Artificial Intelligence as Intangible Capital in Knowledge-Based Economies

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Summary: This paper explores artificial intelligence as an emerging component of intangible capital in knowledge-based economies. Modern economic growth increasingly relies on non-physical assets, including human, structural, and relational capital, with AI playing a transformative role. Focusing on the United States, China, and Qatar, the study analyzes national strategies for AI adoption, investment, and innovation. Findings reveal that AI enhances labor productivity and contributes to GDP growth, although precise measurement remains challenging due to implementation lags and indicator limitations. The United States leads globally in AI, driven by extensive investments and model development. China rapidly closes the technological gap through large-scale adoption and innovation. Qatar demonstrates regional leadership by aligning policy, education, and digital infrastructure, achieving significant productivity gains and positioning itself as a model for Arab knowledge-based economies. The study emphasizes AI's crucial role in shaping the future trajectory of both developed and emerging economies.

Keywords: AI; Intangible Capital; Knowledge Economy; USA; China

Jel Classification Codes : O32 ; O33; O34 ; E22 ; D83

I- Introduction :

The rapid progress in the development and adoption of artificial intelligence technologies has generated a remarkable impact and transformation in modern economies. Unlike previous industrial waves that relied primarily on physical capital and labor, the current technological shift increasingly depends on intangible assets such as research and development, information and communication systems, and organizational capital.—all of which constitute essential components of intangible capital. Nevertheless, the integration of all these components with artificial intelligence remains an area yet to be fully explored (Daniel Saar, 2025).

Today, the "knowledge-based economy" is no longer built solely upon tangible assets; rather, it has increasingly shifted toward a fundamental reliance on intangible ca,pital. In fact, some studies refer to it as the “immaterial economy” (C. Bourret et al., 2008), as these digital economies are witnessing rapid growth (AL MAWLA, 2025).

A notable trend has been the increasing openness of many companies and countries toward artificial intelligence, particularly after 2022—the year marking the emergence of ChatGPT 3.5. This development was accompanied by a rise in corporate revenues and intensified competition among knowledge-based economies seeking to gain leadership in this technology, especially between the U.S and China, followed by other advanced and emerging economiess such as the Gulf countries, notably Qatar.

Building on this premise, our study seeks to explore the experiences of knowledge-based economiess, with a particular focus on the world’s two largest and most influential countries in terms of economic power and global leadership in artificial intelligence—the U.S, as an advanced economyy, and China, as an emerging one. This analysis will be complemented by the Qatari experience, representing a leading Arab country in the Middle East and North Africa that has demonstrated strong competitiveness with both advanced and emerging knowledge-based economiess.

Accordingly, this study raises the following research question: To what extent can it be acknowledged that artificial intelligence, as an emerging component of intangible ca,pital, contributes to the growth of knowledge-based economies?

The nature of this research requires the adoption of an analytical approach focused on selected successful international experiences, namely those of the U.S States, China, and Qatar.

I. Artificial Intelligence as a Component of Intangible Capital

Intangible capital is defined as all non-physical assets that do not appear in a company’s balance sheets or financial statements. Studies have diverged regarding the possibility of measuring it. C. Bourret et al. (2008) argue that it is immeasurable, while most recent research seeks to develop approaches for its assessment. Meanwhile, conventional aggregate data still tend to exclude the majority of IC from measured gross domestic product. According to Carol Corrado et al. (2009), approximately 800 billion USD were omitted from published data in the U-S between 2003 and 2008, representing the exclusion of more than 3 trillion USD in IC.

An observer of today’s dominant global companies—such as Apple, Google, Microsoft, Meta, Amazon, and others—may wonder about the source of their worldwide market dominance. For instance, the five aforementioned firms ranked among the most valuable companies in the S&P 500 index and are all active in the technology sector (Tambe et al., 2019). Further questions arise regarding newer leading entities such as NVIDIA, whose official reports indicate revenues of USD 46.7 billion—an increase of 56% compared to the previous year—and a market capitalization of USD 3.92 trillion as of July 3, 2025. The common answer to these inquiries lies in their substantial

investment in intangible capitall and the emergence of artificial intelligence as a new and integral component thereof (Corrado et al., 2022).

The presence of artificial intelligence as a key component of IC may evolve from being merely a complementary element to becoming an actual substitute for certain components—particularly human capita.l. The continuous increase in its use has led many companies to reduce their workforce, as artificial intelligence systems have replaced some employees, resulting in higher unemployment rates. However, this concern remains in the process of empirical validation, according to several studies (Bessen, 2018; Van, 2019).

