions lying in the hands of AI technologies. Therefore, AI is altering the dynamics between academia and industry, enabling better management of this paradigm shift and allowing the industry to play a significant role in AI research and its diverse applications across various sectors [11]. This study aimed to explore the dimensions of industry-university governance in advancing AI technologies and to examine the experiences of selected countries in this regard.

The proposed innovations and strategies were analyzed across four primary applications of AI [22]: advanced data collection and analysis to facilitate knowledge acquisition, scientific progress, industrial advancements, and informed decision-making [2], increased automation across various industrial sectors [31], improved productivity at the individual level and more effective resource management [32], and promotion of equality and poverty alleviation through AI interventions.

The advanced data collection and analysis facilitated by AI technologies are employed to aid in acquiring appropriate

knowledge and its recognition and transmission. This recognition and transmission can lead to simultaneous scientific and industrial advancements between industry and academia. Additionally, AI technologies enable faster and more informed decision-making processes. Applications such as machine learning, smart sensors, remote sensing, the Internet of Things, computer vision, and the use of virtual reality tools are highly effective. These tools are employed to monitor various phenomena, including weather patterns, species migration, forest health, water systems, public transportation efficiency, and energy consumption [33].

The World Economic Forum, along with the United Nations and the European Union, advocates for the utilization of AI 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 (European Commission, 2018). Within the realm of industry-university governance centered on AI, 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). AI 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 [34] is another key aspect highlighted in studies on industry-university governance driven by AI. Automation, facilitated by technologies like robotics and autonomous vehicles [17], 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 industry-university governance by redirecting attention toward 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 AI 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 industry-university 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 AI contributes significantly to advancing sustainable production practices, particularly in the realm of agricultural progress. Within agriculture, the integration of AI 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%" [9].

Advancement in social equity and poverty alleviation. In the discourse surrounding sustainable development, AI is anticipated to play a crucial role in fostering gender equality. Emphasis is placed on creating new employment opportunities, particularly for women, through AI interventions. Given the competitive edge in AI

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" [35]. Reports from the Global Pulse initiative underscore the positive impact of AI 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.

6. Conclusion and Policy Recommendations

The collaboration among academia, industry, and society forms the foundation of 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 AI 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.

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

Table 1
Key strategies for industry-university cooperation in the development of AI technology in selected countries

	Enhanced decision-making through data analytics	Automation-driven industry-university cooperation	Productivity-focused industry-university partnership	Promoting equity and poverty alleviation through industry-university cooperation
China	Data-Driven Decision-Making in Smart Industries	Establishing AI Legal and Ethical Guidelines	Raising AI Awareness Among Managers and Citizens Enhancing Workforce Skills for Labor Market Needs	Building an AI Financing Ecosystem Investing in AI Research and Development Attracting Investors to Combat Poverty
United Kingdom	Developing Intelligent Data Centers for Analysis Promoting AI and Big Data Research Implementing AI in Public Services	Formulating AI Research and Development Strategies Strengthening AI's Strategic Position Supporting Learning and Sustainable Development with AI Establishing Legal and Ethical Standards for AI Leveraging AI and Data Solutions Creating a Supportive Political Environment Developing Competitive AI Systems	Transforming Senior Management's Perspective on AI Building Specialized Networks Among Stakeholders Fostering International Research and Development Collaboration Providing AI Education and Skills Training Enhancing Workforce Skills for Labor Market Needs (duplicate) Financing and Investment in AI	Strengthening AI Financing in Priority Areas Encouraging Investment in AI Research and Development Facilitating National Data Sharing and Access
Netherlands	Advancing AI and Big Data Research and Development Data Privacy Protection Policymaking	Strategic AI R&D Development in the Netherlands Enhancing AI's Strategic and Institutional Position AI Support for Learning and Sustainable Development	Establishing Ethical Standards for AI Solutions Creating a Supportive Policy Environment for AI	Implementing Human-Centered AI for Social Impact Leveraging AI for Economic and Social Benefits
Canada	Developing AI Training Programs for Workforce Preparation Encouraging AI and Big Data Research Initiatives	Enhancing Capabilities of Intelligent Devices	Improving AI Education and Training Levels Fostering University-Industry-Government Collaboration in AI	Establishing Legal Frameworks for AI and Data Security Facilitating AI Development and Deployment in Canada
Brazil	Researching AI Technologies in Industry and Government Driving Economic Growth Through AI Innovation Enhancing Criminal Investigation and Public Safety with AI Developing AI-Driven Telehealth Solutions During Pandemic	Workforce Improvement and Empowerment Supporting Workforce in AI Technology Development Using AI for Process Automation	Promoting AI Adoption to Reduce Technological Inequalities	Smartening Public Services Optimizing Resource Management Real-Time Policy Evaluation

