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Artificial Intelligence and National Security

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I. Introduction

The advent of artificial intelligence threatens to disrupt established geopolitical dynamics and facilitate a new dimension of competition between major international powers. A key manifestation of this disruption will take the form of a new "artificial intelligence arms race" between the United States and China, which will pose a growing threat to American national security and geopolitical hegemony in the coming decades. One of the greatest challenges for policymakers and politically-minded academics in the 21st century, then, is understanding how the United States can navigate this turbulent era of technological innovation, maintain its competitive edge in the geopolitical competition against rival powers, and ensure its national security in this new and ever-changing environment. The purpose of this paper will be to provide readers with a clear and thorough understanding of the modern US-China artificial intelligence race as it relates to American national security and the broader US-China geopolitical competition. Specifically, it aims to synthesize a wide breadth of existing information regarding the relative development and impact of AI technologies in China and the United States. The result will be a holistic product that will enable readers to understand the modern environment of the US-Chinese AI race.

This paper will focus on four key questions. First and foremost, this paper will seek to comparatively describe the current artificial intelligence capabilities of the United States and China, both in terms of current latent and manifested capabilities as well as the potential for future artificial intelligence development. Additionally, this paper will seek to understand what contributing factors are facilitating or mitigating artificial intelligence development in each country. Moreover, this paper will utilize the differences in these contributing factors in order to explain the disparity in American and Chinese artificial intelligence capabilities. Lastly, this

paper will explore the overall implications of these findings both for American national security as well as for the broader US-China geopolitical competition.

More than just serving as a descriptive analysis, however, this paper will also make several commentaries on the contemporary artificial intelligence race, American and Chinese artificial intelligence policy, and the overall outlook for the US-China competition in the artificial intelligence realm going forward. In particular, this paper will argue that despite China making great strides in closing the gap with the United States in terms of overall artificial intelligence capabilities, the US has maintained its artificial intelligence superiority in the military, economic and informational spheres. Additionally, this paper will argue that the massive technological edge afforded to the US in the realm of artificial intelligence is ultimately rooted in the strength of its private tech sector and in its strategic access to critical technologies and components, a result of both domestic production and close economic ties to key foreign producers. While state-directed initiatives and strategic resource allocations have allowed Chinese industries to emulate some of the successes seen in American private industry, a key challenge for Chinese artificial intelligence development lies in its lack of access to critical technologies and in an overall lack of innovation—indeed, China has made relatively few unique contributions to artificial intelligence development, and their explosive advancement in the field has largely focused on bedogging the successes already seen in American development. This paper will also argue that in the short-to-medium term it is clear that the US is likely to maintain its position as the world leader in artificial intelligence capabilities and developmental potential. The long-term outlook, however, remains up for debate. The outcome of the US-China AI race rests on whether or not China can maintain its current trajectory, as well as how effective the United States will be in safeguarding its current advantages in the field—both of which are

questions that remain to be seen. Lastly, this paper will argue that in order to maintain its dominance in the realm of artificial intelligence, and thus ensure its national security in this ever-changing technological environment, the United States must implement proactive policies in order to maintain the capability gap between its artificial intelligence industry and that of China.

Overall, the significance of this paper will be its simultaneous academic and pragmatic utility. It will contribute to an academic literature concerning the intersection of artificial intelligence and foreign policy, as well as the sociopolitical and economic underpinnings of AI development. Moreover, it will do so in a way that is also accessible to those without expertise in the subject material, allowing it to be a useful and informative resource for guiding the decisions of policymakers and national security officials.

II. Literature Review

Of the countless forces that continue to shape the chaotic geopolitical landscape of the 21st century, there are none so simultaneously pervasive and impactful as the innovation of new and disruptive technologies. The nature of disruptive technology was best articulated by US Air Force Major and West Point international relations scholar Michael Duda (2021), who wrote that in "drawing from the business, economic, and security literature, I define disruptive technology as technology that changes the primary means by which actors (firms in a marketplace; states in the international system) compete" (p. 1). With this definition in mind, it becomes relatively easy to identify the ways in which disruptive technologies have fundamentally altered the operations of the private sector. The impact of 3D printing on production, e-commerce and the blockchain revolutionizing how people do business, and Global Positioning Systems transforming how individuals interact with their geospatial environment are only a few of the countless examples of the disruptions caused by the increasingly-rapid innovation seen over the last several decades.

What is even more important than this private sector shift, however, is that these disruptive technologies also have profound implications for the realm of geopolitics. In particular, disruptive technology promises to fundamentally alter the existing national security dynamic among the major powers of the international system. Michael Duda (2021) stressed the importance of this dimension of disruptive technological innovation, writing that "when we think about the disruptive potential of technology, we must not only consider the material form that such technologies may take but also the political, economic, and social practices that evolve for them to take hold and operate in society… disruptive technology threatens to redistribute power among actors at the international level" (p. 3).

With the impactful role of disruptive technology in mind, there is no more pertinent issue to discuss than that of artificial intelligence. Indeed, many scholars have noted that of all the disruptive technologies that will impact the socio-economic and geopolitical character of the 21st century, none promises to do so on such a pervasive, fundamental level as does artificial intelligence. The most famous proclamation of artificial intelligence's potential impact by well-regarded academics came in the publication of *Research Priorities for Robust and Beneficial Artificial Intelligence: An Open Letter*. In the open letter, Stephen Hawking, Elon Musk, and several experts on artificial intelligence (2021) wrote that "The establishment of shared theoretical frameworks, combined with the availability of data and processing power, has yielded remarkable successes in various component tasks such as speech recognition, image classification, autonomous vehicles, machine translation, legged locomotion, and question-answering systems… There is now a broad consensus that AI research is progressing steadily, and that its impact on society is likely to increase. The potential benefits are huge, since everything that civilization has to offer is a product of human intelligence; we cannot predict

what we might achieve when this intelligence is magnified by the tools AI may provide, but the eradication of disease and poverty are not unfathomable" (p. 2). Hawking et al. posit the emergence of a world in which artificial intelligence is used to augment the existing capabilities of states and societies, with the ultimate goal of revolutionizing virtually every aspect of the modern world. Some major categories identified in the letter transportation, medicine, social equality, information management, and communication. (Hawking & Musk, 2021). Outside of these specific examples, however, their words hinted at an even more profound impact of artificial intelligence. In augmenting the capabilities of human intelligence itself, which exists as the universal mechanism of innovation, artificial intelligence has the potential to impact *every aspect* of modern civilization. Such a transformation in an underlying driving mechanism of the modern world will undoubtedly redefine competition in the global arena. Indeed, the profound impact of artificial intelligence on productivity is highly likely to necessitate its adoption at the highest levels of competition, including in large-scale geopolitical competition between state actors. This is keeping exactly with the definition of disruptive technology, causing a systemic shift in the axes along which actors in both the economic and geopolitical arenas compete, but on a scale that no other technological innovation of the 21st century seems poised to match.

Other scholars have echoed this sentiment. Spyros Makridakis (2017), Director of the Institute for the Future at the University of Nicosia, posited that the potential impact of artificial intelligence on modern society would result in a transformation on a similar scale as the Industrial Revolution when he wrote that "self-driving cars, pilotless airplanes, Skype calls, super computers, smartphones or intelligent robots. Technologies that seemed like pure science fiction… will in all likelihood be in widespread use within the next twenty years… The Industrial Revolution brought far reaching changes to firms and employment… The expected

changes brought by AI technologies will be just as, or even more significant as those of the Industrial Revolution" (p. 8-38). Mounib Khanafer and Shervin Shirmohammadi's (2020) publications on the topic mirrored Makridakis' language regarding the advent of artificial intelligence as a new Industrial Revolution when they wrote that "from technology and medicine to science and sociology, and many others. AI is one of the core enabling components of the fourth industrial revolution that we are currently witnessing, and the applications of AI are truly transforming our world and impacting all facets of society, economy, living, working, and technology" (p. 1). Another scholar, Yuval Noah Harari (2017), noted that a revolution in artificial intelligence technologies is quickly creating an environment in which even the most complex, seemingly human-centric jobs will be greatly impacted, if not driven to obsolescence entirely. Harari states that "The ongoing artificial-intelligence revolution will change almost every line of work, creating enormous social and economic opportunities—and challenges. Computer scientists are developing artificial intelligence (AI) algorithms that can learn, analyse massive amounts of data and recognize patterns with superhuman efficiency… giving rise to algorithms that can successfully analyse us and communicate with us, and that may soon outperform human doctors, drivers, soldiers and bankers" (p. 1-2). Much as the Industrial Revolution engendered sweeping changes in the economic and social organization that can still be felt in the modern day, artificial intelligence is very likely to bring about a drastic change in the socio-economic and geopolitical character of the modern era and is poised to be one of the greatest challenges facing state and non-state actors in the 21st century.