From a historical perspective, the foundations of artificial intelligence began to take shape and develop with the Dartmouth Conference in 1956. This was followed by a period of noticeable slowdown, known as the "artificial intelligence winter," during the 1970s and 1980s. In the late 1980s and 1990s, the focus shifted toward machine learning and computer neural networks. Today, artificial intelligence has emerged to simulate the human mind and even contribute to achieving sustainable development (Kirikkaleli et al., 2025).

Generative artificial intelligence is experiencing particularly strong momentum, having attracted USD 33.9 billion in global private investment in 2024—an increase of 18.7% compared to 2023. Its use in business has expanded remarkably, with reports indicating that 78% of organizations employed artificial intelligence in 2024, representing a 55% increase over 2023 (AI Index Report, 2025). According to the same report, nearly 90% of leading artificial intelligence models in 2024 originated from the industrial sector, marking a 60% rise compared to 2023.

Theories and approaches related to the knowledge economy have increasingly focused on the components of IC, particularly research and development, as well as information and communication technologies, which constitute structural C (Corrado, Hulten, and Sichel, 2009). Knowledge, expertise, and behavior are considered elements of HC, while RC encompasses aspects such as relationships with suppliers and markets, now regarded as the foundation of competitive advantage. However, the technological shift that has led to the emergence of artificial intelligence as an exploratory and still-evolving set of technologies has prompted both nations and companies to focus on artificial intelligence in an unprecedented manner (Daniel Saar, 2025).

II Knowledge-Based Economies' Experiences in Harnessing AI: The Cases of China, the United States, and Qatar

A study conducted by Plikas et al. (2024) indicates that the use of artificial intelligence technologies has a positive and significant impact on gross domestic product. Moreover, the adoption of digital technology practices—such as employing information and communication technology (ICT) specialists, implementing A.I methodologies, and reskilling employees with new competencies—substantially enhances labor productivity, thereby stimulating "economic" growth and increasing G.D.P.

The scientific need arises to examine the validity of this proposition. Through the table below, we seek to focus on selected components of IC as key inputs in knowledge-based economies,, where knowledge represents the main element of HC and innovation constitutes the core of SC, alongside the newly emerging component—artificial intelligence. The objective is to analyze and assess the extent of their impact on the growth of these economies, using the cases of the U-S, China, and Qatar over the past eight years (2017–2024).

Table (1): Intangible Capital and Economic Growth in Knowledge-Based Economies

Country	Years	GDP (Trillion USD)	Growth Rate (%)	A.I Index Rank	Knowledge Index Rank	Innovation Index Rank
United States	2024	29.18	2.8	01	07	03
	2023	27.72	2.9	01	05	03
	2022	26.01	2.5	01	01	02
	2021	23.68	6.1	01	03	03
	2020	21.35	-2.2	/	02	03
	2019	21.54	2.6	/	03	03
	2018	20.66	3.0	/	04	06
	2017	19.61	2.5	/	06	04
China	2024	18.74	5.0	02	06	11
	2023	18.27	5.4	02	29	12
	2022	18.32	3.1	02	31	11
	2021	18.20	8.6	02	30	12
	2020	15.00	2.3	/	35	14
	2019	14.56	6.1	/	31	14
	2018	14.15	6.8	/	38	17
	2017	12.54	6.9	/	39	22
Qatar	2024	0.217	2.8	54	39	49
	2023	0.213	1.2	43	39	50
	2022	0.235	4.2	/	37	52
	2021	0.179	1.6	48	38	68
	2020	0.144	-3.6	/	39	70
	2019	0.176	0.7	/	40	65
	2018	0.183	1.2	/	43	51
	2017	0.161	-1.5	/	41	49

The source : **Prepared by the authors based on (World Bank, GII, GKI)**

It is initially evident from Table (01) that there has been an increase in the Gross Domestic Product of the three countries. The figures rose from 19.61, 12.54, and 0.61 for the United States, China, and Qatar respectively in 2017, to 29.18, 18.17, and 0.21 in 2014 for the same countries, with noticeable fluctuations in growth rates due to the circumstances experienced in recent years, particularly during the COVID-19 pandemic period (World Bank, 2025).