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.

Although no two national strategies are identical, a comprehensive study of various AI strategies can help identify the key dimensions of a national AI strategy [36, 17]. Specific recommendations for achieving national objectives will vary for each country based on its unique national priorities. The following, as outlined in Figure 1, presents key insights proposed for the development of AI technologies in Iran.

The establishment of a standardized set of data protection laws and addressing ethical concerns is essential, as data serves as the fuel for AI [37]. Therefore, creating an integrated and sustainable regulatory environment based on mutual trust between data and organizations is crucial, clearly explaining how data will be collected, stored, processed, shared, and potentially deleted [38, 39].

The results of this study indicate that, in light of the increasing influence of AI solutions on all aspects of life, it is vital to ensure that their development contributes to comprehensive growth at the national level. This growth may be economic, social, or cultural [27]. Achieving this requires addressing the ethical challenges associated with this emerging technology [40], such as bias and discrimination, the deprivation of individual autonomy, and rights. Furthermore, it necessitates the active promotion of the design and implementation of AI solutions through a robust legal framework within the country.

Creating a strong research environment and fostering collaboration between industry and academia is also crucial [41]. The research landscape in AI is distinct when compared to other scientific research sectors, and both companies and academic research potentials hold equal value. Establishing and accessing open data

Figure 1
Key insights proposed for the development of AI technologies in Iran

has become a vital infrastructure upon which AI solution development relies. Almost all countries examined have focused their investments in both fundamental and applied research through various methods. In alignment with the strategic focus and goals of each country, those pursuing AI strategies must propose ways to create an internal research environment that leverages industry-academic collaboration. The emphasis should be on attracting top talent for both fundamental and applied research, as well as exploring how to reform existing incentive structures in research to enhance cross-sector integration between industry and governance [9].

Investment should primarily focus on strategic sectors; in order to succeed in the Fourth Industrial Revolution, countries must capitalize on the comparative advantages of their economies and leading sectors [42]. In practice, they should primarily design their AI ecosystems around the vital industries of their economies. Conversely, it is essential to avoid the distribution of limited resources across all sectors, as this approach is unlikely to yield the highest returns. This concern is particularly pronounced in emerging countries with limited public budgets.

International collaboration is also critical; considering the speed, scope, and global accessibility of AI technologies, it is a mistake to assume that any country can fully benefit by working in isolation [16]. Open ecosystems are more suitable for emerging technologies, as they encompass a diverse range of expertise and capabilities distributed globally, spanning both academia and industry [3]. Therefore, it is imperative that countries develop a strategy to leverage international collaboration. They must strive for cooperation and partnerships not only in the development of AI technologies but also in global efforts aimed at establishing regulations and governance frameworks. The insights and lessons presented in this section, if duly considered by the policymakers and leaders of the country in the pursuit of AI technology development, could lead to four key outcomes aligning with the selected countries studied.

Participation in international collaboration facilitates the exchange of knowledge and innovative technologies in the field of AI, resulting in more data-driven and precise decision-making at a global level. This leads to improved processes, the development of AI, and enhanced quality of services and products. Based on insights from investment in strategic AI sectors, the focus will also be on addressing key challenges faced by the country, such as governance imbalances and related issues, which will contribute to increased efficiency and productivity growth.