Maintaining superiority in the realm of artificial intelligence is thus paramount to ensuring American national security in the 21st century. The advent of artificial intelligence promises to disrupt the realms of national security, geopolitical interaction, and international

competition. As a disruptive technology, the modern impact of artificial intelligence on geopolitics in many ways mirrors the disruptions caused by other technologies in the past, including aerospace and nuclear. Looking at AI as existing within the same context as these historic technological developments could therefore provide an invaluable framework going forward. The advent of widespread aerospace technology in the early 20th century, specifically that in the form of military aircraft, allowed countries to project power over vast geographic distances that quickly dwarfed the capabilities of contemporary naval forces (Lespinois, 2019). As aviation subsumed the navy's historic role as the instrument of power on an international level, airpower became a new and primary means of competition between state actors. The established order was overturned by the emergence of a new axis of competition that would redefine the power distribution among state actors, forcing them to adopt entirely new technologies and doctrines in order to maintain their competitive edge and security in the geopolitical arena (Lespinois, 2019). Something very similar, although on a much grander scale, would occur with the advent of nuclear technology in the mid-20th century. Nuclear weapons meant a shift away from conventional warfare capabilities as a primary means of competition between major powers, and instead created a new dimension of competition focused on the nuclear development security dilemma, the doctrine of mutually assured destruction, and a pointedly non-confrontational atmosphere surrounding large-scale conflict that had never quite been seen before in the realm of geopolitics (Friedman, 2019). In much the same way as these technologies, the power of artificial intelligence in augmenting human innovative and data-processing capabilities will allow states to expand their effectiveness in military, economic, and informational operations greatly, necessitating the adoption of this new technology in the crafting of 21st-century national strategies.

In fact, as is characteristic of disruptive technology, artificial intelligence has opened up a new battleground of the broader US-China competition, and one which is likely to take an increasingly vital role in the coming decades. This emergent AI competition has manifested into what many have termed an "AI race" between the world's major powers. In many ways mirroring the nuclear arms race of the Cold War era, this competition has seen the US and China vie for technological supremacy in the field of artificial intelligence research, development, and implementation, and has been informed by a new Chinese strategy surrounding artificial intelligence. This new Chinese national strategy recognizes AI's role as a disruptive technology and seeks to capitalize upon it as an opportunity to advance its geopolitical position. Adoption of this new national strategy has seen the Chinese state close the gap in terms of capabilities with the United States, and scholars have pointed to several key indicators as evidence for China's rapid artificial intelligence ascendency. Daniel Castro and Michael McLaughlin (2021) provide an excellent and comprehensive list of these major indicators when they write that "First, China has surpassed the EU as the world leader in AI publications… Second, the quality of its AI research has generally trended upward year to year… Third, its software and computer services firms have increased their R&D spending… Fourth, China now has nearly twice as many supercomputers ranked in the top 500 for performance as the United States—the United States led in this indicator as recently as 2017… Finally, China likely continues to lead in the amount of data generated" (p. 7).

To those in the national security community who are well-versed in the disruptive potential of artificial intelligence, the rapid ascendancy of the Chinese AI program has undoubtedly been a point of great alarm. Indeed, there have been several dark pronouncements over the course of the last few years forecasting that the US-China AI race will ultimately spell

the end of American geopolitical hegemony. Perhaps one of the most infamous of these predictions came from Nicolas Chaillan, ex-software chief at the Pentagon whose former position only enhanced the popular concern surrounding his statements, which read "We have no competing fighting chance against China in 15 to 20 years. Right now, it's already a done deal; it is already over in my opinion" (Reuters, 2021, p. 4). While this paper will posit that such foreboding analyses of the contemporary situation overlook several key realities of the US-China AI race, there is some merit to these fears. China *does* have the potential to surpass the United States in terms of artificial intelligence capabilities—and by extension, in the 21st-century geopolitical competition—*if* the realities of the US-China AI race are not properly taken into account. Webster et al. (2017) affirm this claim in their own work, writing that "Looking forward, China may have the potential to lead the world in this new AI revolution, potentially surpassing the United States in the process" (p. 19). Clearly, the artificial intelligence race between the United States and China promises to be one of the foremost defining competitions of the 21st century. With distinct implications for the realms of national security and foreign policymaking, this competition will be at the heart of this discussion.

However, it would be academically remiss to neglect the fact that there is *some* opposition to this interpretation of the present technological competition between the US and China. While this paper ultimately rejects this opposition, it still important to address. On one hand, it is clear that some scholars disagree with the framing of the present US-China technological competition within the "AI race" model. Heather Roff (2019), for instance, opposed the usage of this terminology when she wrote that "There needs to be a change in thinking about AI… The news media should stop framing the global artificial intelligence competition as an 'arms race.' This misrepresents the competition going on among countries" (p.

1). Virginia Dignum (2019) echoed this sentiment but took significantly more issue with the *effect* that viewing artificial intelligence development as a "race" might have, a point she articulated when she wrote that "Press and policy makers are obsessed with the so-called AI race… US executives warned that China may be winning this supposed race… this race discourse is both wrong and dangerous. It puts the focus on competition and brings with it a sense of gloom and despair… Firstly, there is no race and secondly, if there is, it is the wrong race to run… By assuming that this 'race' can be won, means that there would be a moment in which we can stop developing technology, and advancing humankind" (p. 1-2).

While there is some merit to points such as these, they ultimately fail to reflect the geopolitical realities of the 21st century. Despite these prescriptive analyses that claim that academics should refrain from utilizing the term "AI race," it is impossible to deny the importance of the fact that the key players and policymakers *themselves* conceive of the current arrangement as one of technological competition, and that this perception itself shapes the geopolitical environment. Indeed, the Chinese leadership has baked this conception of a US-China AI race, as well as broader ideas of AI disruption as a tool with which to vie for geopolitical hegemony, into their national strategy. Graham Webster et al. (2017) point out this fact in their work on the topic, writing that "The Chinese leadership sees technological innovation, particularly in AI, as a core aspect of international competition. Beyond informatization, China is embarking upon an agenda of 'intelligentization' (智能化), seeking to take advantage of the transformative potential of AI throughout society, the economy, government, and the military" (p. 19). Webster et al. (2017) also go on to discuss China's drive for a domestic AI industry in order to capitalize on the opportunities that artificial intelligence disruption present for the pursuit of their national interests, writing that "Through this new plan,

China intends to pursue ‘indigenous innovation’ in the ‘strategic frontier’ technology of AI in furtherance of a national strategy for innovation-driven development” (p. 19). Chinese leadership clearly has a the *intent* to engage in an artificial intelligence race with the United States, regardless of the academic discourse on the matter.

What’s even more important than this rhetoric, however, is that the intent of the Chinese leadership to capitalize on the potential of artificial intelligence has manifested into *real policy* that affects both the domestic character of the Chinese state as well as how China interacts with other states in a geopolitical sense. Webster et al. (2017) also make a point of this, writing that “If this were only rhetoric, such a focus on innovation might remain aspirational. However, this plan includes an extensive and detailed agenda, with sustained focus and significant funding, to build up China’s capability in innovation capability to enable advances in next-generation AI technologies” (p. 19). These plans have clearly borne fruit—as was previously discussed, China has seen progress in artificial intelligence technology on a scale unmatched by any other major power in the world. Overall, while some may oppose the idea of an artificial intelligence race on a theoretical, moral, or even merely semantic basis, there can be no denying that ideas about the US-China competition are alive within the minds of the Chinese leadership. These ideas have had a tangible influence on the geopolitical arena, and therefore cannot be dismissed so simply. Instead, they demand attention in both an academic and a pragmatic sense, and represent a serious challenge for the American geopolitical position in the coming decades.

III. Key Terms and Methodology

First, it is important to establish a working definition of what artificial intelligence is—a collective understanding of what is meant by this term is essential for framing this discussion. Luckily, the commercial technology community known as Built In provides a clear, concise, and

all-encompassing definition of artificial intelligence, stating that "Artificial intelligence (AI) is a wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence." This will be the definition of artificial intelligence that will be used for the remainder of this paper, as it is perhaps the most easily-understood yet accurate articulation of the term that is available.

Gradience in terminology is still necessary in order to control the scope of this discussion, however, and it will therefore also be helpful to briefly discuss the distinct types of artificial intelligence that exist in the current day, as well as which of those that this paper will be focusing on. Naveen Joshi, the founder and CEO of Allerin, an integrated technology solutions company focused on artificial intelligence and "Big Data," helpfully divides the distinct types of artificial intelligence into four functional categories: Reactive Machine AI, Limited Memory AI, Theory of Mind AI, and Self-Aware AI. Reactive Machine AI, according to Joshi (2019), refers to "the oldest forms of AI systems that have extremely limited capability. They emulate the human mind's ability to respond to different kinds of stimuli [and] do not have memory-based functionality… such machines cannot use previously gained experiences to inform their present actions, i.e., these machines do not have the ability to 'learn'" (p. 5). Perhaps one of the most widely-known examples of such artificial intelligence was IBM's Deep Blue, the machine which bested chess Grandmaster Kasparov in 1997. Other examples of Reactive AI include email spam filters, targeted recommendation engines, and other simple automated algorithms which have seen wide application in the modern era. Limited Memory AI, according to Joshi (2019), refers to "machines that, in addition to having the capabilities of purely reactive machines, are also capable of learning from historical data to make decisions… [reactive machines] are trained by large volumes of training data that they store in their memory to form a reference model for

solving future problems" (p. 6). These systems, which are also referred to as "deep-learning AI," are the most prevalent type of artificial intelligence in the modern world. Examples include numerous present-day AI applications, including image and facial recognition AI, chatbots, virtual assistants, and autonomous vehicles (Joshi, 2019, p. 7).