As for I.C—represented by knowledge, innovation, and artificial intelligence—these countries have shown varying rankings, which nevertheless clearly reflect that they are indeed knowledge-based economie.s. The United States has consolidated its global leadership by maintaining third place worldwide in the Global Innovation Index since 2019. China has made remarkable progress, moving from 22nd place globally in 2017 to 11th place in 2024. Qatar, on the other hand, has demonstrated relative stability over the past three years, achieving its best ranking in 2024 by securing 49th place worldwide. Although this ranking appears modest compared to China and the United States, it remains competitive among other emerging economie.s. Qatar continues to be among the driving forces of Arab and Gulf countries, alongside Saudi Arabia and the United Arab Emirates, which ranked 47th and 32nd respectively in 2024 (GII, 2024).

Regarding the Knowledge Index, the United States recorded its lowest ranking in the past eight years, placing seventh globally in 2024. Meanwhile, China has been steadily strengthening its position among the world's leading economie.s, moving from 34th place globally in 2017 to 29th place in 2024, thus surpassing several advanced and emerging economie.s. As for Qatar, although its performance has fluctuated, this did not significantly hinder its relative progress. The country achieved its best ranking in 2022, reaching 37th place globally, and has maintained 39th place over the past two years. Qatar thus continues to serve as a regional leader among Arab and Gulf countries, alongside Saudi Arabia and the United Arab Emirates (GKI, 2024).

These indicators are used almost consistently in studies measuring I.C However, the Artificial Intelligence Index is still in its experimental stages, making it an emerging indicator compared to other components of I.C. This study aims to examine its compatibility with these indicators on the one hand, and with G.D.P growth rates on the other. It should first be noted that A.I-related data are not available for the past eight years. Nevertheless, data from the most recent three years are sufficient to assess the readiness and leadership of countries in the field of artificial intelligence. The United States has maintained its global leadership throughout all years, which perfectly aligns with its position as the world's largest econom.y, with a G.D.P of USD 29.18 trillion in 2024 (World Bank, 2025). It is followed by China, ranked second globally, also consistent with its classification as the world's second-largest economy, with a G.D.P of USD 18.74 trillion in 2024. It is important to emphasize that this consistency in ranking should not be interpreted as direct causality between A.I and G.DP, but rather as an indication that these are indeed knowledge-based economies. As for Qatar, its ranking has shown some fluctuations, though it remains relatively consistent with its global standings in the Knowledge and Innovation Indices (World Bank, 2025; GII, 2025; GKI, 2025).

It is worth noting that there is a variation among databases that measure the extent, performance, and readiness of countries in artificial intelligence. This variation often leads to differences in country rankings, depending on the nature of the indicators used, particularly since A.I remains an emerging field, as previously mentioned (Tinholt et al., 2018; Shoham et al., 2018). For this reason, we relied on the Global AI Index (Tortoise Media), given the clarity and relevance of its sub-indicators, which closely align with the concept of I.C — such as skills, representing part of HC, and patents and research, which constitute components of SC (Tortoise Media, 2025).

A close examination of Table (01) above reveals a clear correlation between the increase in Gross Domestic Product and the global positioning of countries in the field of artificial intelligence. However, as noted by van Delft (2019), it remains difficult to isolate and quantify the specific contribution of artificial intelligence to G.D.P growth, given that A-I represents one of the emerging components of I.C—a domain that contemporary studies are still exploring in terms of measurement and assessment.

An analysis of global economiic trends over the past decade reveals a slowdown in G.D.P growth accompanied by a significant rise in artificial intelligence capabilities and applications, along with a notable decline in "A.I"-related costs. Several scholarly explanations have been proposed to address this apparent paradox between G.D.P growth and "A.I" advancement, foremost among them the concept of implementation lags. According to Brynjolfsson (2018), even the most advanced "A.I" systems have not yet been widely deployed, suggesting that their future adoption could have a substantial impact on accelerating G.D.P growth.

It is worth noting that implementation lags and the variation in measurement indicators, as previously mentioned, often lead to inaccuracies in assessing artificial intelligence itself, given that "A.I" remains an emerging field still in its early experimental stages. These factors may help explain the observed slowdown in G-D-P growth. As Brynjolfsson et al. (2018) pointed out, such conditions result in imprecise productivity measurements. Similarly, Mark A. Wynne and Lillian Derr (2025), along with Brynjolfsson (2018), express optimism about A-I's future impact on GDP growth. Moreover, Derviş and Qureshi (2016) add that many "A-I"-enhanced information and

communication technology (ICT) products and services are primarily consumer-oriented, and thus their contributions are not clearly reflected in G-D-P measurements.

