# The Misallocation of AI Innovation and Implications for Middle-Income Countries

Viresh Mittal

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**Abstract**

Artificial intelligence (AI) offers the potential for a new era of economic growth, boosting productivity and enhancing innovation. This potential is particularly important for middle-income countries, who have long struggled to reach high-income status. We look at two dimensions of this new AI race: preparedness to adopt and innovation to create AI tools. Drawing on data from the IMF and using citation metrics, we identify countries with "misallocated" AI innovation: countries with low AI preparedness but high AI innovation, ultimately resulting in a low ability to leverage AI. We then look deeper at these countries, finding that they are overwhelmingly middle-income economies with low economic integration via barriers to international trade. Lastly, we discuss how this poses a threat to the growth of these economies, noting that a successful transition to a high-income economy necessitates first prioritizing the adoption of preexisting technologies, then the innovation of new technologies.

# 1 Background

## 1.1 The Middle Income Trap

Middle-income countries, defined as countries with annual income per capita from $1,136 to $13,845, find themselves in a crisis [1]. These countries start with a period of rapid economic growth, but after achieving middle-income status, begin to see growth slowdowns that prevent them from ever reaching the economic prosperity of their high-income peers. This phenomenon, known as *The Middle Income Trap*, is hard to escape: only 250 million people have transitioned from middle-income to high-income status since 1990 [1]. Figure 1 shows this worrisome trend: middle-income countries, while their economies continue to grow, do not grow at the rate needed to become high-income countries. Certain countries like South Korea, have managed to beat the odds and escape the middle-income trap, but these examples are few and far between.

A large proportion of the difference between middle-income countries and high-income countries can be explained through productivity [1]. Figure 2 shows the case of South Korea: thanks to policies that led to massive productivity growth, South Korea was able to avoid growth stagnation. Most countries do not take the same steps that South Korea took, instead ending up like Brazil: stagnating as a result of low productivity. Figure 3 shows that capital alone does not explain why middle-income countries lag behind high-income economies [1]. If that were the case, the GDP per worker would be significantly higher relative to the US. Thus, a large part of escaping the middle-income trap hinges upon closing this gap and improving labor productivity. The Solow growth model, proposed by economist Robert Solow in 1956, found that technological changes account for nearly 80% of the change in the output per worker [2]. This fact has been challenged, but literature

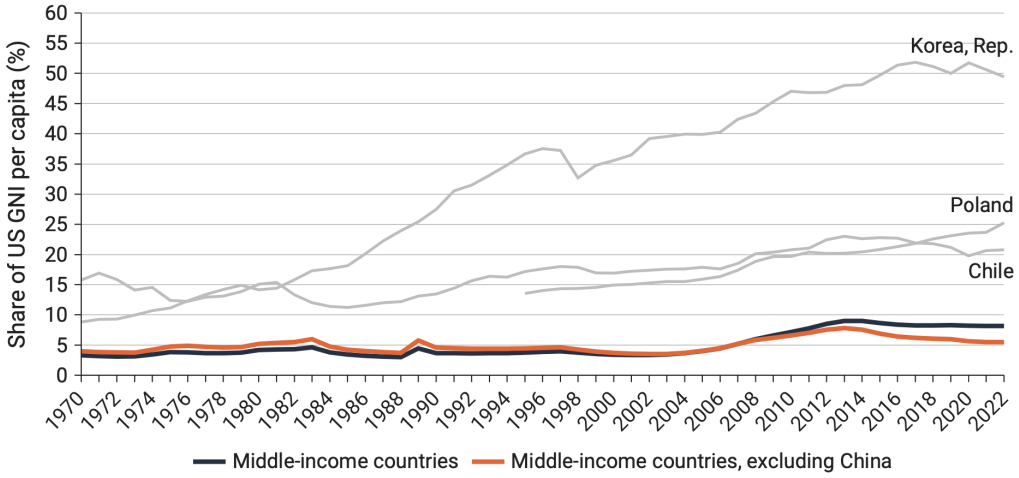


**Figure 1:** The Middle Income Trap. The average income per capita of middle-income countries, relative to the United States, has stagnated for years. Reproduced from World Development Report 2024 [1].

continues to find that technological progress is the largest determinant in output growth. Thus, the key for middle-income economies is improving technology.

## 1.2 Artificial Intelligence as a Tool for Economic Growth

The rise of artificial intelligence (AI) has sparked major excitement and interest regarding its ability to transform economies. Indeed, both global investment and innovation in AI have skyrocketed in recent years (Figures 4 and 5). In particular, the number of patent applications has outpaced the number of patents granted by global patent offices, reflecting the competitiveness of the AI space. This fervor toward AI is driven by AI's ability to serve as a general-purpose technology capable of acting as a point, application, or system solution [3]. As a result, AI will transform business processes at every level: from the most fundamental manufacturing processes to the