While Reactive Machine AI and Limited Memory AI have a relatively long history and are still seen in wide use today, these next two categories of artificial intelligence are largely in their conceptual nascency. The first of these, Theory of Mind AI, refers to artificial intelligence that will be able to incorporate the human psychological concept of the Theory of Mind into its decision-making processes (Cuzzolin et al., 2020). According to Fabio Cuzzolin et al. (2020), Theory of Mind itself refers to "the ability of the human mind to attribute mental states to others," and is largely synonymous with the concept of empathy (Cuzzolin et al., 2020, p. 1). Thus, Theory of Mind AI refers to any artificial intelligence program that can emulate empathy to a degree that is virtually indistinguishable from that of real humans. Joshi (2019) expands on this, writing that Theory of Mind AI "will be able to better understand the entities it is interacting with by discerning their needs, emotions, beliefs, and thought processes… to truly understand human needs, AI machines will have to perceive humans as individuals whose minds can be shaped by multiple factors, essentially 'understanding' humans" (p. 8). In essence, this category of artificial intelligence would be able to emulate a human level of emotional intelligence in order to tackle complex tasks in a more holistic manner. Cuzzolin et al. (2020) stressed the importance of implementing Theory of Mind technologies in future artificial endeavors, as well as the enormous leap in the utility of artificial intelligence when such technology is developed, when he wrote that "far more sophisticated functions need to be in place before AI can be safely deployed in high-risk and potentially dangerous situations… A smart car needs to make reliable

predictions about human behaviour in real time, for example, in order to pre-emptively adjust speed and course to cope with a child's possible decision to abruptly cross the road in front of them… ToM needs to be incorporated into intelligent machines if they are to smoothly share environments built by human beings for human beings" (p. 6). This technology has yet to truly be developed, however, and therefore no current-day examples of Theory of Mind AI exist.

The last of these four categories of artificial intelligence is Self-Aware AI—a category many believe to rest entirely within the realm of science fiction, but which nonetheless poses a number of important questions for contemporary academics. In discussing the implications that such technology would have on socio-economic interactions, Hector Gonzalez-Jimenez (2018) provided an excellent overview of the meaning and history of Self-Aware AI when he wrote that "Since the mid-1950s, AI research has been focused on creating 'thinking machines'… AI with human-like general intelligence as well as robots that will be hosting this AI… In other words, a [Self-Aware AI] will have a conception of its self (or self-concept) and be able to use information and make decisions that reshape its self as an active member of a social environment" (p. 1-3). More than just being able to emulate human emotional intelligence like a Theory of Mind AI could, a Self-Aware AI would have a *real* concept of its own existence, allowing for a significant degree of adaptive behavior that would largely mirror that of a human being. This technology is, like Theory of Mind AI, in its theoretical infancy, and is unlikely to see any form of development for at least the next several decades.

There also exists an alternate classification methodology for artificial intelligence systems that is worth touching upon, if only to provide additional clarity as to the types of artificial intelligence that will be discussed here. This classification methodology may be the one that most readers are familiar with due to its commonplace usage in the media and in tech circles.

Moreover, this secondary classification methodology, while lacking the gradience of the first, is significantly more general in its application and less reliant on complex academic terminology in its articulation, and thus may be of significant use in this discussion despite its dwindling use in the broader academic conversation on the topic. This classification methodology divides artificial intelligence systems into three broad categories based on the sophistication and scope of the system's capabilities. The first of these categories is artificial *narrow* intelligence, commonly referred to as ANI. Also known by some as *weak AI*, ANI is defined by its limited capability and scope. Such systems lack the broad capabilities of human intelligence and can instead only perform a minor selection of narrow tasks—though, of course, they often do so with near-unmatched efficiency. Nicolas Miailhe and Cyrus Hodes (2017) articulated the inherent limitations of ANI systems when they wrote that "Even if they are capable of generalizing pattern recognition, for instance transferring knowledge learned in the frame of image recognition into speech recognition, we are still very far away from the versatility of a human mind" (p. 11). ANI systems are undoubtedly the most prevalent in the modern world, as even "the most advanced artificial intelligence systems available today, such as the famous IBM Watson or Google's AlphaGo, are still 'narrow' (weak), in the sense that they operate strictly within the confine of the scenarios for which they are programmed" (Miailhe and Hodes, 2017, p. 11). Of the three categories of artificial intelligence that are encompassed by this methodology, ANI systems are the only that currently exist—the next two are entirely hypothetical and extrapolated extensions of current artificial intelligence technologies.

The second category for artificial intelligence in this classification methodology is artificial *general* intelligence, commonly abbreviated as AGI. Also known as the first *strong AI*, AGI systems would hypothetically have the capability to operate on the same level as human

intelligence. This not only necessitates human-level efficiency in completing tasks, but the ability to complete an incredibly *broad* selection of tasks—such a machine would be able to apply its problem-solving matrices to solve virtually any challenge that it is presented with, and to do so on a level at or slightly exceeding the capabilities of a human being. Miailhe and Rhodes (2017) also articulated the specific prerequisite capabilities of AGI systems in their work when they wrote that "For a majority of experts, AGI refers to an autonomous machine's ability to perform any intellectual tasks that a human can perform. This implies generalizing and abstracting learning across various cognitive functions" (p. 10).

The final category of artificial intelligence in this classification methodology is artificial *superintelligence,* or ASI. As the eventual end-point development of *strong AI,* an ASI system would hypothetically possess high-level problem-solving capabilities and intelligence that would far surpass the highest capacities of human intelligence. Even the brightest, most gifted human minds would be unable to match the capabilities of such systems. There is a great deal of speculation that exists on this topic, but it was Salvador Pueyo (2018) who best articulated the nature of ASI systems when he wrote that "in a near future, artificial intelligence (AI) could vastly outperform human intelligence in most or all of its dimensions, thus becoming superintelligence… Current AIs have narrow scopes, while a hypothetical superintelligence would be more effective than humans in pursuing virtually every goal" (p. 2). Of these three categories, ASI systems are the furthest from the reaches of modern technological development.

With these classifications in mind, this paper will be focusing primarily on the Reactive Machine AI and Limited Memory AI systems of the first classification methodology as well as the ANI systems of the second classification methodology. While the other systems of artificial intelligence are intriguing prospects for academic inquiry, the fact that they are still in their

theoretical infancy means that it is highly unlikely that these more advanced types of artificial intelligence will make a meaningful impact on geopolitical interactions in the short-to-medium term—or, for that matter, in anything but the most distant long-term scenarios. For the practical purposes of this paper, the discussion will instead focus on the types of artificial intelligence that are either in current use or are on the edge of development. This is to say that the term "artificial intelligence" as it will be used in this paper does not necessarily refer to the advanced, multi-use general intelligence systems that will be seen in the distant future, but will instead refer to any number of existing or near-developed smart machines capable of performing tasks that typically require human intelligence even on their most basic level.

Lastly, this section will discuss the methodology that will be used in discussing the artificial intelligence capabilities of both the United States and China. Specifically, this paper will be investigating the artificial intelligence capabilities of each country as they relate to three major categories: military AI capabilities, economic AI capabilities, and informational AI capabilities. The rationale for this is relatively simple and is largely based upon a previous framework established by Greg Allen and Taniel Chan in their own work on the artificial intelligence and national security intersection. Allen and Chan (2017) justified their own use of this framework quite plainly, writing that "Future progress in AI has the potential to be a transformative national security technology… Advances in AI will affect national security by driving change in three areas: military superiority, information superiority, and economic superiority" (p. 6-7). These three dimensions—military, economic, and informational superiority—have been identified as the ones that are not only most likely to be greatly impacted by the incorporation of artificial intelligence technologies, but which will also have the greatest impact on the US-China geopolitical and national security dynamic. By dividing American and

Chinese AI capabilities into three functional categories, then, we can better understand the nature of the current environment.