We assert, to the best of our knowledge, that measuring artificial intelligence may still suffer from limitations, given that "A.I" has not yet been fully tested or explored and remains in its experimental and non-comprehensive stages—at least for now. This assumption, however, is likely to diminish in the future. The difficulty of measurement does not apply solely to artificial intelligence but also extends to all other components of I.C, as noted earlier, since they represent non-physical assets. Accordingly, we believe that the same challenges encountered in measuring human intelligence equally apply to artificial intelligence, despite the existence of numerous studies and approaches that have attempted to quantify I.C.

According to the PwC report, revenues in industries most open to artificial intelligence have quadrupled since 2022, indicating that the signs of "A.I"'s impact can be observed, albeit temporarily, at present. The same report revealed that the value of the workforce in A-I-adopting companies has been significantly enhanced, with wages rising at a rate twice as high as in industries less open to "A-I". Furthermore, skills—which constitute I.C in their own right—have been substantially affected in "A-I"-driven companies, increasing by 66% compared to other jobs. Workers possessing "A-I"-related skills receive a wage premium of 56%, representing a 25% increase compared to the previous year (PwC, 2025).

All current research and scientific studies examining the relationship between artificial intelligence and G-D-P growth indicate that A_I has a future impact on the economic growth of countries (Shen et al., 2022; Yao et al., 2025; A_I Index Report, 2025; AL MAWLA, 2025). Both the US and China have made significant advancements in A_I, transitioning from laboratory models to everyday applications for citizens across various sectors, including healthcare, transportation, services, and more. For instance, the U.S. Food and Drug Administration has approved 223 A_I-powered medical devices, while autonomous vehicles have become a routine sight on Chinese streets (AI Index Report, 2025).

II.1 The United States of America as an developed Economy

Private investments in artificial intelligence in the US reached USD 109.1 billion in 2024, approximately 12 times China's investments of USD 9.3 billion and twice the United Kingdom's investments of USD 4.5 billion. In the same year, American institutions developed 40 notable A,I models, compared to 15 models in China and three models in Europe (A,I Index Report, 2025).

The US is the largest investor in artificial intelligence, with the A;I market valued at USD 73.98 billion in 2025 and projected to grow at an annual rate of 26.95% by 2031. Together with India, the U.S. accounts for over 50% of the global AI. workforce (Josh, 2025; Founders Forum Group, 2025). According to the AI. Index Report (2025), the US invested USD 248.9 billion in AI. from 2013 to 2023, followed by its closest competitor, China, with USD 95.1 billion.

Figure (01) below presents a historical and projected analysis of the relationship between G-D-P growth and artificial intelligence in the US, along with future scenarios for AI's impact on G-D-P growth.

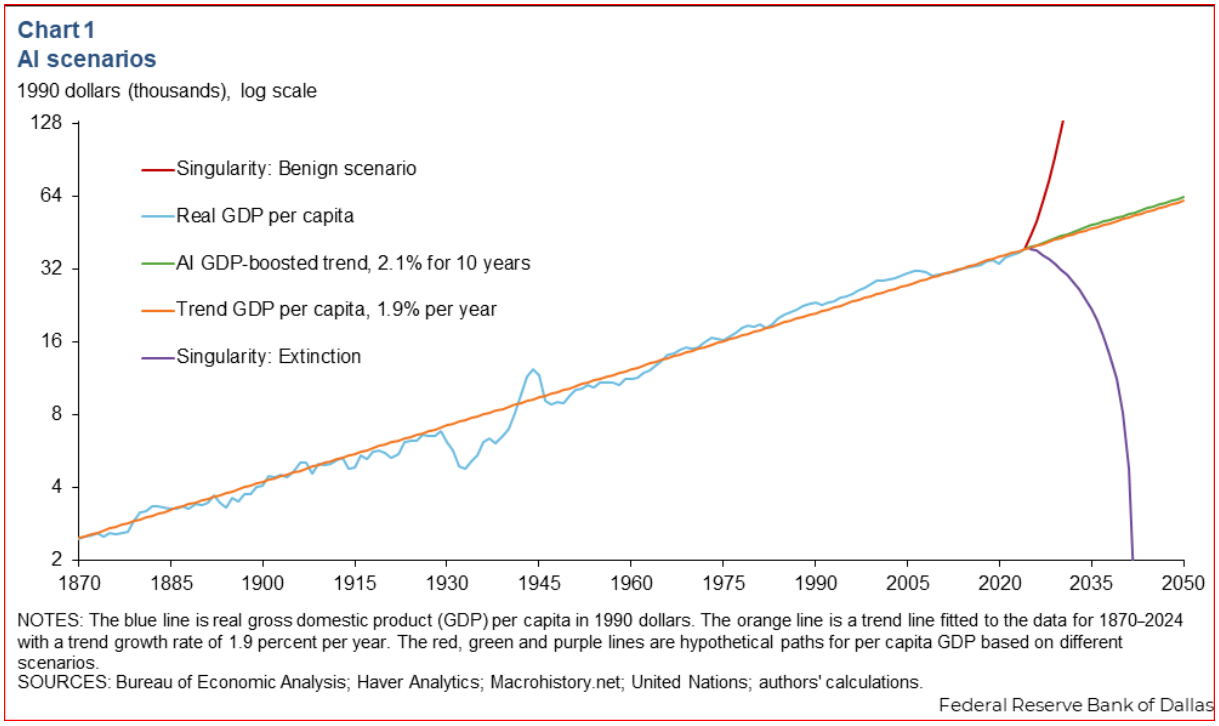
- Scenario 1 (orange line) assumes that AI. will be a continuation of existing technologies and prior innovations, resulting in living standards rising at the historical average of approximately 1.9%.