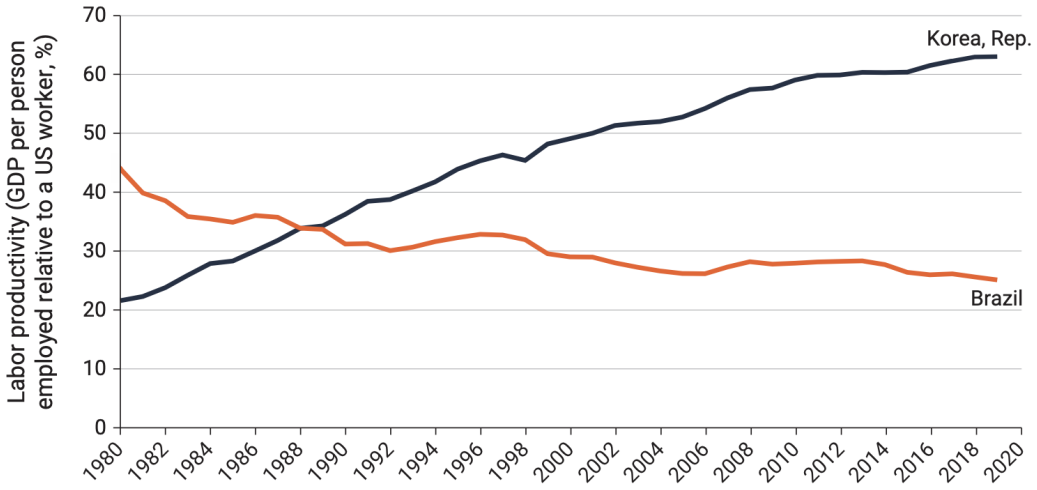


**Figure 2:** Productivity Changes in Brazil vs. South Korea. Korea, an economy that has managed to escape the middle-income trap, did so by rapid productivity growth. Brazil, a country stuck in the middle-income trap, has seen its productivity outpaced by the United States. Reproduced from the World Development Report 2024 [1].

most complex and large supply chains. This capacity is especially critical for middle-income countries, as it could provide a new avenue to escape the middle-income trap. However, this potential cuts both ways: the most aggressive adopters will punch their ticket to high-income status while countries that fail to adopt AI may see their opportunity to achieve high-income status slip away. We highlight a few of the most significant roles AI may play for middle-income countries in the future below.

### 1.2.1 Productivity Growth

AI will play a key role in enhancing the productivity of labor by automating tasks and optimizing processes. Empirical evidence at the firm level is robust: a 1% increase in AI "penetration" resulted in a 14.2% increase in total

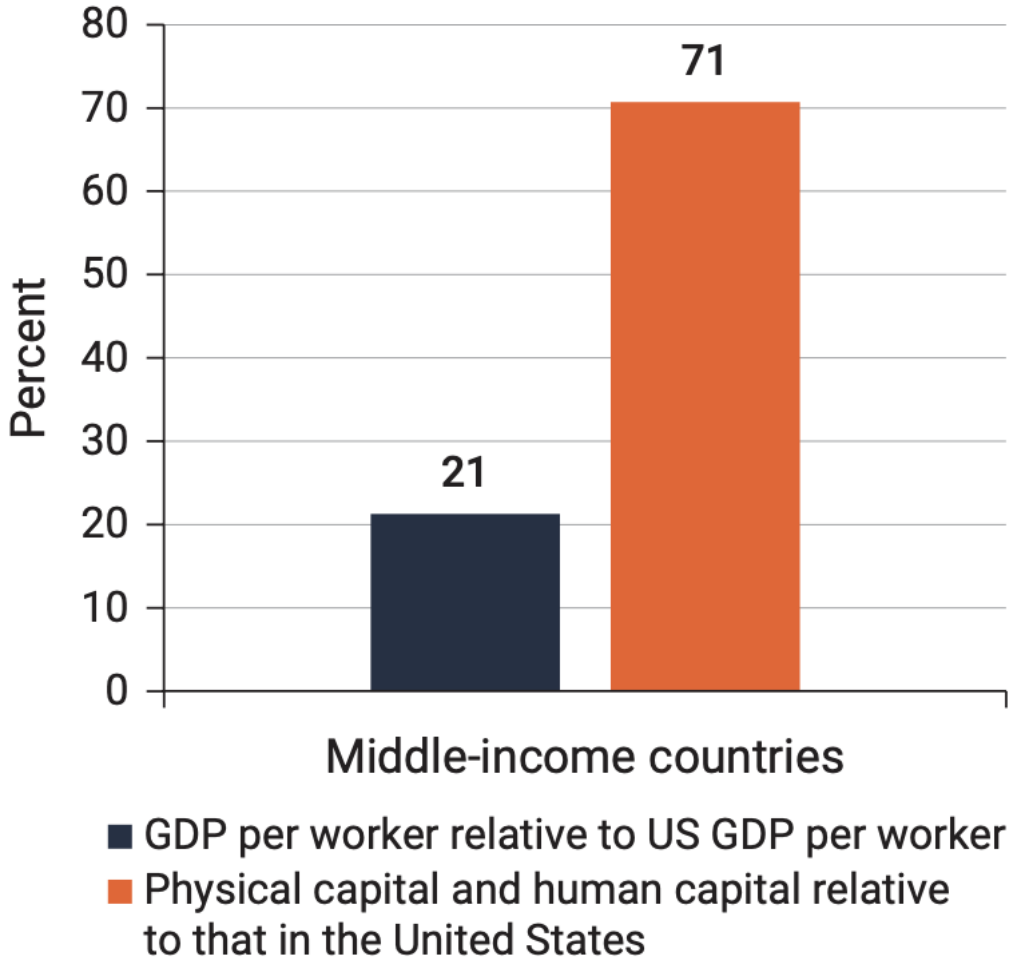


**Figure 3:** Capital Accumulation is Insufficient. Despite containing 71% of the US's capital, middle-income countries are only 21% as productive. Reproduced from the World Development Report 2024 [1].

