The Scholar

Texas National Security Review: Volume 1, Issue 3 (May 2018)
Print: ISSN 2576-1021 Online: ISSN 2576-1153

Artificial Intelligence, International Competition, and the Balance of Power

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World leaders, CEOs, and academics have suggested that a revolution in artificial intelligence is upon us. Are they right, and what will advances in artificial intelligence mean for international competition and the balance of power? This article evaluates how developments in artificial intelligence (AI) — advanced, narrow applications in particular — are poised to influence military power and international politics. It describes how AI more closely resembles "enabling" technologies such as the combustion engine or electricity than a specific weapon. AI's still-emerging developments make it harder to assess than many technological changes, especially since many of the organizational decisions about the adoption and uses of new technology that generally shape the impact of that technology are in their infancy. The article then explores the possibility that key drivers of AI development in the private sector could cause the rapid diffusion of military applications of AI, limiting first-mover advantages for innovators. Alternatively, given uncertainty about the technological trajectory of AI, it is also possible that military uses of AI will be harder to develop based on private-sector AI technologies than many expect, generating more potential first-mover advantages for existing powers such as China and the United States, as well as larger consequences for relative power if a country fails to adapt. Finally, the article discusses the extent to which U.S. military rhetoric about the importance of AI matches the reality of U.S. investments.

In early September 2017, Russian President Vladimir Putin brought artificial intelligence from the labs of Silicon Valley, academia, and the basement of the Pentagon to the forefront of international politics. "Artificial intelligence is the future, not only for Russia, but for all humankind," he said. "It comes with colossal opportunities, but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become the ruler of the world."[1]

Putin's remarks reflect a belief, growing in sectors and regions across the world, that advances in artificial intelligence will be critical for the future — in areas as varied as work, society, and military power. Artificial intelligence is a critical element of what Klaus Schwab, head of the World Economic Forum, calls the Fourth Industrial Revolution.[2] Eric Schmidt, the former CEO of Google, argues that artificial intelligence is so important to the future of power that the United States needs a national strategy on artificial intelligence, just as it had one for the development of space technology during the Cold War.[3] Elon Musk, the head of Tesla and SpaceX, has even said that growth in artificial intelligence technology, left unchecked, could risk sparking World War III.[4] These statements suggest that artificial intelligence will have a large and potentially deterministic influence on global politics and the balance of power.[5]

Whether artificial intelligence has revolutionary consequences or merely incremental effects, it is critical to grasp how and why it could matter in the national security arena. Despite a wave of articles about artificial intelligence in the popular press and trade journals, there has been less in the way of systematic academic work on the national security consequences of such developments. This article attempts to fill that gap by examining the effects on national security of narrow artificial intelligence, or systems designed to do deliberately constrained tasks, such as the Jeopardy-playing version of IBM's Watson or AlphaGo, designed to play the board game Go. Specifically, it assesses the issues AI stands to raise for the balance of power and international competition through the lens of academic research on military innovation, technological change, and international politics.

Popular writing on AI tends to focus almost exclusively on technology development. Technology has played a vital role in shaping global politics throughout history.[6] Hundreds of years ago, technologies such as the printing press allowed the written word to flourish. These set the stage for new forms of political protest and activity.[7] In the 20th century, nuclear weapons significantly increased the destructive capabilities of numerous countries.[8]

Yet the relative impact of technological change often depends as much or more on how people, organizations, and societies adopt and utilize technologies as it does on the raw characteristics of the technology.[9] Consider the aircraft carrier, which the British Navy invented in 1918. As the best in the world at using battleships, the Royal Navy initially imagined the utility of aircraft carriers as providing airplanes to serve as spotters for the battleship. The Japanese and U.S. navies, however, innovated by using the aircraft carrier as a mobile airfield, fundamentally transforming naval warfare in the 20th century.[10] Or, consider the printing press again: Its role in accelerating nationalist political movements depended on the incentives that originally motivated those movements and the movements' ability to take advantage of the new

1 James Vincent, "Putin Says the Nation That Leads in AI 'Will Be the Ruler of the World,'" *Verge*, Sept. 4, 2017, https://www.theverge.com/2017/9/4/16251226/russia-ai-putin-rule-the-world.

2 Klaus Schwab, *The Fourth Industrial Revolution* (New York: Crown Business, 2017).

3 Colin Clark, "Our Artificial Intelligence 'Sputnik Moment' Is Now: Eric Schmidt & Bob Work," *Breaking Defense*, Nov. 1, 2017, https://breakingdefense.com/2017/2011/our-artificial-intelligence-sputnik-moment-is-now-eric-schmidt-bob-work/.

4 Seth Fiegerman, "Elon Musk Predicts World War III," *CNN*, Sept. 4, 2017, http://money.cnn.com/2017/09/04/technology/culture/elon-musk-ai-world-war/index.html.

5 On technological determinism, see Merritt R. Smith and Leo Marx, *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press, 1994).

6 William H. McNeill, *The Pursuit of Power: Technology, Armed Force, and Society Since A.D. 1000* (Chicago: University of Chicago Press, 1982).

7 Jeremiah E. Dittmar, "Information Technology and Economic Change: The Impact of the Printing Press," *Quarterly Journal of Economics* 126, no. 3 (August 2011): 1133-1172, https://doi.org/10.1093/qje/qjr035.

8 Robert Jervis, *The Meaning of the Nuclear Revolution: Statecraft and the Prospect of Armageddon* (Ithaca, NY: Cornell University Press, 1989).

9 In the military dimension, see Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton, NJ: Princeton University Press, 2010). For a critique of technology-focused thinking about the future of war, see Paul K. Van Riper and Frank G. Hoffman, "Pursuing the Real Revolution in Military Affairs: Exploiting Knowledge-Based Warfare," *National Security Studies Quarterly* 4, no. 3 (1998): 4; H.R. McMaster, "Continuity and Change: The Army Operating Concept and Clear Thinking About Future War," *Military Review* (2015), https://www.westpoint.edu/scusa/SiteAssets/SitePages/Keynote Speakers/Continuity and Change by LTG McMaster.pdf.

10 Clark G. Reynolds, *The Fast Carriers; The Forging of an Air Navy*, 1st ed. (New York: McGraw-Hill, 1968); Mark R. Peattie, *Sunburst: The Rise of Japanese Naval Air Power, 1909-1941* (Annapolis, MD: Naval Institute Press, 2001).

technology's capability to spread information.[11]

What role will artificial intelligence play? In many ways it is too soon to tell, given uncertainty about the development of the technology. But AI seems much more akin to the internal combustion engine or electricity than a weapon. It is an enabler, a general-purpose technology with a multitude of applications. That makes AI different from, and broader than, a missile, a submarine, or a tank.

Advances in narrow AI could create challenges as well as opportunities for governments and military organizations. For example, narrow AI applications such as image recognition would help those militaries that are already wealthy and powerful and that can afford to keep up. It is harder to predict how AI applications could affect the heart of military organizations, influencing planning as well as questions of recruiting, retention, and force structure. What happens as militaries increasingly need soldiers who have training in coding and who understand how algorithms work? Or if swarming, uninhabited systems make large conventional military platforms seem costly and obsolete? Leading militaries often struggle in the face of organizationally disruptive innovations because it is hard to make the bureaucratic case for change when a military perceives itself as already leading.

What countries benefit from AI will depend in part on where militarily-relevant innovations come from. Non-military institutions, such as private companies and academic departments, are pushing the boundaries of what is possible in the realm of artificial intelligence. While some AI and robotics companies, such as Boston Dynamics, receive military research and development funding, others, such as DeepMind, do not, and actively reject engaging with military organizations.[12] Unlike stealth technology, which has a fundamentally military purpose, artificial intelligence has uses as varied as shopping, agriculture, and stock trading.

If commercially-driven AI continues to fuel innovation, and the types of algorithms militaries might one day use are closely related to civilian applications, advances in AI are likely to diffuse more rapidly to militaries around the world. AI competition could feature actors across the globe developing AI capabilities, much like late-19th-century competition in steel and chemicals. The potential for diffusion would make it more difficult to maintain "first-mover advantages" in applications of narrow AI. This could change the balance of power, narrowing the gap in military capabilities not only between the United States and China but between others as well.

Experts disagree about the potential trajectory of the technology, however, which means that forecasts of the consequences of AI developments for the international security environment are necessarily tentative.[13] While the basic science underlying AI is applicable to both civilian and military purposes, it is plausible that the most important specific military uses of AI will not be dual use. Technological advances that are more exclusively based in military research are generally harder to mimic. It follows that military applications of AI based more exclusively in defense research will then generate larger first-mover advantages for early adopters. Moreover, if the computational power necessary to generate new, powerful algorithms prices out all but the wealthiest companies and countries, higher-end AI capabilities could help the rich get richer from a balance-of-power perspective. On the other hand, if leading militaries fail to effectively incorporate AI, the potential for disruption would also be larger.

This article defines artificial intelligence and examines what kind of technology AI is. It then turns to key questions and assumptions about the trajectory of narrow AI development that will influence potential adoption requirements for military applications of AI, a factor critical to shaping AI's influence on the balance of power. The paper then assesses how narrow artificial intelligence will affect the balance of power in a

AI seems much more akin to the internal combustion engine or electricity than a weapon.