Allen and Chan go on to describe these three categories as they relate to artificial intelligence and touching upon these descriptions here will help better establish definitions for each category that will be useful in the discussion later in this paper. In terms of military superiority, Allen and Chan (2017) stress the relevance of artificial intelligence when they write that "progress in AI will both enable new capabilities and make existing capabilities affordable to a broader range of actors… activities that currently require lots of high-skill labor, such as Advanced Persistent Threat operations, may in the future be largely automated and easily available on the black market" (p. 7). Thus, for the purposes of this paper, the *military AI capabilities* of the United States and China will refer to the ability of each state to use artificial intelligence in a capacity that augments the efficacy of its military operations on either a strategic and tactical level. This category will include both manifested and latent capabilities, with an important distinction drawn between them.

In terms of economic superiority, Allen and Chan (2017) find that "advances in AI could result in a new industrial revolution… will reshape the relationship between capital and labor in economies around the world" (p. 9). For the purposes of this paper, the *economic AI capabilities* of the United States and China will refer to the ability of each state—as well as its private sector—to use artificial intelligence in a capacity that augments the strength of the nation's economy, and thus the state's effective hard power. This includes the augmentation of the state's economic output, capacity for growth, or resiliency.

Lastly, in terms of informational superiority, artificial intelligence can augment a state's awareness within the context of the geopolitical arena. Allen and Chan (2017) touch on this

potential advantage, writing that "AI will dramatically enhance capabilities for the collection and analysis of data, but also the creation of data" (p. 8). For the purposes of this paper, the *informational AI capabilities* of the United States and China will refer to the ability of each state and its private businesses to use AI in an informational capacity, including things such as intelligence gathering, communications, general awareness, and the overall ability of respectively-affiliated bodies to describe, organize, integrate, share, or govern their informational assets.

By enabling states to achieve superiority in each of these three categories, artificial intelligence promises to provide a new path to geopolitical ascendancy and eventually hegemony. Paying close attention to advancing artificial intelligence capabilities in each of these three categories is essential to understanding the modern environment of the US-China AI race, as well as the outlook for American national security within the context of this geopolitical competition going forward.

IV. United States Artificial Intelligence Capabilities

In this section as well as the one that follows it, this paper will be discussing the present-day artificial intelligence capabilities of the United States and China as they relate to each state achieving dominance in the three aforementioned categories of military, economic, and informational superiority. This is key for the overall analysis of this paper, as a thorough understanding of the US-China AI race environment as it exists today is essential for understanding the long-term outlook for this competition in the coming decades, as well as the implications of American AI capabilities as they relate to Chinese AI for the issue of American national security. This section in particular will explore the artificial intelligence capabilities of the United States. The overall judgment made in this section is that, despite some foreboding

pronouncements about the ascendancy of the Chinese AI program that have dominated the media in recent years, the United States remains the world leader in artificial intelligence technologies in all three categories.

In terms of military AI capabilities, the United States possesses a sophisticated suite of artificial intelligence technologies that can be deployed in pursuance of its military objectives. This has primarily been stirred by the widespread interest of American defense leadership to integrate artificial intelligence systems into traditional defensive suites. According to a 2020 report by the Congressional Research Service, artificial intelligence has captured "the attention of commercial investors, defense intellectuals, policymakers, and international competitors alike" (p. 1). Such interest has manifested into significant research and development in the pursuit of militarily-applicable artificial intelligence technologies. Indeed, the United States military is already "developing AI applications for a range of military functions. AI research is underway in the fields of intelligence collection and analysis, logistics, cyber operations, information operations, command and control, and in a variety of semiautonomous and autonomous vehicles" that can be utilized in the pursuit of military objectives. (CRN, 2020, p. ii). Such research and development has already borne fruit. The U.S. military is already "integrating AI systems into combat via a spearhead initiative called Project Maven, which has used AI algorithms to identify insurgent targets in Iraq and Syria" and which has been used to great effect in these efforts (CRN, 2020, p. 1). One of the greatest applications of AI technologies in augmenting American military capabilities thus far, however, is in the development of autonomous weapons platforms. Currently, all US military services are "working to incorporate AI into semiautonomous and autonomous vehicles, including fighter aircraft, drones, ground vehicles, and naval vessels" (CRN, 2020, p. 13). In the USAF Research Lab,

phase-two tests have been completed for its Loyal Wingman Program, which will see uninhabited fighter jets aid human pilots in the execution of operations (CRN, 2020, p. 13-14). The US Army and the USMC have made similar progress in AI integration, including the Marine Corps' continuing development of the remote-controlled Multi-Utility Tactical Transport and the Army's plans to "field a number of Robotic Combat Vehicles (RCVs) with different types of autonomous functionality, including navigation, surveillance, and IED removal" (CRN, 2020, p. 14). At the US Navy, the development of the Anti-Submarine Warfare Continuous Trail Unmanned Vessel, or "Sea Hunter," is currently underway and would "provide the Navy with the ability to autonomously navigate the open seas, swap out modular payloads, and coordinate missions with other unmanned vessels—all while providing continuous submarine-hunting coverage for months at a time" (CRN, 2020, p. 14). The final example that will be discussed here, although this is by no means a comprehensive list, is the US military's ongoing development of Lethal Autonomous Weapons Systems, or LAWS. These are a "special class of weapon systems that use sensor suites and computer algorithms to independently identify a target and employ an onboard weapon system to engage and destroy the target without manual human control of the system" (CRN, 2020, p. 15). Such systems would enable military operations under conditions that present-day personnel are unable to operate in, such as communications-denied environments. Overall, the US military possesses the most sophisticated array of military AI capabilities in the modern day, and the vast research and development ecosystem it has fostered makes it very likely that it will maintain its dominance in the medium to long term.

In terms of economic AI capabilities, the United States has seen the growth of a thriving private industry surrounding artificial intelligence development and implementation that—as will be discussed more in the advantages section of this paper—has been the primary contributor to

its broader success in the field. The United States has seen artificial intelligence systems deployed to enhance virtually every aspect of its domestic market, from the development of autonomous vehicles to the deployment of AI-powered algorithms in targeted advertisement. According to Paul Oh (2019), the American private sector has embraced AI with open arms, and has been greatly enhanced by it; indeed, he gives a few of countless examples when he writes that "The banking and financial industries are utilizing AI to provide virtual assistants to customers while identifying and eradicate fraud. The medical sector is using AI, like IBM Watson, to provide support to doctors by analyzing data to help identify evidence-based and personalized treatment options. And the insurance industry is looking to AI to improve claims processing via chatbots that use natural language processing and sentiment analysis for personalized service right on one's smartphone" (p. 3). Artificial intelligence is well on the way to becoming a fully integrated aspect of the American economy, and have been greatly leveraged to increase the American economic ecosystem and, by extension, the hard economic power of the United States. On these factors alone, it is clear that the United States maintains dominance in the economic spheres of AI development.

In terms of informational AI capabilities, the United States possesses an impressive array of technologies related to Big Data analytics and open-source intelligence processing that place it very close in terms of overall superiority to China's AI-powered surveillance state. The most important aspect of American informational AI capabilities, however, is the extensive adoption of the technology by the American intelligence community (IC). The IC has seen artificial intelligence utilized in a number of important roles. The Patrick Tucker (2021), American open-source intelligence collection has been enhanced as AI systems help to fille "a role that used to belong to human readers and translators at CIA's Open Source Center: combing through news

articles from around the world to monitor trends, geopolitical developments, and potential crises in real-time" (p. 3). Moreover, AI has also seen use by the National Geospatial-Intelligence Agency, or NGA, where it has been used to "notify sailors and mariners around the world about new threats, like pirates, or new navigation information that might change naval charts" (Tucker, 2021, p. 5). As one final example, the NSA has made extensive use of artificial intelligence in predictive threat analyses, in identifying vulnerabilities in systems that can be exploited to gather intelligence, in processing vast amounts of paperwork and other minute tasks in order to free up analysts, and even in monitoring the activity of NSA personnel to ensure compliance with the strict guidelines of collection that they follow (Tucker, 2021). Across the board, the IC has used artificial intelligence systems "like natural language processing and other AI tools to reduce the timelines reporting, and increase the volume of data" in order to create more accurate reports for their intelligence customers (Tucker, 2021, p 1-5). Overall, the American IC has gone to great lengths to integrate artificial intelligence systems into its everyday practices, and America's informational AI capabilities are all the stronger for this effort.

V. Chinese Artificial Intelligence Capabilities

This section will explore the artificial intelligence capabilities of China in the categories of military, economic, and informational superiority. The overall judgment made in this section is that the United States still greatly outpaces China in terms of artificial intelligence capabilities, though China possesses the world's most sophisticated array of artificial intelligence technologies otherwise. China has made great strides in closing the gap in AI development that has existed between it and the United States, but has not yet surpassed the US in terms of overall capabilities. Despite rapid progress, several key challenges remain for China's artificial intelligence program, which will be discussed later in this paper. These obstacles will question

whether or not China can maintain its current track and surpass the United States, which remains to be seen. Regardless, Chinese AI capabilities, though impressive in their own right, still have a long way to go before they can match those of the United States.