Establishing a robust research environment and fostering integration between industry and academia also promotes innovation and the adoption of novel practices, thereby potentially leading to greater efficiency within industries. Finally, the provision of a standardized set of data protection laws and addressing ethical concerns assures users that their data is managed securely and ethically, which can lead to greater acceptance of technologies and, consequently, contribute to poverty reduction and increased equality.

As previously mentioned, the foundational factors for AI development may vary across different countries, often derived from the cultural contexts and characteristics of those nations, as well as systematic reviews of existing development documents and library reports. Therefore, it is recommended that future research endeavors involve field studies that take into account cultural considerations and the political and economic conditions of the country to validate the results and findings of this study.

Also, several key points need to be addressed regarding the role of science, technology, and innovation policy in Iran, particularly in relation to the development of AI technologies.

First, it is essential for the science, technology, and innovation policy framework in Iran to design and implement appropriate
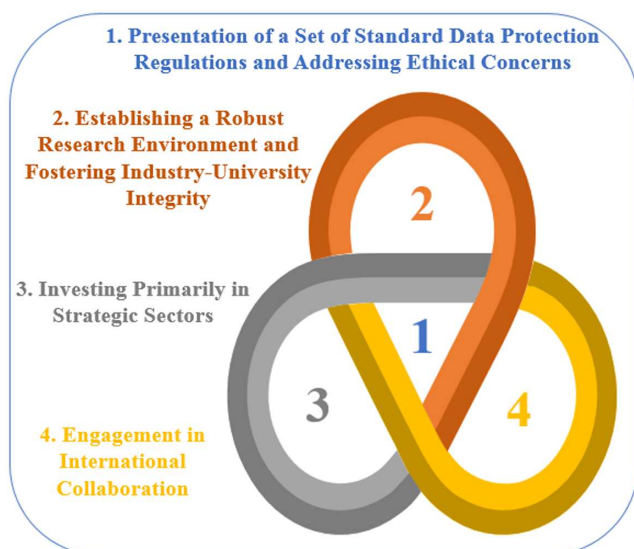
initiatives and actions. This could include the introduction of internship and apprenticeship programs, which would serve as practical platforms for students to gain real-world experience while fostering connections with the industry. By facilitating hands-on opportunities, such initiatives can significantly strengthen the ties between academic institutions and industries.

Additionally, there should be an emphasis on supporting the employment of university graduates. This can be achieved through targeted programs aimed at aligning educational outcomes with industry needs, ultimately enhancing the employability of graduates in the technology sector. Such efforts will not only benefit the graduates but will also contribute to the socioeconomic development of the country.

Creating joint research and development centers between industry and academia is another critical step [32]. These centers can serve as collaborative hubs where both sectors can work together on innovative projects and share valuable insights. Financial support for establishing these centers, possibly through tax exemptions or grants, would further incentivize collaboration and bolster the integration of AI technologies.

Apart from the aforementioned points, it is appropriate for universities and research institutes in Iran, as a developing country, to enter into joint agreements that specifically address the needs of the industry in the field of AI while being goal-oriented and independent. By aligning academic education and research with industry requirements, academic centers can play a pivotal role in producing relevant knowledge and training skilled graduates. The implementation of the proposed policy package and the execution of these policy and strategic recommendations can provide a framework for Iran's policy landscape for the development of AI and the strengthening of industry-university relations in this fourth industrial revolution technology. Enhancing the integration of AI technologies, facilitating the flow of knowledge between industry and academia, and integrating this technology with the existing knowledge base of industry enterprises can serve as the ultimate goals of this study, which should also invite further insights from other researchers.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

Data Availability Statement

The data that support this work are available upon reasonable request to the corresponding author.

Author Contribution Statement

Akbar Mohammadi: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

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