11 Marshall McLuhan, *The Gutenberg Galaxy: The Making of Typographic Man* (Toronto: University of Toronto Press, 1962).

12 Clemency Burton-Hill, "The Superhero of Artificial Intelligence: Can This Genius Keep It in Check?" *Guardian*, Feb. 16, 2016, https://www.theguardian.com/technology/2016/feb/16/demis-hassabis-artificial-intelligence-deepmind-alphago.

13 Katja Grace et al., "When Will AI Exceed Human Performance? Evidence from AI Experts," arXiv (May 2017), https://arxiv.org/abs/1705.08807.

world where dual-use AI has great military relevance and diffuses rapidly as well as a scenario in which military AI developments are more "excludable," limiting diffusion and generating more first-mover advantages.

How all this will play out over the next decade or more is unclear. Already, China, Russia, and others are investing significantly in AI to increase their relative military capabilities with an eye toward reshaping the balance of power. As the field of AI matures, and more implementations become plausible in arenas such as logistics, personnel, and even deployable units, countries will need to figure out how to use AI in practical ways that improve their ability to generate military power. The risk for the United States in terms of balance of power thus lies in taking its military superiority for granted and ending up like Great Britain's Royal Navy with the aircraft carrier in the mid-20th century — a technological innovator that is surpassed when it comes to organizational adoption and use of the technology.

What Is Artificial Intelligence?

What is artificial intelligence? There is no broad consensus on the specific meanings of terms such as artificial intelligence, autonomy, and automation. For the purposes of this article, artificial intelligence refers to the use of computers to simulate the behavior of humans that requires intelligence.[14] Put another way, AI can be thought of as the ability of an artificial agent to achieve goals in a "wide range of environments."[15] A system with artificial intelligence is distinct from a robot or robotic system, which can be remotely piloted or autonomous.[16] For example, the Boston Dynamics SpotMini, which can open a door, is remotely piloted by a human operator so would not qualify as AI.[17] *Automatic* systems, such as a toaster in the civilian world or, to use a military example, an explosive triggered by a tripwire, respond mechanistically to environmental inputs.[18] *Automated* systems, by contrast, operate based on multiple pre-programmed logic steps as opposed to the simplicity of a tripwire.[19] *Autonomous* systems have more latitude and are programmed, within constraints, to achieve goals, optimizing along a set of parameters.[20]

There are two main approaches to AI, broadly conceived. The first is symbolic artificial intelligence — the creation of expert systems and production rules to allow a machine to deduce behavioral pathways. IBM's Deep Blue, which defeated Garry Kasparov in chess in 1997, used a symbolic approach.[21] Computational, or connectionist, approaches to artificial intelligence, in contrast, typically attempt to allow for problem recognition and action by machines through calculations rather than symbolic representation.[22] Machine learning represents a key computational approach to artificial intelligence. Multiple computational techniques are used to create machine-learning algorithms, including Bayesian networks, decision trees, and deep learning. Deep learning, now popularly associated with artificial intelligence, is a technique that harnesses neural networks to train algorithms to do specified tasks, such as image recognition.[23] Some researchers are pursuing hybrid approaches that integrate both symbolic and computational approaches to AI. The

14 This is based on the Russell and Norvig definition that artificial intelligence is about the construction of artificial rational agents that can perceive and act. See Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed. (Englewood Cliffs, NJ: Prentice Hall, 2009). Also see Calum McClelland, "The Difference Between Artificial Intelligence, Machine Learning, and Deep Learning," *Medium*, Dec. 4, 2017, https://medium.com/iotforall/the-difference-between-artificial-intelligence-machine-learning-and-deep-learning-3aa67bff5991.

15 Shane Legg and Marcus Hutter, "Universal Intelligence: A Definition of Machine Intelligence," arXiv, (December 2007): 12, https://arxiv.org/abs/0712.3329.

16 Michael C. Horowitz, "Military Robotics, Autonomous Systems, and the Future of Military Effectiveness," in *The Sword's Other Edge: Tradeoffs in the Pursuit of Military Effectiveness*, ed. Dan Reiter (New York: Cambridge University Press, 2017).

17 Matt Simon, "Watch Boston Dynamics' SpotMini Robot Open a Door," *Wired*, Feb. 12, 2018, https://www.wired.com/story/watch-boston-dynamics-spotmini-robot-open-a-door/.

18 This is based on the discussion in Paul Scharre and Michael C. Horowitz, "An Introduction to Autonomy in Weapon Systems," *Center for a New American Security working paper* (February 2015): 5, https://www.cnas.org/publications/reports/an-introduction-to-autonomy-in-weapon-systems.

19 Michael C. Horowitz, Paul Scharre, and Alex Velez-Green, "A Stable Nuclear Future? The Impact of Automation, Autonomy, and Artificial Intelligence" (Philadelphia: University of Pennsylvania, 2017).

20 Scharre and Horowitz, "Autonomy in Weapon Systems," 6.

21 Murray Campbell, A. Joseph Hoane Jr., and Feng-hsiung Hsu, "Deep Blue," *Artificial Intelligence* 134, no. 1-2 (2002): 57-83, https://doi.org/10.1016/S0004-3702(01)00129-1.

22 Ryszard S. Michalski, Jaime G. Carbonell, and Tom M. Mitchell, eds., *Machine Learning: An Artificial Intelligence Approach* (New York: Springer, 2013); Allen Newell and Herbert Alexander Simon, *Human Problem Solving* (Englewood Cliffs, NJ: Prentice Hall, 1972).

23 Robert D. Hof, "Deep Learning," *MIT Technology Review* (2013), https://www.technologyreview.com/s/513696/deep-learning/; Anh Nguyen, Jason Yosinski, and Jeff Clune, "Deep Neural Networks Are Easily Fooled: High Confidence Predictions for Unrecognizable Images" (Paper presented at the Institute of Electrical and Electronics Engineers conference on computer vision and pattern recognition, 2015), https://arxiv.org/abs/1412.1897.

hope behind hybrid approaches is that creating common languages will enable algorithms that can employ multiple pathways to learn how to do particular tasks, making them more effective.[24]

For the purposes of this article, the specific methods of AI that generate particular capabilities are less critical than understanding the general trajectory of the technology. In many cases, it is too soon to tell which methods will generate which capabilities.

AI Is an Enabler, Not a Weapon

The impact of the invention of a new technology depends, in part, on its potential basic uses.[25] Some communication technologies, such as the telegraph or telephone, were designed to more rapidly connect people in different locations. Munition technologies, such as missiles and bullets, are designed to inflict damage on a target. Railroads are a transportation technology, as is a bicycle. These broad categories of technologies have subcomponents that draw on various technologies themselves. For example, more than 300,000 parts go into an F-35.[26] Another category might then be called "enabling technologies," which are designed not specifically for a single purpose like the examples above but, instead, are general-purpose, with broad applications across many other types of technologies. Electricity is an enabling technology.

So what kind of technology is artificial intelligence? While the rhetoric of the "Third Offset"[27] and other discussions in the defense community sometimes make artificial intelligence seem like a munition, AI is actually the ultimate enabler. AI can be part of many specific technologies, analogous to the internal combustion engine as well as electricity.[28] Andrew Ng of Stanford University argues that, like the invention of electricity, AI could enable specific technologies in fields as diverse as agriculture, manufacturing, and health care.[29]

Artificial intelligence can operate in several dimensions. First, it can be used to direct physical objects, such as robotic systems, to act without human supervision. Whether in tanks, planes, or ships, AI can help reduce the need to use humans, even remotely, or as part of human-machine teams.[30] Swarm techniques, for example, generally involve the creation of supervised algorithms that direct platforms such as drones. Second, artificial intelligence can assist in processing and interpreting information. Image-recognition algorithms can be used for tagging vacation photos and identifying products in stores as well as in Project Maven, a U.S. military program that seeks to develop algorithms to automate the process of analyzing video feeds captured by drones.[31] While the applications in each case are different, the underlying algorithmic task — rapid image identification and tagging — is consistent. Third, overlapping narrow AI systems could be used for new forms of command and control — operational systems, including battle management, that analyze large sets of data and make forecasts to direct human action — or action by algorithms.[32]

What Type of Artificial Intelligence?

It is useful to think about the degree of artificial intelligence as a continuum. On one end are narrow AI applications such as AlphaGo, able to beat the best human Go players in the world. These are

24 Antonio Lieto, Antonio Chella, and Marcello Frixione, "Conceptual Spaces for Cognitive Architectures: A Lingua Franca for Different Levels of Representation," *Biologically Inspired Cognitive Architectures* 19 (January 2017), https://doi.org/10.1016/j.bica.2016.10.005.

25 Calestous Juma, *Innovation and Its Enemies: Why People Resist New Technologies* (Oxford: Oxford University Press, 2016).

26 Lockheed Martin, "Building the F-35: Combining Teamwork and Technology," accessed May 8, 2018, https://www.f35.com/about/life-cycle/production.