- Scenario 2 (red line) represents an optimistic scenario, involving a Technological Singularity, where AI. surpasses human intelligence, enabling machines to produce everything and potentially eliminating economic scarcity.

- Scenario 3 (purple line) depicts a pessimistic scenario, in which AI. becomes hostile to humanity, potentially leading to catastrophic outcomes, highlighting the necessity for scientists and experts to establish limits and regulatory frameworks for AI. use.

- The most realistic and feasible scenario (green line) predicts that AI. will enhance productivity by 0.3% annually, leading to a per capita GD.P increase of several thousand dollars by 2050.

Figure (1): Scenarios of Artificial Intelligence Impact on Growth Rates in the United States



Source: Mark A. Wynne and Lillian Derr, 2025

II.2 China as an Emerging Economy

According to Carol Zhou and Samantha Zhu (2025), China has experienced rapid growth in the artificial intelligence industry, with a market value exceeding USD 70 billion and the establishment of over 4,300 companies contributing to this expansion (World Economic Forum, 2025). The Goldman Sachs (2025) research report emphasized that the emergence of new AI. models in China is likely to accelerate the development and adoption of this technology, thereby directly enhancing productivity and driving GD.P growth (Goldman Sachs Report, 2025).

The early anticipation of this positive impact of AI, which became particularly noticeable in 2023, has fueled the rapid and competitive growth of foundational artificial intelligence models in China, allowing the country to surpass all European Union nations and the United Kingdom, while remaining the primary competitor to the US. Among the most notable artificial_ intelligence models launched in China following the release of the U.S. ChatGPT model is DeepSeek, which was less

costly than its predecessor, thereby creating higher economic growth and prospects, as highlighted by Hui Shan et al. (2025), due to lower costs and increased productivity.

According to the Goldman Sachs (2025) report, generative artificial_intelligence is expected to begin raising potential growth in China by 2026, with a projected contribution of 0.2 to 0.3 percentage points to GD.P by 2030, compared to 0.1 percentage points previously.

Moreover, the remarkable advancement of artificial intelligence in China has led experts to revise their forecasts for the Chinese economy in the 2030s. Earlier projections assumed that China, like other emerging markets, would experience growth ranging between 10% and 20% by 2030. However, China was soon excluded from these general emerging market expectations due to its more optimistic outlook and faster growth, reflecting the investments made over the past two years. Projections indicate that artificial_intelligence adoption in China could exceed 30% by 2030, with full adoption expected within the next 15 years. This transformation is expected to elevate China from the emerging market category toward a more developed economy.

This potential future impact of artificial_intelligence on China's GD.P growth has prompted the country to increase its technological investments, particularly in semiconductors, data centers, cloud services, software, and telecommunications companies (Goldman Sachs Report, 2025). For example, China launched a semiconductor fund valued at USD 47.5 billion ('AI' Index Report, 2025).

This Chinese leadership in artificial intelligence, expected to boost GD.P, has led the country to prioritize investments in knowledge, innovation, and 'AI', improving its global rankings in recent years (see Table 01). For example, in scientific research, China produced approximately one-third of 'AI' related journal articles and saw an increase in global citation rates in 2021. Additionally, it attracted around USD 17 billion to fund 'A_I' startups. In the technology sector, companies such as Alibaba and ByteDance have emerged prominently both in China and globally, due to their consumer 'AI' applications that have achieved national and international reach, encompassing a large base of digital consumers (Shen et al., 2022).