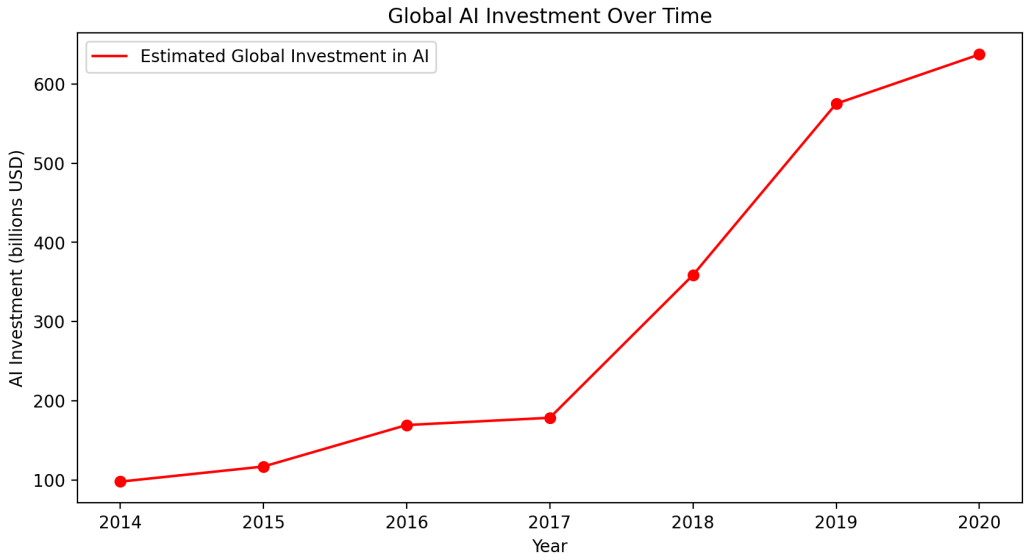


**Figure 4:** Global AI investment from 2014 to 2020. Produced with data from [4].

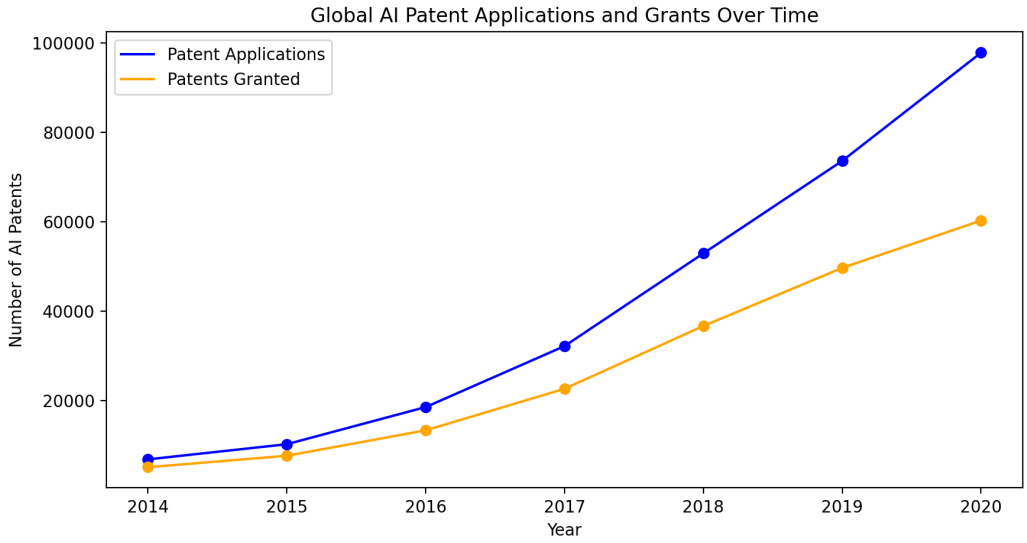


**Figure 5:** Global AI patent applications (blue) and granted patents (orange) from 2014 to 2020. Produced with data from [4].

factor productivity [5]. These gains occur through a multitude of pathways. Primarily, AI results in a value-added enhancement effect, where process efficiency increases result in higher productivity. Additionally, AI has enhancement effects on labor and capital: AI integration results in increased hiring of highly-skilled employees as well as frontier technological upgrades, which help stimulate higher output [5].

AI has a particularly strong impact on industrial processes, as part of Industry 4.0 [6]. AI-powered automation through the Internet of Things (IoT) and smart manufacturing pipelines enables improved resource efficiency and minimal human intervention [7]. As these industrial processes improve, lower-tech and more labor-intensive industries start to give way to higher-skilled industries, and countries acquire the long-term, sustainable economic growth needed to escape the middle-income trap.

### 1.2.2 Innovation

Previously, we discussed how innovations that use AI can enhance productivity. However, AI's potential goes far beyond that. Instead, AI can act as a tool for innovation itself. AI can automatically integrate massive amounts of published scientific knowledge and experimental data, effectively highlighting new logical relationships and facilitating the creation of innovative hypotheses with minimal human intervention [8]. By automating hypothesis generation, AI is capable of not only speeding up the scientific process but also uncovering new, novel interdisciplinary linkages that human researchers would traditionally overlook due to cognitive and cultural biases inherent in research approaches.

This increased novelty that AI catalyzes is not limited to AI alone. A study looking at how AI changes human decision-making in the context of the

popular board game Go found that AI can encourage creative thinking and novel decision-making [9]. Unbounded by biases and traditions, AI can formulate new strategies and modes of thinking, which in turn inspire humans to internalize these insights and innovate beyond existing conventions.