27 The "Third Offset" was a Department of Defense initiative led by Deputy Secretary of Defense Robert Work that was designed to preserve U.S. military superiority through exploiting a generation of emerging technologies. Robert O. Work, *Deputy Secretary of Defense Remarks to the Association of the U.S. Army Annual Convention*, Oct. 4, 2016, https://www.defense.gov/News/Speeches/Speech-View/Article/974075/remarks-to-the-association-of-the-us-army-annual-convention/.

28 Walter Frick, "Why AI Can't Write This Article (Yet)," *Harvard Business Review*, July 24, 2017, https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence#/2017/07/why-ai-cant-write-this-article-yet.

29 Andrew Ng, "Artificial Intelligence Is the New Electricity," *Medium*, April 28, 2017, https://medium.com/@Synced/artificial-intelligence-is-the-new-electricity-andrew-ng-cc132ea6264.

30 Mick Ryan, "Building a Future: Integrated Human-Machine Military Organization," *Strategy Bridge*, Dec. 11, 2017, https://thestrategybridge.org/the-bridge/2017/12/11/building-a-future-integrated-human-machine-military-organization; Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* (New York: W.W. Norton, 2018).

31 Gregory C. Allen, "Project Maven Brings AI to the Fight Against ISIS," *Bulletin of the Atomic Scientists*, Dec. 21, 2017, https://thebulletin.org/project-maven-brings-ai-fight-against-isis11374.

32 Note that this illustrates the importance of data in training algorithms. While there is some promise to synthetic data for training algorithms, there is not currently a substitute for data based on real-world experience. Thus, access to large quantities of useful data will be critical to designing successful algorithms in particular arenas. For an example of basic defense research on using AI to increase situational awareness, see Heather Roff, "COMPASS: A new AI-driven situational awareness tool for the Pentagon?" *Bulletin of the Atomic Scientists*, May 10, 2018, https://thebulletin.org/compass-new-ai-driven-situational-awareness-tool-pentagon11816.

machine-learning algorithms designed to do one specific task, with no prospect of doing anything beyond that task. One can imagine narrow AI as relatively advanced forms of autonomous systems, or machines that, once activated, are designed to complete specific tasks or functions.[33]

On the other end of the spectrum is a "super-intelligent" artificial general intelligence. This kind of AI would consist of an algorithm, or series of algorithms, that could do not only narrow tasks but also could functionally think for itself and design solutions to a broader class of problems. Describing an extreme version of this, Nick Bostrom writes about the risk of a superintelligent AI that could plausibly take over the world and perhaps even decide to eliminate humans as an inadvertent consequence of its programming.[34] In the middle of this spectrum, though perhaps leaning toward artificial general intelligence, is "transformative AI," or AI that can go beyond a narrow task such as playing a video game but falls short of achieving superintelligence.[35]

This article focuses on the potential effect that narrow applications of artificial intelligence could have on the balance of power and international competition. Among current AI technologies and advances, narrow applications are most likely to affect militaries — and with them the balance of power — over the next two decades. Moreover, even experts disagree about whether artificial general intelligence of the type that could outpace human capabilities will emerge in the short to medium term or whether it is still hundreds of years away. AI experts also disagree about the overall trajectory of advances in AI.[36] Surveys have found that only 50 percent of AI researchers believe that an AI system will be capable of writing a best-selling book by 2049. About 75 percent of AI researchers thought it could be 2090 before an AI system could write a best-selling book. That even highly trained experts disagree about these development issues illustrates a high degree of uncertainty in the field.

Given these questions about which AI technologies will be developed, this article focuses on the capabilities that are most likely to emerge in the next generation.

Technology and the Balance of Power

Emerging technologies primarily shape the balance of power through military and economic means.[37] Technologies can directly influence countries' abilities to fight and win wars. They can also indirectly affect the balance of power by impacting a country's economic power. After all, countries cannot maintain military superiority over the medium to long term without an underlying economic basis for that power.[38] Recall the decline of the Ottoman Empire or Imperial China.

However, it is not yet clear how the invention of specific AI applications will translate into military power. Despite continuing investment, efforts to integrate AI technologies into militaries have been limited.[39] Project Maven is the first activity of an "Algorithmic Warfare" initiative in the U.S. military designed to harness the potential of AI and translate it into usable military capabilities. Still, many investments in the United States and elsewhere are in early stages. As Missy L. Cummings writes:

> Autonomous ground vehicles such as tanks and transport vehicles are in development worldwide, as are autonomous underwater vehicles. In almost all cases, however, the agencies developing these technologies are struggling to make the leap from development to operational implementation.[40]

It is important to distinguish these potential technological innovations from military innovations. While military innovations are often linked to changes in technology,[41] it is not always the case. Military innovations are significant changes in organizational behavior and ways that a military fights that are designed to increase its ability to

33 Scharre and Horowitz, "Autonomy in Weapon Systems," 5.

34 Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford: Oxford University Press, 2014).

35 Allan Dafoe, "Governing the AI Revolution: The Research Landscape" (New Haven, CT: Yale University, 2018), https://machine-learning-and-security.github.io/slides/Allan-Dafoe-NIPS-s.pdf.

36 Grace et al., "When Will AI Exceed Human Performance?"

37 McNeill, *The Pursuit of Power*.

38 David A. Baldwin, "Power Analysis and World Politics: New Trends versus Old Tendencies," *World Politics* 31, no. 2 (January 1979): 161-194, https://www.jstor.org/stable/2009941; Robert Gilpin, *War and Change in World Politics* (New York: Cambridge University Press, 1981).

39 Scharre and Horowitz, "Autonomy in Weapon Systems."

40 Missy L. Cummings, "Artificial Intelligence and the Future of Warfare," *Chatham House*, January 2017, https://www.chathamhouse.org/publication/artificial-intelligence-and-future-warfare.

41 Napoleonic warfare, or levée en masse, is an example of a military innovation not considered tied to technological innovations.

effectively translate capabilities into power.[42] The use of aircraft carriers as mobile airfields by the United States and Japan is a prototypical example. While AI could potentially enable a number of military innovations, it is not a military innovation itself, and no applications of AI have been used in ways that would count as a military innovation at this point.

Because AI research and technology are still in their early stages, usage of AI in warfare is not even yet analogous to the first use of the tank in World War I, let alone effective use of combined arms warfare by the Germans in World War II (the military innovation now known as blitzkrieg). This limits analyses about how narrow AI might one day affect the balance of power and international politics. Most research on technology and international politics focuses on specific, mature technologies, such as nuclear weapons, or on military innovations.[43] Since AI is at an early stage, examining it requires adapting existing theories about military technology and military innovation.[44]

My adoption capacity theory provides insight into how developments in AI will affect the balance of power.[45] This theory argues that the relative financial and organizational requirements for adopting a military innovation influence the rate of diffusion of that innovation and its impact on the balance of power. Financial considerations include calculating the unit costs of the hardware involved and determining whether the underlying capability is based on commercial or militarily-exclusive technology. Other considerations include assessing the extent to which adopting the innovation requires disrupting the critical task of the military (i.e., what an organization views itself as attempting to achieve) or the status of key organizational elites (for example, fighter pilots in an air force). Given that adoption capacity theory focuses on major military innovations, however, it requires adaptation to be applied to artificial intelligence at present.

While AI could potentially enable a number of military innovations, it is not a military innovation itself.

To determine how technological changes will shape the balance of power, adoption capacity theory suggests that three questions must be answered. First, while technology itself is rarely, if ever, determinative, how might use of a technology influence the character of warfare? Consider the machine gun. When deployed asymmetrically, it proved useful for the offense. But in combination with barbed wire, when possessed symmetrically, this technological advance helped create the trench-warfare stalemate of World War I.[46] More broadly, the Industrial Revolution and the shift in manufacturing to factories and mass production were behind the rifle’s evolution from a niche, craft weapon possessed by a small number of forces to a widely available capability. This change influenced the relative lethality of battles as well as how militaries organized themselves and developed tactics.[47]

Second, how might different actors implement a given technology or be bureaucratically constrained from implementation, and what possibilities for military innovation will that generate? This question is particularly relevant because the challenges of organizational adoption and implementation of a technological innovation are closely linked with effectiveness. Those challenges are critical to determining how an innovation will impact international politics.

Decades of research demonstrates that the impact of technological change on global politics — whether it is change in economics, society at large, diplomacy, or military power — depends much more on how governments and organizations

42 On military innovation in general, see Adam Grissom, "The Future of Military Innovation Studies," *Journal of Strategic Studies* 29, no. 5 (2006): 905-934, https://doi.org/10.1080/01402390600901067.

43 Bernard Brodie et al., eds., *The Absolute Weapon: Atomic Power and World Order* (New York: Harcourt Brace, 1946); Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991); Barry R. Posen, *The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars* (Ithaca, NY: Cornell University Press, 1984).

44 Posen, *Sources of Military Doctrine;* Rosen, *Winning the Next War,* Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the U.S., and Israel* (Stanford, CA: Stanford University Press, 2010); Theo Farrell, "World Culture and Military Power," *Security Studies* 14, no. 3 (2005): 448-488, https://doi.org/10.1080/09636410500323187; Emily O. Goldman and Leslie C. Eliason eds., *The Diffusion of Military Technology and Ideas* (Stanford, CA: Stanford University Press, 2003).