In terms of military AI capabilities, despite what on the surface seems to be similar levels of investment in AI-driven military systems, China is lagging behind the United States. At first glance, it would seem that China is keeping pace with America's military in the AI sphere due to the fact that each military spends similar amounts on AI development. According to Jon Harper (2022), "the US military and China's People's Liberation Army are both pursuing artificial intelligence capabilities which could give them a leg up in future conflicts. PLA investment in AI is now on par with the Pentagon's… analysts estimate that annual Chinese military spending on AI is in "the low billions" of U.S. dollars, a level of funding that is "on par" with Pentagon's investments" (p. 8). However, this raw data is quite misleading, and in fact conceals an important reality of China's military budget that hints at the truth of their military AI capabilities. While China has nearly matched American spending on military AI technology, the vast majority of this spending has gone into *research and development*, with only a small amount being spent on the production of AI systems. As Jon Harper (2022) points out, "laboratories affiliated with the Chinese military are actively pursuing AI-based target recognition and fire-control research, which may be used in lethal autonomous weapon systems… However, because it is still an emerging technology… more funding is captured in research and development rather than off-the-shelf technology procurement" (p. 4-7). This is not to say that Chinese military AI capabilities are entirely negligible—though lagging behind the United States, China's successes in AI development thus far have allowed it to amass a sophisticated military AI suite that is likely only second to that of the United States. In their 2021 study *Harnessed Lightning: How the*

Chinese Military is Adopting Artificial Intelligence, Ryan Fedasiuk et al. (2021) highlight the implementation of AI into the Chinese military when they write that the PLA has successful procured AI for "intelligence analysis, predictive maintenance, information warfare, and navigation and target recognition in autonomous vehicles" (p. 6). However, this *is* to say that the Chinese military has a quite a ways to go before it matches the military AI capabilities of the US military. Ryan Fedasiuk et al. (2021) also highlighted this fact in their study, stating that compared to the United States' own impressive investments, "AI so far only represents a small fraction of overall purchasing activity" for the PLA. Moreover, they highlighted that even the Chinese leadership is aware of this disparity, with the PLA hoping "to use AI to generate asymmetric advantages vis-à-vis the United States, which it regards as a "strong enemy" (强敌)" but which it still must look to as "a role model for AI development" (Fedasiuk, 2021, p. 9). Overall, while the sophistication of Chinese military AI capabilities are virtually unmatched by any other power and may present a challenge for the United States in the long term, they have yet to fully eclipse American capabilities.

In terms of economic AI capabilities, China's use of AI in the economic realm has so far manifested in their post-COVID economic recovery efforts as well as in preventative measures taken in order to preemptively confront the challenges that the economy will be facing in the coming decades. In this way, China's economic utilization of artificial intelligence has been much more reactive than that of the United States, whose own forward-facing and innovative approach to AI likely gives it the edge in the economic sector in at least the short term. However, this is not to say that China is underutilizing its AI resources in enhancing its economic capabilities. Quite the contrary, China's utilization of AI in recovery and economic future-proofing will likely allow the state to reap dividends in the future. Kai-Fu Lee (2021), the

chairman and CEO of Sinovation Ventures and author of *AI 2041: Ten Visions for Our Future*, provides some insight into China's usage of artificial intelligence when he writes that "The Chinese economic recovery from its short-lived pandemic blip has been boosted by its world-beating adoption of artificial intelligence (AI)… Commercial applications are flourishing: a new wave of automation and AI infusion is crashing across a swath of sectors, combining software, hardware and robotics" (p. 2). Chinese developers have deployed artificial intelligence systems across a broad range of industries, laying the groundwork for a diverse AI market as the technology continues to evolve. Kai-Fu Lee (2021) also provides some specific examples of industries that have already enjoyed the benefits of AI, which include, but are not limited to: the company XAG revolutionizing Chinese agriculture by "sending drones, robots and sensors to rice, wheat and cotton fields, automating seeding, pesticide spraying, crop development and weather monitoring"; MegaRobo making dangerous research and development work safer by designing "AI and robots to safely perform repetitive and precise laboratory work in universities, pharmaceutical companies and more, reducing to zero the infection risk to lab workers"; EP Equipment optimizing warehouse operations by launching "autonomous [forklift] models that are able to maneuver themselves in factories and on warehouse floors"; and Yutong Group, which has already brought autonomous transport to Chinese cities with the "driverless Mini Robobus… in partnership with autonomous vehicle unicorn WeRide" (p. 5-7). Overall, as Chinese industries face rising labor costs due to an oncoming population deficit, Chinese developers are deploying artificial intelligence to reduce operational costs, enhance efficiency and productivity, and generate revenue growth (Lee, 2021). Such intelligent use of this technology will stabilize the Chinese economy in the long term, and will provide the groundwork

for economic growth that will greatly increase China's geopolitical hard power in the coming decades,

In terms of informational AI capabilities, China is virtually tied with the United States thanks to its robust and sophisticated data-harvesting regime. China has significant capabilities in the sphere of AI-powered analytics, allowing mass-scale data harvesting not only domestically, but on a global scale (NSCAI, 2022). The nature of this data-harvesting network is pervasive and nearly inescapable for its residents, who are subject to state scrutiny due to their online activity. Cate Cadell (2021) touched on this aspect of China's informational AI capabilities when she wrote that "China maintains a countrywide network of government data surveillance services—called public opinion analysis software—that were developed over the past decade and are used domestically to warn officials of politically sensitive information online" (p. 2). China's informational AI capabilities are also capable of tapping into the data sources of the United States and the broader Western world, and have been used to create and process large databases of open-source information on Western targets. According to Cadell (2021), "…a $320,000 Chinese state media software program that mines Twitter and Facebook to create a database of foreign journalists and academics; a $216,000 Beijing police intelligence program that analyzes Western chatter on Hong Kong and Taiwan" (p. 5). The strength of these AI-powered analytic capabilities have also been leveraged against domestic targets, which Cate Cadell (2021) also speaks to when she highlights one example in the form of "a cybercenter in Xinjiang, home to most of China's Uyghur population, that catalogues the mainly Muslim minority group's language content abroad" (p. 5). Lastly, China has developed a number of practical-use technologies that have served in gathering vast amounts of highly-personalized and private data on its citizens for national security purposes. According to Zachary Arnold et al. (2021),

"security and biometrics applications such as facial recognition, which have obvious governmental uses, account for a larger share of private-market investment in China than elsewhere" (p. 10). Overall, China's *informational* AI capabilities are clearly its strongest, though it has primarily focused them inward. Though they have used this technology against Western targets for the purposes of data harvesting, it is clear that their strongest applications of this technology have been in the facilitation of domestic surveillance and control.

VI. United States Artificial Intelligence Development – Advantages and Constraints

In this section as well as the one that follows it, this paper will be discussing the present-day factors that are influencing the artificial intelligence capabilities of the United States and China. In order to understand the contemporary AI race environment, as well as the outlook for this competition going forward, it is essential to understand the underlying mechanisms responsible for characterizing the artificial intelligence industries in each nation. This section is particularly focused on the factors affecting American intelligence development in the United States, and will primarily be divided into two parts: advantages and constraints.

One of the greatest advantages that the United States possesses in the AI race is the sheer strength of its private technology sector. The American tech industry is virtually unmatched by any in the world, with the United States ranking second in terms of technological advancement in the World Population Review's 2021 aggregate ranking (WPR, 2022). American giants such as Google and IBM continue to pioneer new software and hardware solutions for the most pressing challenges in the field of artificial intelligence development. According to researchers at Statista, the artificial intelligence private sector in the United States dominates the global artificial intelligence market, with Statista reporting that "The United States leads in private investments for AI when compared with other regions around the world, especially considering that the top

three investors for AI investments in the world are U.S. companies, namely Intel Capital, 500 Startups, and Y Combinator. The U.S. dominance in AI investment contributes to its increased role in the global AI industry" (SRD, 2022, p. 3). Moreover, the success of the *major* US tech giants has had the effect of enabling smaller technology companies to build upon the systemic foundations that they have created. Namely, cloud services have been used by smaller businesses in their pursuit of artificial intelligence development, driving innovation on a massive scale. In his investigative reporting on this topic, Giacomo Lee (2021) wrote that "Amazon, Microsoft, Google and IBM are all leaders in their offerings of machine learning (ML) solutions via cloud services. ML systems can be costly to create in-house, especially as there is a skills shortage, so many businesses prefer to 'rent' ML, and other AI services, from the cloud" (p. 32). Below, this paper will discuss several of the major actors in the American tech sector that have played a key role in enabling the remarkable success of the American artificial intelligence industry.