The impact of innovation on economic growth is well-established. According to endogenous growth theory, growth is driven by technological progress that itself is driven by innovation from economic activities [10]. Thus, the role of AI in innovation processes fosters economic growth from interdisciplinary technological spillovers and the creation of knowledge. This kind of growth is sustainable in the long-run, and exactly the kind countries need to escape middle-income status.

## 1.3 Investment, Infusion, and Innovation

Economies that seek to develop their economies and transition into high-income status must typically progress through three broad and sequential phases of economic growth, each with a distinct mix of investment, infusion, and innovation—commonly referred to as the *3i* model of development [1]. These phases are not rigidly linear but instead approximate the evolving capabilities and needs of an economy as it develops. Figure 6 illustrates the relative contribution of each factor varying with the distance of a country from the technological frontier.

In the initial stage, investment, particularly in physical infrastructure, basic industry, and human capital, dominates growth. Low- and lower-middle-income countries are typically in a position to realize rapid returns on such investments by plugging core gaps in roads, energy, ports, education systems, and institutional capacity. These investments pave the way for more advanced economic activity and open up opportunities for integration into

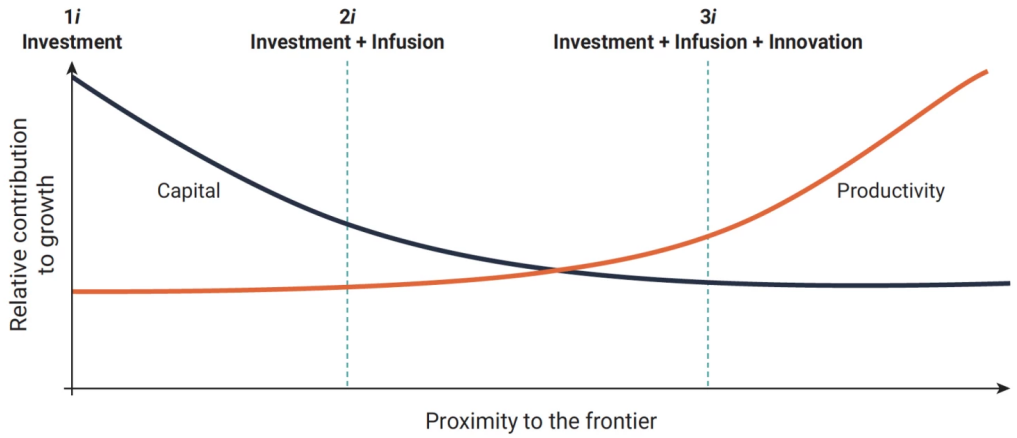


**Figure 6:** Investment, Infusion, and Innovation. Economies must correctly balance each of these distinct forces in order to maximize economic growth and reach a high-income status. Reproduced from the World Development Report 2024 [1].

value chains in the world economy. However, in the longer term, the marginal rate of return on investment in infrastructure begins to decline, especially when institutional inefficiencies set in.

It is at this point that economies must transition to the infusion phase, where growth is a result of the adoption and adaptation of technologies already developed elsewhere—largely in high-income or frontier economies. This is generally referred to as technological catch-up, where countries leverage world knowledge spillovers to accelerate productivity growth. The law of backwardness, a theory developed by Alexander Gerschenkron [11], presumes that lagging behind the technological frontier enables countries to grow rapidly by skipping intermediate stages of technological development and advancing straight to newer systems with greater efficiency. Fruitful infusion is made possible not just through increased receptivity to trade and foreign direct investment, but also institutional and labor capacity to absorb and adopt imported technologies.

Finally, as countries converge with frontier economies, they will increasingly need to rely on the creation of new products, processes, and technologies to propel growth. This final stage requires intensive investment in research and development (R&D), very talented human capital, and robust intellectual property regimes that favor entrepreneurship and risk-taking. In the absence of domestic innovation capacity, middle-income countries stand the risk of becoming stuck.

These facts are especially true in the context of AI. To truly take advantage of the power unlocked by AI, a middle-income country must use the same $3i$ principles. The AI race is underpinned by the adoption of AI technologies (infusion) and the creation of new AI technologies (innovation). Middle-income countries must incorporate technology exogenously, and only then can they move toward endogenous technology.

These realities motivate the remainder of this report. We look at a subset of countries that have "misallocated" AI innovation. That is, countries with a high degree of innovation but low preparedness for infusing existing AI technologies into their economies. We first find that they are overwhelmingly middle-income countries. We then look at these countries more closely, finding that the countries with misallocated AI innovation are those with lower economic freedoms that prevent economic integration with the broader world.

# 2 Misallocated AI Innovation

## 2.1 Selecting Countries

Countries with misallocated AI innovation are those that are outputting new advancements in AI but are not themselves in a position to inject these advancements into their economy due to low AI preparedness. We define AI preparedness through the International Monetary Fund (IMF) 2023 AI Preparedness Index [12]. The index assesses the AI preparedness of 174 countries as an aggregate of 4 subindices, each of which measures a dimension necessary for frictionless adoption of new AI technologies. Each of the 4 subindices are summarized in Table 1.

| **AI Preparedness Index Subindices** | |
|---|---|
| *I. Foundational AI Preparedness* | |
| ***Digital Infrastructure*** | Accessible, affordable, and secure internet access |
| | E-commerce infrastructure (private and public) |
| ***Human Capital and Labor Market Policies*** | Education, digital skills, and STEM graduates |
| | Flexibility in labor markets and wage policies |
| *II. Second-Generation AI Preparedness* | |
| ***Innovation and Economic Integration*** | R&D spending, frontier technology readiness, and domestic credit to private sector |
| | Freedom to trade internationally, ease of movement of capital and people |
| ***Regulation and Ethics*** | Legal framework adaption to digital age |
| | Government effectiveness and accountability |