45 Horowitz, *Diffusion of Military Power*, 10-11.

46 This relates to questions about the offense/defense implications of technology, though technology itself is rarely predictive. See Keir A. Lieber, *War and the Engineers: The Primacy of Politics Over Technology* (Ithaca, NY: Cornell University Press, 2005).

47 Stephen D. Biddle, *Military Power: Explaining Victory and Defeat in Modern Battle* (Princeton, NJ: Princeton University Press, 2004).

make choices about the adoption and use of new capabilities than on the technologies themselves.[48] Scholarship on military innovation by Barry Posen, Stephen P. Rosen, and others shows that technological innovation alone rarely shapes the balance of power.[49] Instead, it is *how* militaries use a technology that makes a difference.[50] A military's ability to employ a technology depends in part on the complexity of the technology, how difficult it is to use, and whether it operates in predictable and explainable ways. These factors influence the trust that senior military leaders have in the technology and whether they use it.[51] Additionally, the more bureaucratically disruptive it is to adopt a technology, the more challenging it can be for older, more established organizations to do so — particularly if the organization is underinvested in research and development designed to integrate new technologies and ideas.[52]

Consider that every country in Europe in the mid-19th century had access to railroads, rifles, and the telegraph around the same time. But it was the Prussian military that first figured out how to exploit these technologies, in combination, to rapidly project power. After that, other militaries adapted their organizations to take similar advantage.[53]

The example of the British Navy and the aircraft carrier further illustrates how organizational processes determine the impact of technology on military power.[54] As referenced above, despite having invented the aircraft carrier, the Royal Navy's institutional commitment to the battleship meant that it initially saw the value of this new technology almost exclusively in its ability to facilitate the use of airplanes to act as "spotters" for battleships. The United States and Japan, as rising naval powers with less invested in the importance of the battleship, thought more creatively about this innovation and realized that the aircraft carrier's real value lay in the independent striking power it offered.[55] Since battleships — and admirals with experience and comfort operating them — dominated the navies of many countries, thinking about the aircraft carrier as a mobile airfield required a difficult conceptual shift.[56]

Even after it became clear that the optimal use of aircraft carriers was as a mobile airfield, adopting carrier warfare proved challenging. The Chinese navy has been working on carrier operations for two decades and is only just starting to build real competency. The Soviet Union attempted to adopt carrier warfare for decades and failed. Simply put, the systems integration tasks required to operate the ship, launch and recover airplanes from the ship, and coordinate with other naval assets are very difficult to execute.[57] The larger the change within the organization required for a military to effectively utilize new technologies, the greater the bureaucratic challenges and, with them, the likelihood that powerful countries will not have the organizational capability to adopt. This is a key mechanism through which the balance of power can change.

Third, how will a new technology spread? The answer to this question will help determine relative first-mover advantages gained from adopting the technology.[58] While Kenneth Waltz initially suggested that emulation of military

48 This is not meant to endorse or reject the notion of technology as a social construction. On that point, see Trevor J. Pinch and Wiebe E. Bijker, "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," *Social Studies of Science* 14, no. 3 (1984): 399-441, http://www.jstor.org/stable/285355. What is key is that it is in the context of organizational behavior that the impact of technological change becomes clearest.

49 Posen, *Sources of Military Doctrine;* Rosen, *Winning the Next War;* Adamsky, *The Culture of Military Innovation.*

50 Nuclear weapons are arguably an exception to this pattern, given their unique destructive power. But they may be the exception that proves the rule.

51 Andrea Gilli and Mauro Gilli, "Military-Technological Superiority: Systems Integration and the Challenges of Imitation, Reverse Engineering, and Cyber-Espionage," *International Security* (forthcoming).

52 Mancur Olson, *The Rise and Decline of Nations: Economic Growth, Stagflation, and Social Rigidities* (New Haven, CT: Yale University Press, 1982); Horowitz, *Diffusion of Military Power.*

53 Dennis E. Showalter, *Railroads and Rifles: Soldiers, Technology, and the Unification of Germany* (Hamden, CT: Archon Books, 1975); Geoffrey L. Herrera and Thomas G. Mahnken, "Military Diffusion in Nineteenth-Century Europe: The Napoleonic and Prussian Military Systems," in *The Diffusion of Military Technology and Ideas*, ed. Emily O. Goldman and Leslie C. Eliason (Stanford, CA: Stanford University Press, 2003).

54 Another example is the tank. Applied to AI and drones, see Ulrike E. Franke, "A European Approach to Military Drones and Artificial Intelligence," *European Council on Foreign Relations*, June 23, 2017, http://www.ecfr.eu/article/essay_a_european_approach_to_military_drones_and_artificial_intelligence. In general, see David E. Johnson, *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917–1945* (Ithaca, NY: Cornell University Press, 1998).

55 Horowitz, *Diffusion of Military Power.*

56 Horowitz, *Diffusion of Military Power.*

57 Horowitz, *Diffusion of Military Power.*

58 See Gilpin, *War and Change in World Politics;* Daniel R. Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century* (New York: Oxford University Press, 1981); Horowitz, *Diffusion of Military Power.*

technologies happens quickly, subsequent research demonstrates that it is far more complicated.[59] The rate of diffusion matters: In the case of technologies that diffuse slowly, the country that first implements will have a sustainable edge over its competitors. But when other countries can rapidly adopt a new technology, the relative advantages of being first diminish.[60]

The diffusion of military technology occurs through multiple mechanisms, just like the diffusion of technologies in general.[61] Adoption capacity theory suggests a few factors that will be key in influencing the diffusion of narrow AI. The first is the unit cost of creating AI systems. The greater the hardware and compute costs associated with creating militarily-relevant algorithms, the higher the barrier to entry will be. Alternatively, once the algorithms have been created, they become software and can more easily diffuse.

Moreover, technologies that have only military purposes tend to spread more slowly than technologies where commercial incentives drive their development. If a technology has only military uses — such as stealth technology — and it has a high unit cost and level of complexity, the number of actors who can emulate or mimic that technology is minimized.[62]

On the other hand, technologies with commercial incentives for development generally spread much faster. In the 19th century, the railroad, used as a "military technology," enabled rapid power projection and the massing of military forces to a greater degree than had previously been possible. Yet it was the commercial incentives for the fast shipping of goods that helped speed the construction of dense railroad networks around the world, making it difficult for countries to gain sustainable advantages in railroad capabilities.[63]

The Impact of AI on the Balance of Power

If Eric Schmidt, Vladimir Putin, Elon Musk, and others are correct that AI is a competitive battleground, what will be the character of that competition?[64] The United States and China seem to be furthest ahead in the development of AI. As the two most powerful countries in the world, the competition for global leadership in AI technology evokes, for many, 20th-century competitions such as the space race. Retired Marine Corps Gen. John Allen and SparkCognition CEO Amir Husain have argued that the United States therefore needs to do more to get and stay ahead.[65]

Global investments in artificial intelligence for economic and national security purposes are increasingly described as an arms race.[66] China published a national strategy on artificial intelligence in 2017 that said AI represents a "major strategic opportunity" and proposed a coordinated strategy to "build China's first mover advantage" and lead the world in AI technology.[67] Russia is investing heavily as well, especially in the military domain. Reports suggest that the Russian military is designing autonomous vehicles to guard its ballistic missile bases as well as an autonomous submarine that could carry nuclear weapons. In

59 Kenneth N. Waltz, *Theory of International Politics* (New York: McGraw-Hill, 1979).

60 Marvin B. Lieberman and David B. Montgomery, "First-Mover Advantages," *Strategic Management Journal* 9, no. 1 (1988): 41-58, https://doi.org/10.1002/smj.4250090706; Marvin B. Lieberman and David B. Montgomery, "First-Mover (Dis)Advantages: Retrospective and Link with the Resource-Based View," *Strategic Management Journal* 19, no. 12 (1998): 1111-1125, https://doi.org/10.1002/(SICI)1097-0266(1998120)19:12<1111::AID-SMJ21>3.0.CO;2-W; Gerard J. Tellis and Peter N. Golder, *Will and Vision: How Latecomers Grow to Dominate Markets* (New York: McGraw-Hill, 2002).

61 Everett M. Rogers, *Diffusion of Innovations*, 5th ed. (New York: Free Press, 2003).

62 Horowitz, *Diffusion of Military Power*. For a recent argument about the complexity of stealth and the challenges of adoption, see Gilli and Gilli, "Military-Technological Superiority."

63 Showalter, *Railroads and Rifles;* Geoffrey L. Herrera, *Technology and International Transformation: The Railroad, the Atom Bomb, and the Politics of Technological Change* (Albany, NY: State University of New York Press, 2006).

64 Eric Schmidt, "Keynote Address at the Center for a New American Security Artificial Intelligence and Global Security Summit," *Center for a New American Security*, Nov. 13, 2017, https://www.cnas.org/publications/transcript/eric-schmidt-keynote-address-at-the-center-for-a-new-american-security-artificial-intelligence-and-global-security-summit.