A household name for many, the Nvidia Corporation has served as a cornerstone of the American artificial intelligence industry. Specializing in the production of high-end Graphics Processing Units (GPUs) for both entertainment and professional settings as well as highly-sophisticated "system on a chip" units often used in mobile devices and transportation, Nvidia's chipsets have served as the catalyst for numerous deep learning and machine learning systems. This is thanks to the unparalleled level of processing power in Nvidia-designed chipsets—Nvidia is thus far one of the only companies across the globe that has designed computer chips that can handle the processing demands of advanced AI systems. Stephen McBride (2020), the chief analyst at the disruption research firm RiskHedge, has gone so far as to claim that Nvidia's high-end chipsets have "powered nearly every major AI breakthrough" in the United States, that Nvidia's AI-capable chips are "lightyears ahead of the competition" abroad, and even that Nvidia

is “America’s most important company” thanks to its contributions to the artificial intelligence sector (p. 1-27). One specific example that McBride provides is Nvidia’s cutting-edge A-100 chip, designed specifically for use in artificial intelligence systems. McBride (2020) describes the processing power of the A-100, and in doing so speaks to the capabilities of Nvidia’s chips more generally, when he writes that “With more than 54 billion transistors, it’s the most powerful chip system ever created… just one A100 packs the same computing power as 300 data center servers. And it does it for one-tenth the cost, takes up one-sixtieth the space, and runs on one-twentieth the power consumption of a typical server room (p. 34). Overall, Nvidia has provided the American artificial intelligence industry with the raw processing power needed to embark on ambitious, cutting-edge forays into artificial intelligence innovation—such as machine learning algorithms, autonomous vehicles, supercomputing, and even deep learning and neural networking AI systems—and have enabled the United States to maintain a competitive edge in the AI race.

Another major contributor to the success of the American artificial intelligence industry is Microsoft, an American-based tech giant which primarily focuses on producing operating systems and other computer software, consumer electronics, personal computers, and other related web services. Microsoft has made several major contributions to artificial intelligence in the United States, but the most notable can be found in its cloud services. Microsoft has allowed numerous artificial intelligence developers access to its online resources for their own development. By working in tandem with these smaller businesses, Microsoft has enabled major steps forward in artificial intelligence innovation. Wayne Duggan (2022) touches on one of the most famous of these developments, as well as Microsoft’s broader contributions to American artificial intelligence development, when he writes that “In 2020, Microsoft announced the

construction of a new supercomputer hosted in Azure, Microsoft's cloud computing network. The supercomputer was built in collaboration with OpenAI LP to train AI models with the ultimate goal of producing large AI models and related infrastructure for other organizations and developers. In late 2021, Microsoft also debuted Context IQ, an AI application that can predict, seek and suggest information for employees" (p. 6). By allowing AI systems to be hosted on its cloud servers—one of the largest in the world—Microsoft mirrors Nvidia in providing an important foundation for innovation. As such, Microsoft is a key facilitator for the domestic development of cutting-edge AI technologies that give the United States an edge in the US-China AI race.

The International Business Machines Corporation, also known as IBM, is another contributor to the American artificial intelligence industry.IBM's business is primarily concerned with the production and sale of computer hardware and software. Like Microsoft, IBM provides a major cloud hosting service to artificial intelligence software developers. More than this, however, IBM is particularly notable for its *own* research into artificial intelligence; in fact, IBM is a major research and development center for computer systems, holding the record for most annual U.S. patents generated by a business for an unmatched 28 consecutive years as of 2020. (Bajpai, 2021). Perhaps the most relevant result of this impressive innovative track record is its famous work on the Watson AI supercomputing system. Tiziana Russo-Spena et al. (2018) provide a deeper look into the workings and capabilities of IBM's Watson system when they write that "IBM Watson is a cognitive, problem-solving supercomputer designed to help find answers and insights that are hidden in huge volumes of data. Watson can understand all forms of data, interact naturally with people, and learn and reason at scale… Watson can read, analyse and learn from natural language, just as humans, and it makes informed, context-specific

decisions as it is expected from a person, as opposed to an unintelligent search engine" (p. 23). With one of the most sophisticated AI systems in the modern world, IBM serves as a trailblazer for innovation in the American artificial intelligence industry. IBM Watson is in many ways exemplary of the successes seen in American artificial intelligence, and contributes a great deal of insight regarding both the capabilities and demands of advanced AI systems that the rest of the domestic artificial intelligence industry can use as a guiding star for future development.

Alphabet, Inc, more widely known as the parent company of both YouTube and Google, is a constant driver of artificial intelligence innovation. This is because Alphabet has incorporated artificial intelligence into every aspect of its business model, and in doing so has pioneered investment and development in the industry. In particular, it has made extensive use of "Big Data"-related artificial intelligence systems—that is, it has made significant use of AI algorithms to process vast amounts of data in order to fine-tune its operations and optimize its revenue streams. Duggan (2022) delves into this aspect of Alphabet's AI contributions when he writes that "Google and YouTube parent company Alphabet uses AI and automation in virtually every facet of its business, from ad pricing to content promotion to email spam filters… Alphabet has AI and machine learning advantages across its product range, and AI could help the company further fine-tune its industry-leading online advertising business over time" (p. 3). Alphabet has thus made enormous contributions to the American artificial intelligence industry in terms of its economic capabilities, paving the way for significant advancements in targeted advertising and other forms of online content promotion that have formed the bedrock of the modern online ecosystem. Moreover, Alphabet has made minor contributions to other aspects of the artificial intelligence field; namely, in the development of autonomous vehicle technologies that are revolutionizing American public transport. According to Duggan, Alphabet is also

"Google is also the parent of autonomous vehicle company Waymo LLC, which made history by launching the first fully driverless commercial taxi service on public roads in 2020" (p. 3). Undoubtedly, Alphabet's research and development into both data-processing and autonomous vehicle applications for the AI systems have not only contributed to the strength of America's domestic AI industry, but also the United States' broader competitive edge in the economic aspects of the AI race.

Like Alphabet, Meta Platforms, is one of the primary pioneers of the Big Data AI industry. The parent company of Facebook, Instagram, and WhatsApp, Meta Platforms has already gone to great lengths in developing highly-complex AI algorithms for use in its news feed and advertising systems. Moreover, Meta Platforms has followed in the footsteps of IBM in its development of supercomputing systems; namely, the AI Research SuperCluster (RSC), which is "among the fastest AI supercomputers running today and will be the fastest in the world once fully built out in mid-2022… [it] can currently perform tasks like translating text between languages and helping identify potentially harmful content" (Meta, 2022, p. 1). More than just marking an important step forward in Meta Platform's own artificial intelligence program, however, this supercomputing system promises to be the catalyst for future developments across the broader American intelligence industry. Meta Platforms expressed its wishes for the power of the AI Research SuperCluster to be utilized in the furtherance of artificial intelligence research, saying that "the next generation of AI will require powerful supercomputers capable of quintillions of operations per second… RSC will help Meta's AI researchers build better AI models that can learn from trillions of examples; work across hundreds of different languages; seamlessly analyze text, images and video together; develop new augmented reality tools and more" (Meta, 2022, p. 2). Lastly, Meta Platforms is utilizing artificial intelligence to pave the

way for the development of a brand-new online ecosystem the likes of which the world has never seen: the metaverse. Described as the next evolution of social connection in which digital 3D spaces will enable users to socialize, learn, and collaborate, the development of the metaverse will be a milestone in the development of artificial intelligence technology and a manifestation of American private industry's mastery of this new field of technological development (Meta, 2022). Meta Platforms expresses its intent that ultimately, "the work done with RSC will pave the way toward building technologies for the next major computing platform—the metaverse, where AI-driven applications and products will play an important role" (Meta, 2022, p. 2). The innovation seen in Meta Platform's artificial intelligence and broader computing program is therefore significant to the American artificial intelligence industry for its mindful development of current technologies that will make an exponential contribution to the developmental capabilities of the industry in the long term.

The last major contributor to the American artificial intelligence industry that will be discussed here is Amazon, another American tech giant focused on e-commerce, cloud computing, digital streaming, and artificial intelligence. According to James Jacoby et al. (2020), Amazon is "a business empire that is without precedent in the history of American capitalism" with an unrivaled power to "to shape everything from the future of work to the future of commerce to the future of technology" (p. 1). Amazon has leveraged this economic power to become one of the foremost private research organizations in the development of artificial intelligence systems, and has since become deeply familiar with the development, integration, and proliferation of the technology. According to Blake Morgan (2021), Amazon "keeps AI innovation humming along and encourages energy and knowledge to spread… Amazon acts as a catalyst for AI and machine learning growth in other areas… The company was one of the first

to use the technology… [AI is] a central stone at the summit of the company, connecting the organization together" (p. 4). Like Microsoft and IBM, Amazon is significant for its provision of cloud computing in the form of Amazon Web Services (AWS), providing a final piece of the foundation that the American artificial intelligence industry stands upon. Data scientist and statistician Varishu Pant (2020) reported on the contributions of AWS to the broader development of AI in the United States, writing that "AWS has made AI tools broadly available so that businesses can innovate and improve their products. Amazon Web Services offers a range of services in AI by leveraging Amazon's internal experience with AI and machine learning. These services are separated here according to four layers: AI services, AI platforms, AI frameworks, and AI infrastructure (p. 2). At the forefront of American artificial intelligence development, Amazon has introduced AI systems to the mainstream American economy: the Alexa, the Amazon Go Store, and the Amazon recommendation aspects have become touchstones of everyday life. Moreover, AWS is paving the way for a wide range of AI development by smaller firms, allowing the American artificial intelligence industry to flourish in the way that it has. Amazon is clearly one of the greatest contributors to American success in the field.