**Table 1:** Descriptions of subindices in the AI Preparedness Index [12].

To measure innovative capacity, we use citation metrics for AI publications from the Center for Security and Emerging Technology (CSET) [4]. Citation metrics were chosen to operationalize innovation in this capacity because of the time lag associated with patent offices reporting data, meaning recent data is likely incomplete [4]. Moreover, citation metrics are a sufficiently robust measure of innovation [13]. We define the AI Innovation Score ($S_I$), ranging from 0 to 1, as a logarithmic scaling for a given number of citations $N$ in a country $C$ as follows:

$$S_I = \frac{\log N - \log N_{\min}}{\log N_{\max} - \log N_{\min}}$$

To select the countries with misallocated AI innovation, we selected those countries with a below-average AI Preparedness Index (0.49) and above-average AI Innovation Score (0.49). As a result, we only considered countries in which sufficient data on preparedness and innovation were available; this led to a sample size of 140 countries. This corresponds to countries in the upper-left quadrant of Figure 7. In Figure 8, we highlight the selected countries on a map and note that all of the countries are in the Middle East and North Africa (MENA), South Asia, or South America. In Table 2, we provide the full list of countries with high innovation but low preparedness.

## 2.2 Causes of Misallocated Innovation

Having identified the countries that are unable to take advantage of existing AI technologies, we wanted to delve deeper into the common characteristics that these economies share that can explain this misallocation. First, we conducted a set of tests on each of the subindicators for the AI Preparedness Index (Table 1) to see if these countries lagged behind the average due to certain dimensions of AI preparedness rather than a holistic lack of pre-

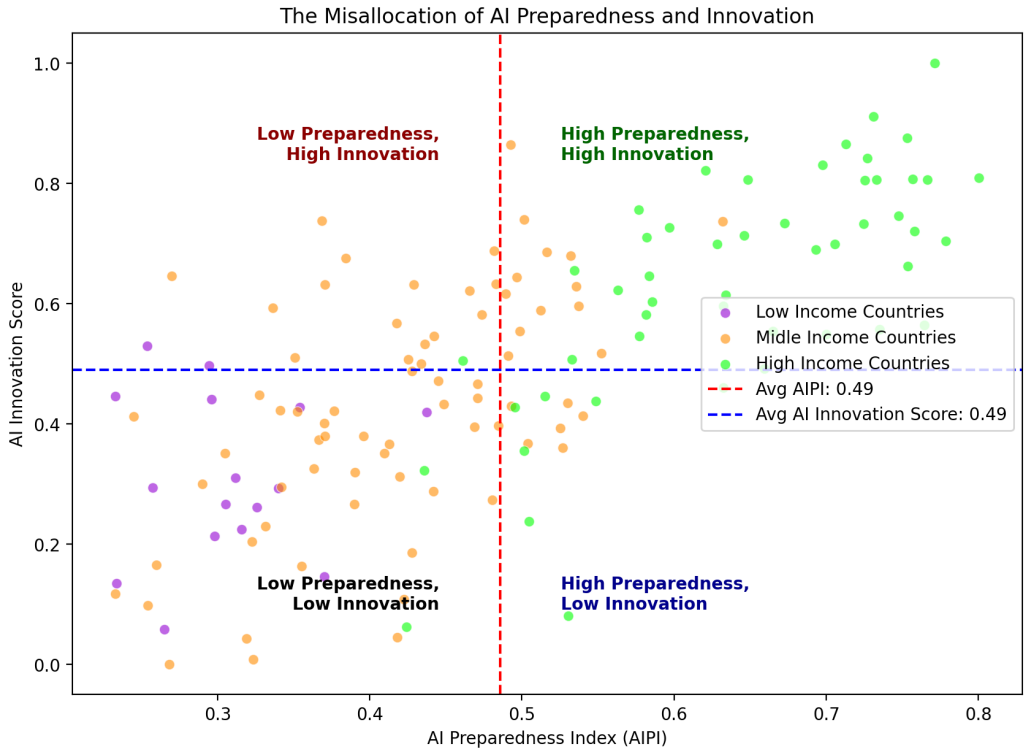


**Figure 7:** The Misallocation of AI Innovation. Countries in the upper-left quadrant, predominantly middle-income countries, are those countries with the most misallocated AI innovation. Produced with data from the IMF and CSET [12, 4].

paredness. Table 3 summarizes the results of running $t$-tests for independent means on the 19 misallocated countries and the other 121 countries. Based on the results, only the Innovation and Economic Integration Index is statistically significant ($p < 0.01$), measuring a country's commitment to R&D as well as ease of integrating global technologies, expertise, and collaboration [12].