65 John R. Allen and Amir Husain, "The Next Space Race Is Artificial Intelligence," *Foreign Policy*, Nov. 3, 2017, http://foreignpolicy.com/2017/2011/2003/the-next-space-race-is-artificial-intelligence-and-america-is-losing-to-china/.

66 Tom Simonite, "For Superpowers, Artificial Intelligence Fuels New Global Arms Race," *Wired*, Sept. 8, 2017, https://www.wired.com/story/for-superpowers-artificial-intelligence-fuels-new-global-arms-race/; Zachary Cohen, "US Risks Losing Artificial Intelligence Arms Race to China and Russia," *CNN*, Nov. 29, 2017, https://www.cnn.com/2017/11/29/politics/us-military-artificial-intelligence-russia-china/index.html; Julian E. Barnes and Josh Chin, "The New Arms Race in AI," *Wall Street Journal*, Mar. 2, 2018, https://www.wsj.com/articles/the-new-arms-race-in-ai-1520009261.

67 Graham Webster et al., "China's Plan to 'Lead' in AI: Purpose, Prospects, and Problems," *New America Foundation*, Aug. 1, 2017, https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/.

robotics, Russia is deploying remotely piloted tanks, such as the Uran-9 and Vehar, on the battlefield.[68]

China and Russia are not the only actors outside the United States interested in national security applications of AI. The character of AI technology, like robotics, makes many countries well-positioned to design and deploy it for military purposes.[69] Commercial incentives for AI developments and the dual-use character of many AI applications mean that countries with advanced information economies are poised to be leaders in AI or at least fast followers.[70] In Southeast Asia, Singapore is on the cutting edge of AI investments (both military and non-military). Other Southeast Asian nations are making advances in AI research as well.[71] In the military domain, South Korea has developed the SGR-A1, a semi-autonomous weapon system designed to protect the demilitarized zone from attack by North Korea.[72]

AI also provides opportunities for capital-rich countries, which creates incentives to develop the technology. Wealthy, advanced economies that have high levels of capital but also have high labor costs or small populations — middle powers such as Australia, Canada, and many European countries — often face challenges in military recruiting. For these countries, technologies that allow them to substitute capital for labor are highly attractive. Indeed, Gen. Mick Ryan, commander of Australia's Defence College, argues that countries can take advantage of the intersection of AI and robotics to overcome the problems caused by a small population.[73] France's 2017 defense strategy review points to the development and incorporation of artificial intelligence as critical to the French military's ability to maintain "operational superiority."[74] Israel, a classic example of an advanced economy with more capital than labor, also funds military AI investments that would predict rocket launches and analyze video footage.[75] Lt. Col. Nurit Cohen Inger,

[T]echnologies that have only military purposes tend to spread more slowly than technologies where commercial incentives drive their development.

who heads the unit of the Israeli Defense Forces (IDF) in charge of assessing the military relevance of AI, said in 2017 that, for the IDF, AI "can influence every step and small decision in a conflict, and the entire conflict itself."[76]

Given these investments, how might developments in AI affect military organizations and the character of war, and how might they diffuse?

AI and the Character of War

The "character of warfare" in a period can be defined as the dominant way to fight and win conflicts given existing technologies, organizations, and polities. The character of warfare changes in concert with the tools that become available and how they influence the ways militaries organize

68 Samuel Bendett, "Russia Is Poised to Surprise the US in Battlefield Robotics," *Defense One*, Jan. 25 2018, https://www.defenseone.com/ideas/2018/01/russia-poised-surprise-us-battlefield-robotics/145439/; Barnes and Chin, "The New Arms Race in AI"; Samuel Bendett, "Red Robots Rising," *Strategy Bridge*, Dec. 12, 2017, https://thestrategybridge.org/the-bridge/2017/12/12/red-robots-rising-behind-the-rapid-development-of-russian-unmanned-military-systems; Valerie Insinna, "Russia's nuclear underwater drone is real and in the Nuclear Posture Review," *Defense News*, Jan. 12, 2018, https://www.defensenews.com/space/2018/01/12/russias-nuclear-underwater-drone-is-real-and-in-the-nuclear-posture-review/.

69 For an overview of AI and national security, see Daniel S. Hoadley and Nathan J. Lucas, "Artificial Intelligence and National Security," *Congressional Research Service*, Apr. 26, 2018, https://fas.org/sgp/crs/natsec/R45178.pdf. Also see Benjamin Jensen, Chris Whyte, and Scott Cuomo, *Algorithms at War: The Promise, Peril, and Limits of Artificial Intelligence*, Working Paper (2018).

70 This is similar to what is going on in robotics. See Horowitz, "Military Robotics, Autonomous Systems, and the Future of Military Effectiveness."

71 Sachin Chitturu et al., "Artificial Intelligence and Southeast Asia's Future," *McKinsey Global Institute*, September 2017, 1, https://www.mckinsey.com/~/media/McKinsey/Global Themes/Artificial Intelligence/Artificial-intelligence-and-Southeast-Asias-future.ashx; Ng Eng Hen, "Speech at Committee of Supply Debate," Ministry of Defense, Singapore, Mar. 7, 2014, https://www.mindef.gov.sg/web/portal/mindef/news-and-events/latest-releases/article-detail/2014/march/2014mar06-speeches-00341/!ut/p/z0/fY07D4IwFIV_iwNjcy-IMKMOalQWNNjFVLxKFcqjDei_t8hq3M53ch7AIQWuRCfvwshKicLyiQfnMF4uVuh7-3iWuBgdk2Q7m-_XhzCADfD_Abs.

72 Mark Prigg, "Who Goes There? Samsung Unveils Robot Sentry That Can Kill From Two Miles Away," *Daily Mail (UK)*, Sept. 15, 2014, http://www.dailymail.co.uk/sciencetech/article-2756847/Who-goes-Samsung-reveals-robot-sentry-set-eye-North-Korea.html.

73 Ryan, "Building a Future: Integrated Human-Machine Military Organization."

74 "Strategic Review of Defence and National Security: 2017," French Ministry of Defense, Dec. 22, 2017, 3, https://www.defense.gouv.fr/dgris/politique-de-defense/revue-strategique/revue-strategique. On the European approach to drones and AI, also see Franke, "A European Approach to Military Drones and Artificial Intelligence."

75 Eliran Rubin, "Tiny IDF Unit Is Brains Behind Israeli Army Artificial Intelligence," *Haaretz*, Aug. 15, 2017, https://www.haaretz.com/israel-news/tiny-idf-unit-is-brains-behind-israeli-army-artificial-intelligence-1.5442911; Yaakov Lappin, "Artificial Intelligence Shapes the IDF in Ways Never Imagined," Aglemeiner, Oct. 16, 2017, https://www.algemeiner.com/2017/10/16/artificial-intelligence-shapes-the-idf-in-ways-never-imagined/.

76 Lappin, "Artificial Intelligence Shapes the IDF in Ways Never Imagined."

themselves to fight wars.[77] The shift to mass mobilization in the Napoleonic era exemplifies a non-technological development that changed the character of warfare.

Applications of AI have the potential to shape how countries fight in several macro ways. On the broadest level, autonomous systems, or narrow AI systems, have the potential to increase the speed with which countries can fight, yet another similarity between AI and the combustion engine. Even if humans are still making final decisions about the use of lethal force, fighting at machine speed can dramatically increase the pace of operations.[78]

There are several military applications of AI currently in development or under discussion that can be considered, though many are at early stages. For example, some research shows that the way that neural networks can utilize imagery databases and classify particular scenes (such as a mountain), allows for a more accurate assessment of specific locations.[79] Additionally, the processing power that is possible with narrow AI systems has the potential to increase the speed of data analysis, as Project Maven in the United States aims to do. Investments in image recognition offer the hope of achieving faster, more accurate results than humans can achieve today, and is a likely avenue for continued investment and application (setting aside the questions of accidents, hacking, and other ways that systems could go awry[80]).