In addition to major technology firms, the American artificial intelligence industry has also enjoyed a significant amount of stimulation from a rich variety of startups and individual entrepreneurs. Indeed, the United States is unique in the world for its prominent AI entrepreneurialism. Castro and McLaughlin (2021) report that in 2019, the United States had "an unmatched number of AI start-ups, which received $8 billion more in venture capital and private equity funding than did China" speaking to the strength of this growing industry (p. 6). This smaller-scale tech industry has made a number of significant contributions to the American

success in the artificial intelligence field. Notable AI startups in the United States include, but are not limited to: Cruise Automation, Waymo, Argo AI, Nuro, and Pony.ai, which have together made significant developments in autopilot systems for personal vehicles; SambaNova, which seeks to facilitate the integration of machine learning into data analytics platforms; DataRobot, which has employed automated machine learning in order to build comprehensive and effective predictive models; Olive, which utilizes artificial intelligence to automate and optimize minute tasks of healthcare organizations; Zymergen, which has used machine learning to discover and engineer novel molecular products for the creation of new and useful materials; and OpenAI, a research and development company primarily concerned with facilitating communication and fostering growth across the American artificial intelligence industry (AISO, 2022). Overall, these smaller companies are a unique and important facet of America's current dominance in the field of artificial intelligence.

Aside from the strength of the American private sector, another key aspect driving American success in the realm of artificial intelligence is its unique degree of access to critical technologies necessary for artificial intelligence development. On February 8, 2022, the National Science and Technology Council named a number of technologies that were critical to artificial intelligence development, including "semiconductors and microelectronics" which serve as specialized/tailored hardware components for artificial intelligence" (FTASCET, 2022). In addition to the advantage afforded to the US by the presence of Nvidia and its sophisticated chip designs, American access to these critical AI technologies is also enabled by its close relationship with Taiwan. This is because Taiwanese manufacturers are not only essential in producing the cutting-edge chipsets that Nvidia designs, but are also key suppliers of the high-powered semiconductors and other microelectronics that are essential hardware in the

development of advanced computing and artificial intelligence systems. The most prominent example of this comes in the form of the Taiwan Semiconductor Manufacturing Company, or TSMC. TSMC is the pinnacle of Taiwan's electronics industry, TSMC is world-renowned—it possesses the world's largest dedicated semiconductor foundry, and it has been described as the world's most valuable semiconductor manufacturer. (Nellis and Shepardson, 2020; IC Insights, 2018). Foreign partnerships with nations like Taiwan have thus given the United States a significant advantage in the artificial intelligence industry.

Though the private AI sector has flourished well on its own, it has nonetheless been constrained by a lack of direct government involvement. Indeed, the United States has taken a relatively laissez-faire approach to the artificial intelligence industry, allowing efforts furthering the development of AI systems to succeed or fail on their own merits and circumstances alone. Moreover, the US government has been slow to adopt the AI systems that have been developed, leaving little incentive for domestic AI companies to develop technologies that would directly serve America's national security interests. Jamie Berryhill et al. (2019) speak to this fact when they say that "While the potential benefits of AI are significant, attaining them is not an easy task. Government use of AI trails that of the private sector" (p. 2). In essence, the American AI industry is driven entirely by market forces, and thus cannot always be utilized effectively in the pursuit of American national security goals. It is due to this lack of support or incentivization that, according to Zachary Arnold et al. (2021), that "National security applications attract little direct private-market investment. While many AI technologies might be *adapted* for government use, just a tiny percentage of all AI companies receiving investment make products designed *specifically* for government and military use [my emphasis]" (p. 10). At a time when it is clear that artificial intelligence superiority is the key to success in the geopolitical arena and security at

home, it is incredibly strange that there is such a dearth of sponsorship for domestic AI development programs. If the United States wants to be able to effectively capitalize on the strength of its domestic AI industry in the pursuit of its national objectives, it will need to take a more active role in directing, financing, and incentivizing its private actors to produce technologies that are directly useful in these roles.

Another constraint on the United States' artificial intelligence development is, in contrast with the US-Taiwanese partnership, a severe *lack* of cooperation with the world's third-largest AI powerhouse and an otherwise close American connection: the European Union. Whereas the United States and the European Union are closely aligned in the political and economic arena, there has been virtually no cooperation between the two powers in terms of matching or opposing Chinese gains in the AI race (Klotsonis and Echikson, 2022). As Tony Samp (2021) notes, "The US and the EU, together home to 780 million people, have not always been completely in synch in their… approaches to AI" (p. 13). This division will seriously hamper both the American and the European ability to maintain prominence in the AI race in the coming decades, potentially allowing the Chinese program to eclipse them both. As Klotsonis and Echikson (2022) state, "Without a transatlantic partnership, China and Russia will face little opposition… US inaction risks undermining its global influence" (p. 11). Failing to achieve such a partnership will undoubtedly limit the United States' artificial intelligence industry's potential for growth in the medium and long term.

VII. Chinese Artificial Intelligence Development – Advantages and Constraints

The greatest advantage that the Chinese artificial intelligence industry has at its disposal is the state-sponsorship that its domestic developers enjoy. Chinese leadership, recognizing that artificial intelligence is a policy imperative on the road to geopolitical hegemony, has poured

exorbitant resources into stimulating their domestic artificial intelligence sector. According to Shriram Ramanathan (2019), "China's rapid rise in artificial intelligence has been largely driven by its government's ambition to become the global leader in AI. To achieve this goal, the Chinese government has adopted a series of policies to support the development and adoption of AI" (p. 4). The two most important of these policies include what is known as the "Next Generation AI Development Plan," and the "AI Three-Year Action Plan 2018-2020," policies which established China's roadmap to achieve global AI leadership by 2030 and which outlined the country's 2020 AI development goals, respectively (Ramanathan, 2019). These policies have seen a great deal of success in fostering the innovation and commercialization of AI technologies in the Chinese market (Ramanathan, 2019). Moreover, these policy imperatives have translated into successful initiatives and tangible benefits for artificial intelligence developers. Ramanathan delves further into this and provides several examples of the tangible results of Chinese policy when he writes that "the Chinese government has successfully put these policies and associated funding into place by establishing science parks, development zones, and incubators" (p. 4). The Chinese military has been a particularly generous state sponsor of domestic artificial intelligence development. This is due to their most recent adoption of a new military doctrine around which they plan to organize their military operations in the near future: the doctrine of *intelligent warfare*. Within the framework of the intelligent warfare doctrine, the PLA is driven by a rationale that sees the next military revolution as fundamentally resting on the creation of military forces dominated by AI and autonomy (Pollpeter and Kerrigan, 2021). This government emphasis on intelligent warfare has resulted in a significant amount of military investment in the development of AI systems to be directed in support of military-applicable R&D (Pollpeter and

Kerrigan, 2021). Overall, the roots of China's successful ascendancy in the AI realm can be traced back to an unmatched foundation of state support for the field.

In addition to the active contributions of government sponsorship, Chinese AI development has been augmented by the lack of an extensive civil liberties regime that is commonly found in the United States and other democratic nations. As Michael Wade and Amanda Bris (2018) put it, China has "relatively few privacy protection laws, providing the government with extensive access to consumer data, a key to AI development" (p. 3). While civil liberties may provide a barrier to artificial intelligence development in democratic nations, Chinese AI development has been able to thrive unstifled by such constraints. Moreover, this Big Brother approach means that Chinese leadership is able to utilize developed technologies without concern for ethical considerations, which has allowed China "to rapidly adopt AI technologies for applications such as traffic management, people tracking, and public security thereby accelerating the commercialization of AI technologies; now, many of these AI technologies have also started percolating other spheres such as social and economic welfare, and education" (Ramanathan, 2019, p. 6). Altogether, this means that Chinese artificial intelligence companies are able to proceed from research and development to mass-scale implementation and impact research much faster than their foreign counterparts. This has no doubt given the Chinese AI industry an edge in the global competition.