Of course, expecting a difference in the Innovation and Economic Integration Index is not all that surprising, as these countries are superior innovators. However, the direction of the difference subverts expectations: the average

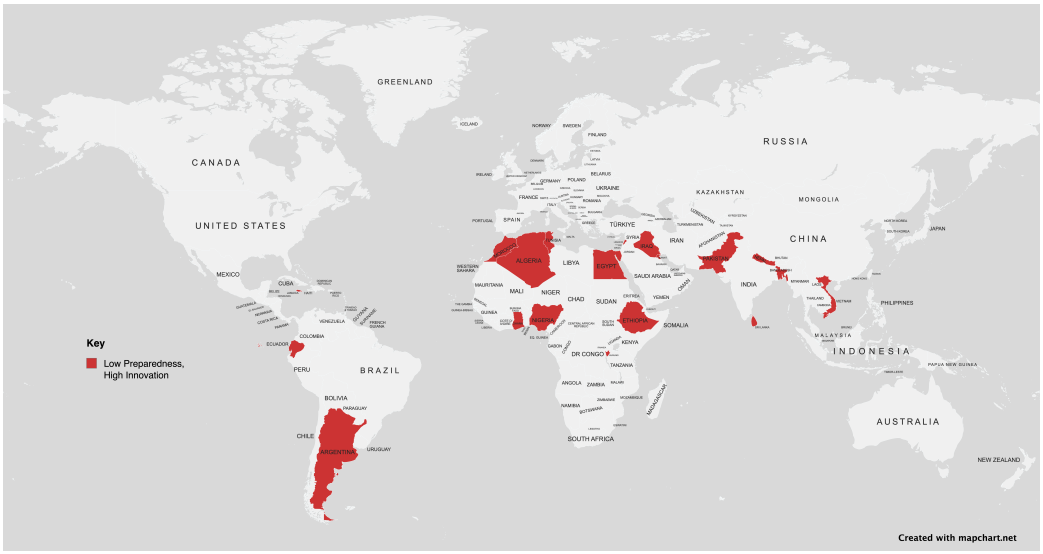


**Figure 8:** Geographic Distribution of Misallocated AI Innovation. Misallocated are in the Middle East and North Africa (MENA), South America, and South Asia. Created with MapChart.

score for misallocated countries was 0.093 while the average score for the other countries was 0.123. This difference suggests that misallocated countries have significantly worse economic freedom than the rest of the world. This freedom is so much weaker that despite their higher innovation tendencies, they still score lower on the index.

To confirm whether or not this is the case, we incorporated the Economic Freedom Index from the Fraser Institute [14]. This index, a score between 0 and 10, incorporates the size of government, property rights, legal system, monetary stability, trade freedoms, and regulations to determine how economically free a country is. The average for the misallocated economies is 5.88, while the other economies have an average of 6.73 on the index. This difference is statistically significant ($p < 0.01$). Across each of the different areas in the index, trade freedoms show the most significant deviation between the two groups of countries. A country's score in the trade freedoms

| Country | AI Preparedness Index | AI Innovation Score | Income Group |
|---|---|---|---|
| Algeria | 0.37 | 0.63 | Middle income |
| Argentina | 0.47 | 0.58 | Middle income |
| Bangladesh | 0.38 | 0.68 | Middle income |
| Burundi | 0.29 | 0.50 | Low income |
| Ecuador | 0.44 | 0.55 | Middle income |
| Ethiopia | 0.25 | 0.53 | Low income |
| Ghana | 0.43 | 0.51 | Middle income |
| Iraq | 0.27 | 0.65 | Middle income |
| Jamaica | 0.43 | 0.50 | Middle income |
| Jordan | 0.48 | 0.63 | Middle income |
| Kuwait | 0.46 | 0.51 | High income |
| Lebanon | 0.42 | 0.57 | Middle income |
| Morocco | 0.43 | 0.63 | Middle income |
| Nepal | 0.35 | 0.51 | Middle income |
| Nigeria | 0.34 | 0.59 | Middle income |
| Pakistan | 0.37 | 0.74 | Middle income |
| Sri Lanka | 0.44 | 0.53 | Middle income |
| Tunisia | 0.47 | 0.62 | Middle income |
| Vietnam | 0.48 | 0.69 | Middle income |

**Table 2:** Misallocated AI Innovation Countries. These 19 countries, largely middle-income, have a low ability to adopt new AI technologies, but a high ability to contribute to developing these technologies through innovation.

category measures 4 different restrictions: tariffs, quotas, administrative constraints, and restrictions on currency exchange and capital inflows/outflows. In sum, misallocated innovative countries are less likely to exchange ideas and capital with other countries.

Thus, the inability of a country to integrate with the global economy is the leading factor that explains the misallocation of AI innovation. These countries contain the research and development capacities to find breakthroughs in AI, but are unable to incorporate the broader set of existing technologies in their economies, preventing them from being leaders in AI.

| Index | $t$-statistic | $p$-value |
|---|---|---|
| Digital Infrastructure Index | $-2.16$ | $3.22 \times 10^{-2}$ |
| Human Capital Index | $-1.94$ | $5.43 \times 10^{-2}$ |
| Innovation and Economic Integration Index | $-4.11$ | $6.70 \times 10^{-5}$** |
| Regulation Index | $-2.52$ | $1.28 \times 10^{-2}$ |