Successful implementation of AI beyond areas such as image recognition might lead to new concepts of operation that could influence force structure and force employment, or how militaries organize themselves and plan operations. One possibility is the use of large numbers of smaller platforms, known as swarms, for military operations. Algorithms and control systems designed to enable "swarming" already exist in the private sector and in academia.[81] Military-grade algorithms would require coordination with other military systems, including early-warning aircraft, inhabited aircraft, satellites, and other sensors. Deployed swarms in a combat environment would have to be capable of real-time adaptation to optimize operations if some elements of the swarm were shot down — a challenge that commercial applications would not necessarily face. Methods for developing swarming algorithms could include behavior trees or deep learning.[82]

Another potential application for narrow AI that could shape the character of war is coordination through layers of algorithms that work together to help manage complex operations. These algorithms could be expert systems that generate decision trees. Or they could involve algorithms developed through generative adversarial networks. In this approach, algorithms compete against each other to teach each other how to do various tasks. Some algorithms will need to be trained to assist in coordinating multiple military assets, both human and machine. In that case, adversarial learning could help compensate for the unique character of decision-making in individual battles and the problem of learning to adapt beyond the available training data.[83]

The ability to operate faster through algorithms

77 One could also argue AI has the potential to go beyond shaping the character of war and change the nature of war itself. From a Clausewitzian perspective, that war is human fundamentally defines its nature. Carl von Clausewitz, *On War*, trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1989). Thus, the nature of war is unchanging. In theory, could AI alter the nature of war itself because wars will be fought by robotic systems, not people, and because of AI's potential to engage in planning and decision-making that were previously human endeavors? U.S. Defense Secretary James Mattis speculated in February 2018 that AI is "fundamentally different" in ways that raise questions about the nature of war. See "Press Gaggle by Secretary Mattis En Route to Washington, D.C.," *Department of Defense*, Feb. 17, 2018, https://www.defense.gov/News/Transcripts/Transcript-View/Article/1444921/press-gaggle-by-secretary-mattis-en-route-to-washington-dc/. This is an important debate but one beyond the scope of this paper. For elements of this debate, see Kareem Ayoub and Kenneth Payne, "Strategy in the Age of Artificial Intelligence," *Journal of Strategic Studies* 39, no. 5-6 (2016): 793-819, https://doi.org/10.1080/01402390.2015.1088838; Frank G. Hoffman, "Will War's Nature Change in the Seventh Military Revolution?" *Parameters* 47, no. 4, (2018): 19-31, https://ssi.armywarcollege.edu/pubs/parameters/issues/Winter_2017-18/5_Hoffman.pdf. Also see Kenneth Payne, *Strategy, Evolution, and War: From Apes to Artificial Intelligence* (Washington, DC: Georgetown University Press, 2018).

78 Robert O. Work, *Deputy Secretary of Defense Speech at Center for a New American Security Defense Forum*, Dec. 14, 2015, http://www.defense.gov/News/Speeches/Speech-View/Article/634214/cnas-defense-forum; John R. Allen and Amir Husain, "On Hyperwar," *Proceedings of the United States Naval Institute* 143, no. 7 (July 2017), https://www.usni.org/magazines/proceedings/2017-07/hyperwar.

79 Bolei Zhou et al., "Places: A 10 Million Image Database for Scene Recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence* (July 2017), https://doi.org/10.1109/TPAMI.2017.2723009.

80 Miles Brundage et al., "The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation," Working Paper (2018), https://arxiv.org/abs/1802.07228; Stephanie Carvin, "Normal Autonomous Accidents", *Social Science Research Network* (2018), http://dx.doi.org/10.2139/ssrn.3161446.

81 For example, see Vijay Kumar, Aleksandr Kushleyev, and Daniel Mellinger, "Three-Dimensional Manipulation of Teams of Quadrotors," Google Patents, 2017, https://patents.google.com/patent/US20150105946.

82 Simon Jones et al., "Evolving Behaviour Trees for Swarm Robotics," in *Distributed Autonomous Robotic Systems*, ed. Roderich Grob, et al. (Boulder, CO: Springer, 2018).

83 Tero Karras et al., "Progressive Growing of GANs for Improved Quality, Stability, and Variation," published as a conference paper at *International Conference on Learning Representations 2018* (2018), https://arxiv.org/abs/1710.10196.

that assist human commanders in optimizing battle plans, including real-time operations, could shift force employment and force structure, especially in the air and at sea. Since World War II, modern militaries have been engaged in a shift from quantity to quality in military systems. The thinking is that smaller numbers of expensive, high-quality systems are more likely to lead to victory in battles. AI could accelerate trends that challenge these long-running force-structure imperatives, such as the need to defeat adversaries with advanced anti-access, area-denial (A2/AD) networks with tolerable costs.

If algorithms and coordination at machine speed become critical to success on the battlefield, expensive, high-quality platforms could become vulnerable to swarms of sensors and lower-cost weapons platforms that are effectively networked together. AI could thus help bring quantity back into the equation in the form of large numbers of robotic systems. In the near to mid-term, however, optimal use of AI may lie in leveraging machine learning to improve the performance of existing platforms.

Incentives exist for nearly all types of political regimes to develop AI applications for military purposes. For democracies, AI can decrease the relative burden of warfare on the population and reduce the risk to soldiers, even more so than with remotely piloted systems, by reducing the use of personnel. For autocracies, which do not trust their people in the first place, the ability to outsource some elements of military decision-making to algorithms, reducing reliance on humans to fight wars, is inherently attractive.[84]

Organizational Politics and Artificial Intelligence

Despite uncertainty about specific military applications of AI, the examples of how AI can be used in a military context described above reveal that these capabilities have the potential to significantly disrupt organizational structures. Take the example of battle management coordination (whether in human-machine teams or not): Successfully operating even semi-autonomous battle management systems is likely to require new occupational specialties and shifts in recruiting, training, and promotion to empower individuals who understand both military operations and how particular AI systems function. Rosen shows that altering the promotion of military personnel to empower those with expertise in new areas is critical to adopting military innovations in general. AI should be no exception.[85]

As described above, the use of AI systems at the operational level could generate options for how militaries organize and plan to use force, due to the potential to use larger numbers of networked systems operating at machine speed instead of relying exclusively on small numbers of high-quality inhabited aircraft. Implementing such concepts, however, could require disruptive organizational shifts that could threaten to change which military occupations provide the highest status and are gateways to leadership roles. Already, this can be seen with the Air Force, dominated by fighter pilots, which has been relatively hesitant when it comes to investments in uninhabited aerial vehicles. It would also challenge entrenched bureaucratic notions about how to weigh quantity versus quality. Adopting narrow AI in the most optimal way could prove challenging for leading militaries, which will need trained personnel who can do quality and reliability assurance for AI applications to ensure their appropriate and effective use.

Other applications, such as Project Maven in the U.S. Department of Defense, are easier to implement because they are sustaining technologies from the perspective of literature on organizational innovation.[86] Autonomous systems that can rapidly and accurately process drone footage do not disrupt high-status military occupational specialties, nor do they disrupt how military services operate as a whole. It is when optimal uses of narrow AI would require large shifts to force structure that the adoption requirements, and bureaucratic anti-bodies, ramp up. One example of bureaucratic resistance preventing the production of a new technology that could have proved disruptive is the U.S. military's failure to fund the X-47B drone, a next-generation system that could take off from and land on aircraft carriers autonomously. This illustrates the way bureaucratic politics and organizational competition can hinder the adoption of innovative technologies.[87]

The strategic or organizational culture of a military or society can also indicate which will be best positioned to exploit potential advances in

84 Michael C. Horowitz, "The promise and peril of military applications of artificial intelligence," *Bulletin of the Atomic Scientists*, Apr. 23, 2018, https://thebulletin.org/military-applications-artificial-intelligence/promise-and-peril-military-applications-artificial-intelligence.

85 Rosen, *Winning the Next War.*

86 Clayton M. Christensen, *The Innovator's Dilemma* (Boston, MA: Harvard Business School Press, 1997). This also relates to strategies for innovating within militaries. See Peter Dombrowski and Eugene Gholz, *Buying Military Transformation* (New York: Columbia University Press, 2006).

87 Cummings, "Artificial Intelligence and the Future of Warfare," 9. Also see Lawrence Spinetta and Missy L. Cummings, "Unloved Aerial Vehicles: Gutting Its UAV Plan, the Air Force Sets a Course for Irrelevance," *Armed Forces Journal* (November 2012): 8-12, http://hdl.handle.net/1721.1/86940.

AI,[88] specifically, how open those cultures are to innovation. There is a risk of tautology, of course, in cultural arguments at times since it can be hard to measure whether an organization is capable of adopting a technology until it has tried to do so or done it. However, Emily Goldman's work on the Ottoman Empire suggests the value of developing metrics of cultural openness when it comes to predicting willingness to experiment and adopt AI systems.[89]

Interestingly, norms regarding force structure could also play a role in inhibiting the use of AI for certain military tasks. As Theo Farrell's research on the Irish Army after independence shows, militaries often mimic the functional form of more powerful actors even when doing so is not in their interest. Applying his insight in the case of artificial intelligence, some militaries may be less likely to use AI in ways that are organizationally disruptive, especially if doing so would involve shifts in visible force structure, such as a move from small numbers of advanced inhabited aircraft to swarming concepts that use cheaper, more disposable aircraft.[90]

The character of AI technology, like robotics, makes many countries well-positioned to design and deploy it for military purposes.

Arguments about organizational and strategic culture are generally consistent with adoption capacity theory, since both focus on the challenges that innovations present when they disrupt the identity of an organization.[91] After all, militaries that already spend a lot on research and development, that are younger, and that have broad conceptions of their critical task are more likely to be culturally "open" and able to adopt new technologies or full innovations further down the development line.

The Diffusion of Militarily-Relevant AI: Two Scenarios

There is a fundamental question about the extent to which militarily-relevant uses of narrow AI will diffuse easily. Answering this question is necessary for predicting the first-mover advantages associated with a technological innovation, which in turn helps to determine its relative impact on the balance of power and warfare. To determine how easily a new technology will diffuse, adoption capacity theory suggests looking at the unit cost of the technology, especially the physical hardware.