Although China has not surpassed the U.S in developing 'A,I' models, Chinese models have succeeded in rapidly narrowing the quality gap, with performance differences on key benchmarks such as MMLU and HumanEval decreasing from double-digit gaps in 2023 to near parity in 2024. Additionally, China continues to lead in A;I publications and patents (A;I Index Report, 2025).

II.3 Qatar as a Leading Arab Experience

While "A:I" model development was previously concentrated in the American and Chinese giants, it has become increasingly global, encompassing several other advanced and emerging countries in the Middle East, Latin America, and Southeast Asia (A:I Index Report, 2025). Among the most prominent countries in the Middle East are Qatar, Saudi Arabia, and the United Arab Emirates, which have demonstrated leadership even in the development of A;I guidelines and regulations. The A:I Index ranks these countries as the top three Arab nations in terms of A:I investment, innovation, and application (Barry et al., 2024).

According to PwC, the potential economic impact of artificial intelligence on the Gulf region, particularly in knowledge-based economies—namely Saudi Arabia, Qatar, and the UAE—could reach USD 277 billion by 2030 (Tongfang Yuan, 2025). For example, Saudi Arabia launched the Transcendence Project with an initiative valued at USD 100 billion (A:I Index Report, 2025) and established the Saudi Data and A:I Authority. Qatar created the Qatar Center for Artificial Intelligence and a national A:I strategy in 2019, based on six pillars: education, data access, employment, business, research, and ethics (Barry et al., 2024). In 2021, Qatar established the A;I Committee and supported the Digital Agenda 2030, emphasizing the alignment and coherence of

these strategies to promote sustainable economic growth in the Third National Development Strategy (NDS3) as well as Qatar National Vision 2030 (Yuan, 2025).

Qatar's A;I strategy reflects a path similar to that of the Chinese and American giants, with a strong emphasis on scientific output. Research production in this field has grown rapidly, with Qatar University emerging as a national leader. Additionally, Qatar has implemented incentive measures such as the "fast-track visa system" to attract and retain global A I experts, and has focused on developing technological skills, particularly in A I, through the National Digital Qualification Program in collaboration with Microsoft. As a result, Qatar has achieved an annual growth rate of 45% in data centers (Yuan, 2025).

Qatar has allocated substantial financial resources for investment in artificial intelligence. In 2024, it announced a package of incentives worth $2.5 billion, positioning the country at a very advanced level compared to other emerging economies, while striving to improve its standing relative to advanced markets. Moreover, certain preparatory measures have made Qatar comparable even to some of the most developed countries, particularly in the field of digital infrastructure, in terms of both quality and cost (Yuan, 2025). This positions Qatar as one of the key digital enablers to enhance leadership in A I and promote future economic growth.

The Oxford Insights (2025) report highlighted that Qatar surpasses the average of advanced economies in terms of government vision and approaches them in digital capabilities, infrastructure, and HC. This represents a positive indicator, positioning Qatar as a future leading driver in the Middle East and North Africa, serving as a successful Arab model.

Regarding the current productivity levels resulting from the use of artificial intelligence in Qatar, some companies have recorded gains of up to 6.8% in sales per worker in A I-adopting firms. It is expected that A I will contribute between 0.3 and 3 percentage points to the annual productivity growth rate, a figure surpassing that of emerging and developing economies, which are projected to achieve between 0.7 and 1.3 percentage points, due to their greater reliance on sectors less affected by and less dependent on A I, such as agriculture (Comunale & Manera, 2024).

Accordingly, the Qatari economy, as a knowledge-based economy, like the other advanced and emerging economies under study (the U.S and China), faces similar future scenarios if investments are made in it and in HC, as key components of I..C. We emphasize the most probable scenario, as well as the optimistic scenario, which could increase labor productivity in Qatar by an additional 1 percentage point above what is assumed in the baseline scenario (Yuan, 2025).

Conclusion

This research paper highlights several key findings. Foremost, artificial intelligence has become a central component of I-C, on which knowledge-based economies heavily rely. Currently, measuring its impact on the growth of these economies remains challenging due to implementation lags and measurement difficulties. Nevertheless, optimistic scenarios suggest a positive effect of A I on national G.D.P growth, particularly in knowledge-based economies, whether advanced or emerging. Both the United States and China recognized early the importance of investing in A I, and the diminishing notion of monopoly between these two giants has allowed other countries, such as Qatar, to chart their path toward Arab leadership in A I.

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