**Table 3:** T-test Results for AIPI Subindicators (Significance level: ** for $p < 0.01$).

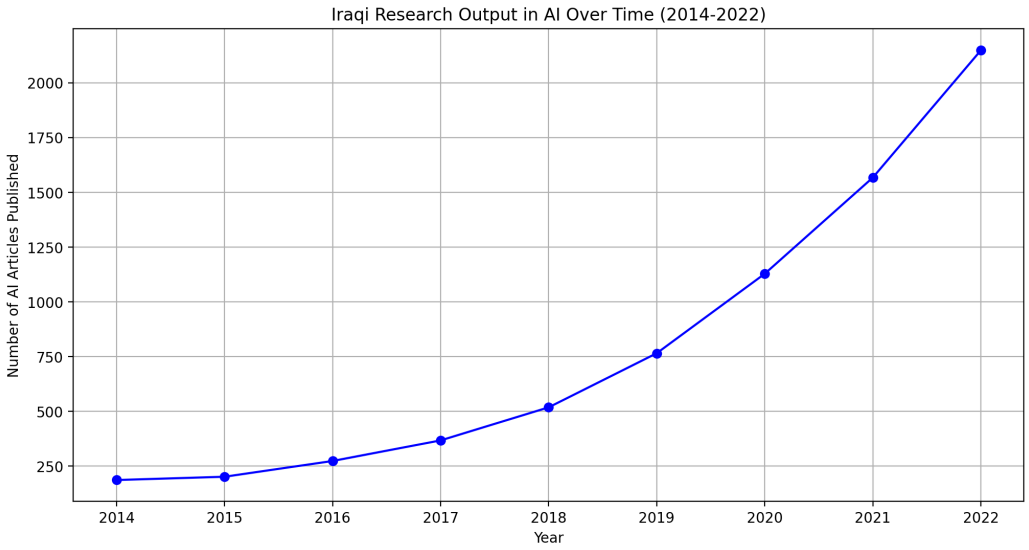


**Figure 9:** Research Output in Iraq Over Time. The average growth rate in the number of AI publications is 36.24% per year. Produced using data from [4].

## 2.3 Case Study: Iraq

In this section, we look at Iraq as a microcosm of the issues these countries face with regards to AI technologies.

Iraq has an AI Preparedness Index of just 0.27, but an AI Innovation Score of 0.65. Several factors limit its ability to integrate with the broader global AI ecosystem. First, many AI technologies fall into the category of dual-

use (having both civilian and military applications), which adds increased restrictions and regulations when exporting to Iraq [15]. Additionally, Iraq is not a signatory to many trade agreements like the World Trade Organization's Information Technology Agreement (ITA). The ITA eliminates tariffs on a range of technology products, which include AI-critical hardware like semiconductors and processors [16]. Iraq's lack of participation in these agreements makes it harder to build commercial-scale AI and prevent it from taking advantage of the technological spillover from the rest of the globalized economy. Indeed, Iraq's imports of information and technology goods in 2014 (the most recent year for which data is available) were only 0.5% of its total imports, well below the rest of the world at 11.7% [17]. In spite of these barriers to adopting technologies, Iraqi researchers have continued to grow their research output at an average rate of 36.24% per year since 2014 (See Figure 9). This rate far exceeds the rest of the world, which has grown its AI research output at an average rate of 12.86% per year since 2014 (See Figure 10). Thus, while Iraq has shown remarkable capability in contributing to the development of new technologies, its economy is unable to infuse the AI tools being built by other countries.

# 3 Conclusions

## 3.1 Limitations

This research has various limitations to be kept in mind while interpreting the results. Firstly, our measure of AI innovation was derived from citations instead of patents. While citation data provided a more up-to-date description of innovation activity, patents are typically considered to be a robust and traditional technological innovation proxy. However, because there existed considerable lag times for patent applications and approvals, their use

was not an option for an update of the work pace in AI.

Second, the data used to mark AI readiness and technological adoption consist of subjective evaluations that might be affected by prejudice or misinformation. The subjective measurements based on expert judgments may be poor in portraying the objective AI adoption capabilities of the countries involved in this report.