Designing AI capabilities requires both software and hardware. This influences how to think about the "unit cost" of AI. Military capabilities based in hardware often spread more slowly than those based in software, generating more sustainable advantage for the first adopter of a given capability, especially when the unit costs of that capability are relatively high. The high unit cost of flattop aircraft carriers, for example, means that only wealthy and powerful countries adopt them.[92]

When it comes to platforms, algorithms are software rather than hardware. Take the example of the MQ-9 Reaper, a current-generation U.S. military armed drone. The MQ-9 is remotely piloted, meaning that a pilot at another location directs the airframe and makes decisions about firing weapons against potential targets. The difference between this and an autonomous version that is piloted and operated by an algorithm is software. From the outside, the platform would look the same.

But, if narrow AI is software from the perspective of military technology, it is software that requires substantial hardware for its creation. The associated hardware costs — especially for advanced narrow AI applications — are potentially significant.[93] The more complex the algorithm, the more up-front computational hardware is required to "train" that algorithm.[94] Thus, corporate and academic AI research leaders have to invest in teraflops of computing power. This is a different kind of hardware than a tank or a cruise missile, but it is hardware all the same. Rapid advances in AI through deep learning and neural networks over the last decade have thus required advances

88 Adamsky, *Culture of Military Innovation.*

89 Emily O. Goldman, "Cultural Foundations of Military Diffusion," *Review of International Studies* 32, no. 1 (2006): 69-91, https://doi.org/10.1017/S0260210506006930.

90 Farrell, "World Culture and Military Power."

91 Horowitz, *Diffusion of Military Power.*

92 Horowitz, *Diffusion of Military Power.*

93 Tim Hwang, "Computational Power and the Social Impact of Artificial Intelligence," Mar. 23, 2018, https://ssrn.com/abstract=3147971.

94 Hof, "Deep Learning."

in computing hardware. Joel Emer, an electrical engineering and computer science professor at MIT, states it plainly: "Many AI accomplishments were made possible because of advances in hardware."[95] After an algorithm has been trained, however, it can be applied without access to that computing environment, and the power necessary to run completed algorithms is dramatically reduced.

How rapidly AI capabilities will diffuse via simultaneous invention or mimicry will depend, in part, on the availability of computing power. If the cost of computing power continues to decline as chips become more efficient, then countries that are already home to advanced technology companies will have more access to AI capabilities faster than other countries without those kinds of technology companies.

Incentives exist for nearly all types of political regimes to develop AI applications for military purposes.

If, on the other hand, the hardware costs of developing complex algorithms remain beyond the capacity of companies in most countries, diffusion will happen only deliberately, such as through trade or bilateral agreements at the nation-state level, or via espionage (i.e., hacking). This would likely slow the diffusion of most AI advances, increasing the advantages for innovators.

Determining the extent to which militarily-relevant applications of AI are based on commercial technology versus exclusively military research is also a critical question raised by adoption capacity theory. While it is hard to know the answer at present, examining both scenarios will illustrate how that answer might shape the way AI affects the balance of power and the structure of international competition.

Dual-Use AI

Research on the future of work suggests that strong commercial drivers are incentivizing the development of AI around the world. A 2017 McKinsey Global Institute report found a midpoint estimate of 400 million people, or 15 percent of the workforce, that are likely to be disrupted by automation before 2030.[96] Widely cited research by Carl B. Frey and Michael A. Osborne estimates that 47 percent of jobs in the United States are at risk of being replaced by automation. That includes lawyers, stock traders, and accountants, not just blue-collar jobs.[97] Companies across the economy have incentives to develop and use algorithms.

Commercial interest in AI is so high that some argue it — and the finite number of talented AI engineers — is holding back military developments.[98] What's more, the higher salaries and benefits that commercial companies can offer mean that militaries may have to turn to civilian companies to develop advanced AI capabilities. Google's decision to partner with the U.S. Defense Department on Project Maven illustrates how the same talent and knowledge that will drive commercial innovation in AI may also be necessary for military technology innovation.[99]

When technology advances derive primarily from the civilian sector, rapid adoption of new technologies around the world becomes more likely. Commercial companies may spread the technology themselves, and the profit motive incentivizes rapid mimicry by related companies in different countries.[100] Companies in Brazil, Germany, Japan, and Singapore could become AI leaders or at least fast followers.

A commitment to open-source development by

95 Meg Murphy, "Building the Hardware for the Next Generation of Artificial Intelligence," *MIT News*, Nov. 30 2017, http://news.mit.edu/2017/building-hardware-next-generation-artificial-intelligence-1201.

96 James Manyika et al., "What the Future of Work Will Mean for Jobs, Skills, and Wages," *McKinsey Global Institute report*, November 2017, https://www.mckinsey.com/global-themes/future-of-organizations-and-work/what-the-future-of-work-will-mean-for-jobs-skills-and-wages.

97 Carl B. Frey and Michael A. Osborne, "The Future of Employment: How Susceptible Are Jobs to Computerisation?" *Technological Forecasting and Social Change* 114 (January 2017): 254-280, https://doi.org/10.1016/j.techfore.2016.08.019.

98 Cummings, "Artificial Intelligence and the Future of Warfare": 10.

99 Kate Conger and Dell Cameron, "Google Is Helping the Pentagon Build AI for Drones," *Gizmodo*, Mar. 6, 2018, https://gizmodo.com/google-is-helping-the-pentagon-build-ai-for-drones-1823464533.

100 Horowitz, *Diffusion of Military Power*.

many of the major players in AI could also increase the rate of diffusion. In 2015, for example, Google opened up TensorFlow, its artificial intelligence engine, to the public.[101] Elsewhere, researchers committed to the open development of AI to help reduce the safety risk of algorithms that "break" in high-leverage situations publish their findings in ways that advance their cause — and make it easier for their algorithms to be copied.[102]

Even though advanced applications of commercial AI would require significant hardware and expertise, adoption capacity theory suggests that as the underlying basis of a technology gets more commercially oriented, it spreads relatively faster, as explained above. Companies like DeepMind have an edge today. But in such a scenario, there would be more companies around the world with relevant technological capacity. It is also easier for governments to leverage private-sector companies when those private-sector actors have non-governmental market incentives for developing or copying technology.

So how would dual-use AI being critical to military applications of AI shape global power? As noted above, the period in which a technological innovator enjoys a market advantage shrinks when countries and companies can acquire or copy others' advances relatively easily. This makes it hard to stay ahead qualitatively.[103] In the AI and robotics realms, it is possible that this will create yet another incentive for countries to focus on quantity in military systems. If leads in AI development prove difficult to sustain, advanced militaries are likely to have systems of approximately the same quality level, presuming they all reach the same conclusion about the general potential of integrating AI into military operations. In that case, countries may be more likely to try to gain advantage by emphasizing quantity again — this is in addition to the inherent incentives for mass that narrow AI might create.

If dual-use AI is critical to military applications of AI, the ability to design forces, training, and operational plans to take advantage of those dual-use applications will be a differentiating factor for leadership in AI among the great powers. The 1940 Battle of France illustrates what could ultimately be at stake in the most extreme case. Both the Germans on one side and the British and French on the other had tanks, trucks, radios, and airplanes that they could, in theory, have used for close air support. What gave the Germans such a large edge was blitzkrieg — a new concept of operations that could overwhelm even another advanced adversary.[104]

Let's return to the comparison between AI and the space race. If AI technology diffuses more rapidly because it has both commercial and military purposes, making first-mover advantages more difficult to sustain, comparisons to the space race may be limited. The space race was a bilateral challenge between the United States and the Soviet Union designed to put a person on the moon, which included both developments in rockets and technologies designed to keep humans alive in space, land on the moon, and return safely. The rocket development itself was also part of the creation of intercontinental ballistic missiles (ICBMs). And critical economic spillovers from the space race included development of the satellites that led to GPS and other key enablers of the Information Age. Yet overall, the race to the moon was run by two governments for national purposes — not primarily for dual-use economic gain.

The commercial drivers of AI technology, and the speed with which new algorithms diffuse, would make competition much broader than it was during the bilateral space race. Competition is much more likely to be multilateral, featuring countries and companies around the world. A better analogy might be to the competition surrounding the development of Second Industrial Revolution technologies in the late 19th and early 20th centuries. France, Germany, Britain, Japan, the United States, and others vied for supremacy in steel production, chemicals, petroleum, electricity, and other areas.

For military applications of AI where the underlying technology is driven by commercial developments, the impact of a country getting ahead in AI technology, over time, would have unclear implications for relative power if a rival country was close enough to be a fast follower.

101 Cade Metz, "Google Just Open Sourced TensorFlow, Its Artificial Intelligence Engine," *Wired*, Nov. 9, 2015, https://www.wired.com/2015/11/google-open-sources-its-artificial-intelligence-engine/.

102 Dario Amodei et al., "Concrete Problems in AI Safety," arXiv, July 25, 2016, https://arxiv.org/abs/1606.06565. This commitment to openness has limits. Google has many proprietary algorithms, and Microsoft's Watson (which first came to fame when it defeated Ken Jennings, the greatest living human Jeopardy player) is also proprietary.

103 In extreme examples where first-mover advantages are difficult to generate, there can be advantages for rapid followers that do not have to pay initial R&D costs. Alexander Gerschenkron, *Economic Backwardness in Historical Perspective: A Book of Essays* (Cambridge, MA: Harvard University Press, 1962).