While there are a number of factors that have contributed to the rapid success of the Chinese artificial intelligence program, China faces a number of challenges and constraints to the future growth of its domestic AI industry that could prove to be even more significant in the long term. The first of these is a severe lack of innovative talent. While Chinese technical expertise largely matches that of American developers, there are several studies that point to stifled

creativity. According to Wade and Bris (2018), “Chinese students at top-ranked institutions were less creative than those at less prestigious institutions. Once they enter the workforce, these graduates struggle to step out of their disciplined and rigidly structured environment. As a consequence, they tend to produce superficial, mechanical innovations that require little imagination” (p. 8). As a result, China has been forced to rely on expertise from abroad. This dependency is also best articulated by Wade and Bris (2018), who write that “China has been importing its AI talent from overseas. According to LinkedIn’s Global AI Talent report published in July 2017, 44% of the overseas AI talent working in China comes from the US, followed by the UK and France as the second and third source countries. Roughly 90% of AI positions advertised in Mainland China go unfilled unless companies offer them to overseas workers” (p. 7). This overreliance on foreign talent, to the degree that China has gone to great lengths to drain the innovative talent of its competitors to fuel its own development programs, hints at deeper problems—a large gap between available expertise and Chinese demand for it (Webster et al., 2017). A lack of domestic talent is likely unhealthy, or even untenable, for the growth of the Chinese artificial intelligence industry in the long term.

The greatest challenge for China, however, will come in its severe lack of access to the critical technologies that have driven the American artificial intelligence industry. Without companies such as Nvidia or TSMC creating high-powered chips for use in supercomputing, the Chinese AI industry is facing physical capability barriers in the form of hardware limitations that threaten to cap the potential of Chinese AI developers. Webster et al. (2017) speak to this fact, writing that China has “lagged in critical components, such as high-performance chips for machine learning” (p. 20). As a result of these physical limitations, China is left dependent on the American technology sector for access to these critical technologies. This dependency speaks

to a larger imbalance between the American and Chinese AI programs, and shifts the entire AI race starkly in the favor of American developers. Castro and McLaughlin (2021) touch upon this imbalance and China's failed attempts to alleviate it, writing that "despite China's growing attempts to reduce its reliance on U.S. semiconductors, the United States is still the world leader in designing chips for AI systems" (p. 6). This imbalance has resulted in tangible foreign policy outcomes that have highlighted the disastrous impact of dependency on the broader Chinese AI industry. Elsa Kania (2018) highlights one case in which the Chinese tech sector was left essentially at the mercy of American policy thanks to this advantage in access to critical technologies, when she writes that "in response to a violation of sanctions by telecommunications company ZTE, the US introduced a temporary ban to prevent [China] from buying American technology. The move brought ZTE to the brink of collapse. This was a harsh awakening at a time when enthusiasm about the Made in China 2025 innovation plan was reaching a new peak. It also highlighted how the US might deny China the technology it needs, especially given the backdrop of a new era of confrontation and a potential decoupling in the bilateral relationship" (p. 8). Lack of access to critical technologies leaves the Chinese artificial intelligence industry at a stark disadvantage. This imbalance results in China simultaneously lacking the high-powered components it needs for further development while also being reliant on and subject to the United States with regard to the technologies it does have access to. If China cannot achieve critical technology independence, the long-term prospects of it winning the AI race against the United States are grim.

VIII. Analysis and Outlook

Overall, the key to American success lies in its private industries and its partnerships abroad, although there is much more that the United States could do in order to solidify its lead

in the US-China AI race. There is a severe lack of government support for the artificial intelligence industry in the US when compared to China, in spite of the fact that such support could serve to stimulate an already powerful private tech sector. In terms of international partnerships, although the current level of integration between the American and Taiwanese tech sectors has been a boon for the American artificial intelligence industry, there remains a great deal of untapped potential in the tech markets of America's other close political allies; namely, the EU. In China's case, though the early successes of the Chinese artificial intelligence program are unquestionably impressive, they are not necessarily indicative of a trend that will continue into the future. China still has many challenges and obstacles to overcome, and this makes it difficult to suggest unequivocally that China will continue to see the same type of artificial intelligence growth that it has seen in the past few years continue in the long term.

Nonetheless, the growing strength of Chinese artificial intelligence capabilities, the sprawling nature of the American cyber, online, and artificial intelligence ecosystem, and the drive of Chinese leadership to achieve artificial intelligence superiority means that AI development will be the battleground on which the US must contend with Chinese competition for the foreseeable future. As Ryan Fedasiuk et al. (2021) put it plainly: "Chinese leaders view AI as the key to transforming the PLA into a "world-class," globally competitive military force. PLA advances in AI and autonomy will create new vulnerabilities for the United States" (p. 8). China's pursuit of this national interest in the geopolitical competition means that China has reason to threaten US AI dominance, and by extension, its national security and geopolitical hegemony. It is therefore imperative that the US not only take steps to maintain its current superiority in all three categories of the AI race, but also to maximize its lead over China to the greatest possible degree. With this in mind, one question remains: what actions should

policymakers and other aspects of American leadership take in order to navigate this turbulent era of technological development? In this closing section, this paper will discuss potential policy directions that the United States could implement in order to safeguard its national interests and national security as the AI-defined geopolitical environment continues to evolve.

First and foremost, it is clear that the United States must seek to solidify its artificial intelligence partnerships with its allies abroad. In this, maintaining a close relationship with a secure Taiwan is of the utmost importance. China has in recent years taken an increasingly threatening stance towards Taiwanese sovereignty, and this has only further been emboldened by Taiwan's role as a cornerstone of American AI superiority. The United States must take actions to defend the sovereignty of Taiwan at all costs, as well as to maintain its direct access to a Taiwanese tech market that China sorely lacks. Moreover, the United States should seek to bring the European Union into the fold. There is certainly a willingness to cooperate on both sides of a potential US-EU partnership. According to Klotsonis and Echikson (2022), "the EU and US agree on the need to cooperate on AI regulation and offer alternatives to China's authoritarian model" (p. 1). Moreover, September 2021 saw the United States and the European Union agree on "a series of 'common principles' regarding artificial intelligence (AI), semiconductor chip shortages, and a range of investment and competition issues during the inaugural Trade and Technology Council (TTC)… TTC is a new forum, launched by American and European leaders… designed to deepen economic ties, coordinate digital policy, and ensure that disputes are resolved swiftly" (Samp, 2021, p. 1-2). While these are steps in the correct direction, this paper posits that these steps do not go far enough. The United States and the European Union must do more than simply align on matters of normative policy. The two powers *must* take steps to integrate and collaborate in the research and development of artificial intelligence

technologies if they wish the Western world to maintain its competitive advantage in the A unified US-EU AI tech bloc would vastly outperform the Chinese tech market in terms of investment and innovation, and would allow the cooperative and creative spirit of the American private tech sector to proliferate on an international scale. Klotsonis and Echikson (2022) put it best when they said that "A deal is possible. The US needs partners… if democracies fight over AI, the ultimate winner risks being China" (p. 14). International cooperation on AI should be a key consideration for American policymakers in the coming decades.

Moreover, it is imperative that the US takes steps to facilitate growth in its powerful domestic artificial intelligence development industry. If the United States wishes to maintain its edge in the AI race, policies of government sponsorship in furtherance of domestic AI development should be taken into close consideration. Up to this point, the United States has taken a laissez-faire approach to its own artificial intelligence development industry, allowing development to arise as a product of market forces and demand for highly advanced technologies. However, the case of China has demonstrated that even in an environment where artificial intelligence technologies are in extremely high demand, there is still *much* to be gained from government sponsorship of artificial intelligence development firms. Simply put, China has demonstrated that government stimulation of the artificial intelligence industry *works*. While one may, under usual circumstances, be hesitant to take policy lessons from Beijing, the results of their "intelligencization" programs are undeniable—the leap that the Chinese state has seen in its artificial intelligence capabilities in the past few years is an impressive and unprecedented feat. The United States has already taken some steps in this direction, showing that the capability and inclination to implement such policies does exist. In June 2021, the White House Office of Science and Technology Policy (OSTP) and the National Science Foundation (NSF) announced

a “newly formed National Artificial Intelligence (AI) Research Resource Task Force which will write the road map for expanding access to critical resources and educational tools that will spur AI innovation and economic prosperity nationwide” (WHP, 2021, p. 1). If the United States wishes to do more than just maintain *any* edge, but instead wishes to regain its status as the unquestioned world leader in artificial intelligence in this age where AI development is the key to geopolitical dominance and security at home and abroad, there should be great consideration paid to policies that would incentivize and reward innovation in the domestic artificial intelligence industry.

IX. Conclusion

Overall, it is clear that the AI race between the United States and China will be the defining competition of the 21st century. Thus, it is imperative that *winning* the AI race becomes a cornerstone of American policy. The AI race is not a forgone conclusion, as some even within US defense circles have believed it to be. Though there is certainly much to be said about the progress that China has made in the past few years, it is important to recognize that it has essentially been playing catch-up to a well-established American industry. While the AI revolution in the Western world seems to parallel the technological breakthrough of the Industrial Revolution, the success of the Chinese artificial intelligence program is instead much more akin to the Great Leap Forward—an attempt to achieve parity at all costs, but failing to advance beyond that. What will ultimately become of the Chinese bid for AI supremacy will depend on whether or not the Chinese leadership can find ways to overcome the difficult challenges they will face in the near future, as well as how the United States chooses to respond.

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