Thirdly, the analysis wasn't performed on all nations since there were miss-

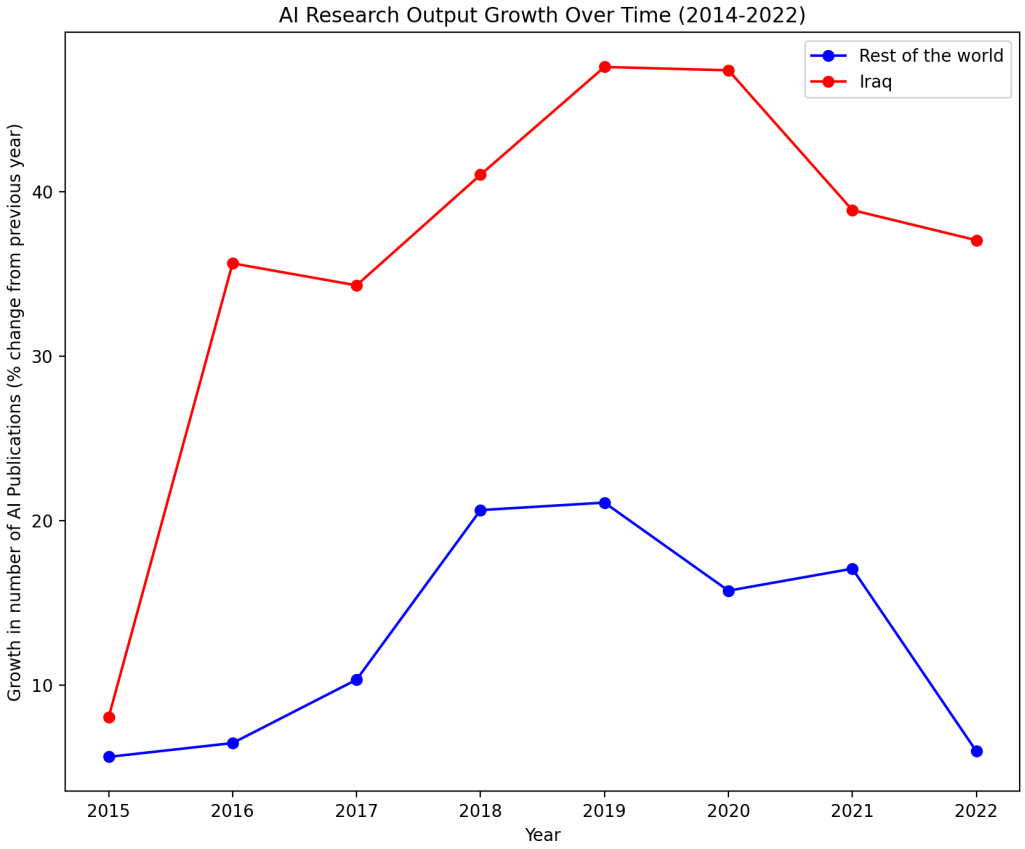


**Figure 10:** Research Output in Iraq vs. The Rest of the World. Iraq's research output has grown at a pace far exceeding the rest of the world since 2014. Produced using data from [4].

ing coverage areas, especially for lower-income or smaller nations. Hence, the findings might not generalize fully across the globe, and caution must be exercised when projecting results beyond the subset of nations that was studied.

## 3.2 Implications for Middle-Income Countries

In this final section, we discuss the implications for these economies more broadly, noting that most of these countries are middle-income. As discussed in 1.3, an economy seeking to escape the middle-income trap must manage a balance of investment, infusion, and innovation. Middle-income countries must move past capital accumulation toward infusing existing technologies from frontier countries, and then later, move toward innovation. These facts are particularly problematic for the countries with misallocated AI innovation. In particular, these economies have failed to make the first transition and are trying to skip directly to the second one. Other middle-income countries have the opportunity to leapfrog by leveraging mature AI solutions already optimized in other parts of the world. By bypassing this step and aiming straight for innovation, they risk inefficient use of resources and a growing technological gap. The countries that prioritize infusing existing AI technologies into their economies will see a massive increase in economic growth capable of propelling them to high-income status. Figure 11 shows how countries with higher preparedness and lower innovation differ from countries with lower preparedness and higher innovation. In the past few years, their growth rates have already begun to diverge as the pace of AI integration in the global economy has accelerated. This trend will only continue unless countries with low preparedness begin to take steps to ensure they are not left behind.

Thus, the path moving forward for these countries is clear: shifting pol-

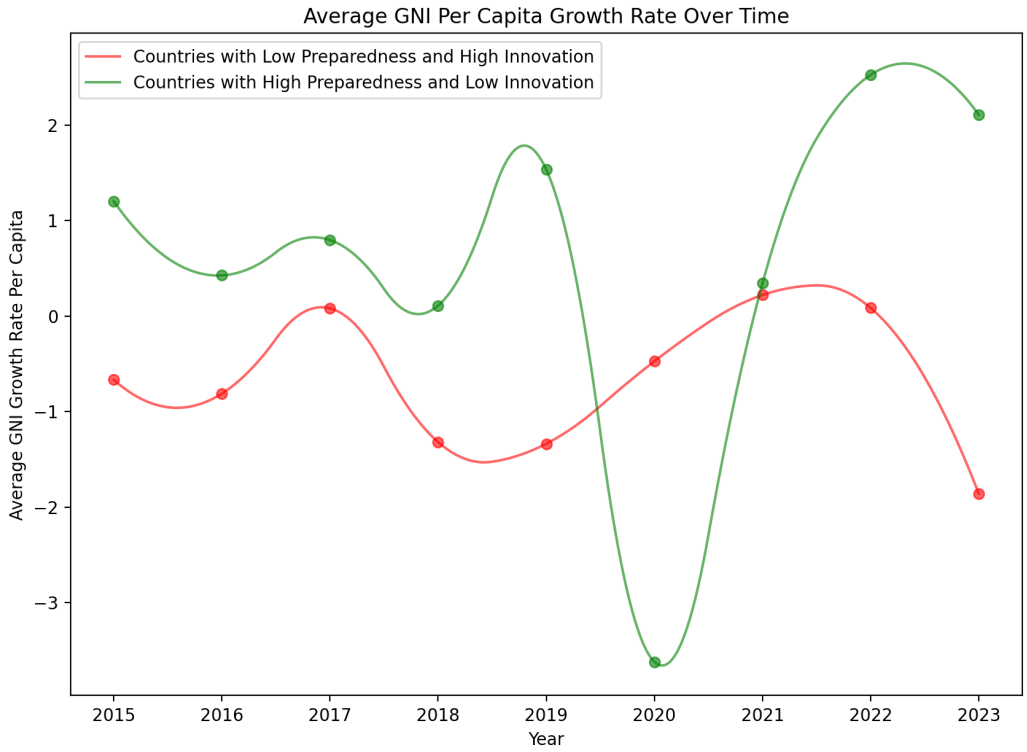


**Figure 11:** Average Gross National Income Per Capita Growth Rate Over Time. Countries with high preparedness and low innovation are experiencing higher growth rates than countries with lower preparedness and higher innovation. Produced with data from the World Bank.

icy and spending toward global partnerships to adopt AI tools in order to infuse frontier countries' technologies into their own. The longer these countries wait, the more misaligned their development of AI will become, and the more the gap will grow. They will fail to get easy wins in key sectors like agriculture, healthcare, and education. Middle-income countries across MENA, South Asia, and South America will remain deeply entrenched in the middle-income trap, lacking the foundations to compete with other countries with AI-driven economies.

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