104 The Germans did not call it blitzkrieg, explicitly. Ernest R. May, *Strange Victory: Hitler's Conquest of France* (New York: Hill and Wang, 2000); Posen, *Sources of Military Doctrine*.

Advances in commercially driven AI technology are about building new industries, changing the character of existing industries, and ensuring that the leading corporations in the global economy that emerges are based in one's own country.

Militarily-Exclusive AI

The alternative to military applications of AI that are based in commercial developments is a world where military applications of AI are driven instead by research that is applicable only to militaries. Copying technological innovations of "excludable" technologies — those not based on widely available commercial technology — requires espionage to steal the technology (as the Soviets did with the atomic bomb) or mimicry based on observable principles of the technology.[105] There are several reasons, however, to think that many military applications of narrow AI will be unique in ways that will make them more difficult to copy.

First, the complexity of advanced military systems can make emulation costly and difficult. This is especially true when a number of components are not available on the commercial market and the ability to build them depends, in part, on classified information.[106] The same can also be said for some advanced commercial technology, of course, but this is not the norm. The inability to adapt commercial algorithms for some military purposes could limit the capacity of most states to produce relevant AI-based military capabilities, even if they have advanced commercial AI sectors. It could also mean that systems integration challenges for using militarily-relevant algorithms are large enough to deter many militaries from investing heavily.[107]

Whatever the uncertainty about how specific AI advances will translate into military capabilities, some of the most important military applications of narrow AI — those with a potentially substantial impact on larger-scale military operations — may not have obvious civilian counterparts. Battle management algorithms that coordinate a military operation at machine speed do not necessarily have commercial analogues — even if supervised by a human with command authority — excluding the development of a narrow AI designed, say, to run a factory or operational system from top to bottom. In these arenas, military-grade algorithms may require conceptual breakthroughs that other countries may find hard to rapidly mimic.

China's AI strategy highlights the way many countries increasingly view AI as a global competition that involves nation-states, rather than as a market in which companies can invest.

Second, some military AI applications , such as image recognition, do have obvious commercial counterparts. Even in those cases, however, the cybersecurity concerns and reliability associated with military-grade technology can differ from those for civilian applications. Military AI systems deployed in the field may require hardening for electronic warfare and extra protections from spoofing and hacking that would be of relatively less concern in the civilian world. In military environments, adversaries' efforts to hack and spoof increase the need for security.

The potential for countries to have strong commercial AI research sectors may mean that even narrow AI developments with applications geared toward military use may be easier to mimic than, say, stealth technology has been over the last generation. But stealth is an outlier: It has proven uniquely difficult to copy relative to other military technologies over the past few hundred years.

For AI developments that do not have clear commercial analogues, there could be substantial first-mover advantages for militaries that swiftly adopt AI technologies, particularly if they can achieve compute-driven breakthroughs that

105 The issue of algorithm theft raises questions of cybersecurity. This differs from more common questions about whether cyberweapons are autonomous weapons. On cyber in general, see Thomas Rid, *Rise of the Machines: A Cybernetic History* (New York: W. W. Norton, 2016); Rebecca Slayton, "What Is the Cyber Offense-Defense Balance? Conceptions, Causes, and Assessment," *International Security* 41, no. 3 (2017): 72-109, https://doi.org/10.1162/ISEC_a_00267; Ben Buchanan, *The Cybersecurity Dilemma: Hacking, Trust, and Fear Between Nations* (Oxford: Oxford University Press, 2017); Nina Kollars, "The Rise of Smart Machines," in *The Palgrave Handbook of Security, Risk, and Intelligence*, ed. Robert Dover, Huw Dylan, and Michael Goodmans (London: Palgrave MacMillan, 2016), 195-211.

106 Stephen G. Brooks, *Producing Security: Multinational Corporations, Globalization, and the Changing Calculus of Conflict* (Princeton, NJ: Princeton University Press, 2005); Andrea Gilli and Mauro Gilli, "The Diffusion of Drone Warfare? Industrial, Organizational and Infrastructural Constraints," *Security Studies* 25, no. 1 (2016): 50-84, https://doi.org/10.1080/09636412.2016.1134189.

107 Gilli and Gilli, "Military-Technological Superiority." Note this extends the argument to AI.

are difficult to copy. What would this mean for AI competition? As described above, China's AI strategy highlights the way many countries increasingly view AI as a global competition that involves nation-states, rather than as a market in which companies can invest.[108] As Elsa Kania writes, the People's Liberation Army (PLA)

> is funding a wide range of projects involving AI, and the Chinese defense industry and PLA research institutes are pursuing extensive research and development, in some cases partnering with private enterprises.[109]

Adopting militarily-exclusive AI technologies could also generate significant organizational pressure on militaries. Even if it would be hard for most countries to be fast followers, or mimic the advances of other militaries, great-power competition in AI would generate risk for those powers that are unable to adapt in order to organizationally exploit advances in AI, even if they are able to make technical advances. Traditionally, this risk is highest for the world's leading military power, in this case the United States. Leading military powers often struggle to envision how to use new technologies in ways that are organizationally disruptive. They can also be blind to that fact, believing they are in the lead right up to the point when their failure of creativity matters.[110]

From a balance-of-power perspective, this scenario would be more likely to feature disruption among emerging and great powers but not a broader leveling of the military playing field. The ability to exclude many countries from advances in AI would concentrate military competition among current leading militaries, such as the United States, China, and Russia. There could be significant disruption within those categories, though. A Chinese military that more rapidly developed critical algorithms for broader battle management, or that was more

108 Elsa B. Kania, "Battlefield Singularity: Artificial Intelligence, Military Revolution, and China's Future Military Power," *Center for a New American Security*, Nov. 28, 2017, https://www.cnas.org/publications/reports/battlefield-singularity-artificial-intelligence-military-revolution-and-chinas-future-military-power.

109 Kania, "Battlefield Singularity": 4. .

110 Gilpin, *War and Change in World Politics*.

willing to use them than the United States, might gain advantages that shifted power in the Asia-Pacific. This assumes that these algorithms operate as they are designed to operate. All militarily-useful AI will have to be hardened against hacking and spoofing. Operators will use narrow AI applications only if they are as or more effective or reliable as existing inhabited or remotely-piloted options.[111]

While this discussion has focused on narrow AI applications, the notion of bilateral competition in AI may be most pressing when thinking about artificial general intelligence.[112] Although artificial general intelligence is beyond the scope of this paper, it would matter as a discrete competitive point only if there is a clear reward to being first, as opposed to being a fast follower. For example, developing artificial general intelligence first could lock in economic or military leadership. Then others would not have the ability to adopt it themselves, or their adoptions would be somehow less relevant, and that could be a discrete "end point" to competition. It seems unlikely, however, that such development would be that discrete or that one country would get a lead in this technology that is so large that it can consolidate the impact of being a first mover before others catch up.

China is spending much more than the United States on AI research.

Conclusion

Technological innovations, whether the machine gun, the railroad, or the longbow, can influence the balance of power and international conflict. Yet their impact is generally determined by how people and organizations use the technology rather than by the technology itself.[113] It is too early to tell what the impact of narrow AI will be, but technology development suggests it will have at least some effect.

As an "enabling" technology that is more like electricity or the combustion engine than a weapon system, narrow AI is likely to have an impact that extends beyond specific questions of military superiority to influence economic power and societies around the world. This article demonstrates that technological innovation in AI could have large-scale consequences for the global balance of power. Whatever the mix of dual-use AI or militarily-exclusive AI that ends up shaping modern militaries over the next few decades, the organizational adoption requirements are likely to be significant. Militaries around the world will have to grapple with how to change recruiting and promotion policies to empower soldiers who understand algorithms and coding, as well as potential shifts in force structure to take advantage of AI-based coordination on the battlefield.

Military and economic history suggests that the effect of narrow AI could be quite large, even if suggestions of AI triggering a new industrial revolution are overstated. Adoption capacity theory shows that changes in relative military power become more likely in cases of military innovations that require large organizational changes and the adoption of new operational concepts. Even if the United States, China, and Russia were to end up with similar levels of basic AI capacity over the next decade, the history of military innovations from the phalanx to blitzkrieg suggests it is *how* they and others use AI that will matter most for the future of military power.

Whether AI capabilities diffuse relatively slowly or quickly, major military powers will likely face security dilemmas having to do with AI development and deployment. In a slow diffusion scenario, if countries fear that adversaries could get ahead in ways that are hard to rapidly mimic — and small differences in capabilities will matter

111 Paul Scharre, "Autonomous Weapons and Operational Risk," *Center for a New American Security*, working paper, (February 2016), https://www.cnas.org/publications/reports/autonomous-weapons-and-operational-risk.

112 Thanks to Heather Roff for making this point clear.

113 H.R. McMaster, "Continuity and Change: The Army Operating Concept and Clear Thinking About Future War."

on the battlefield — that will foster incentives for quick development and deployment. In a rapid diffusion scenario, competitive incentives will also exist, as countries feel like they have to race just to keep up.[114] Moreover, it will be inherently difficult to measure competitors' progress with AI (unlike, say, observing the construction of an aircraft carrier), causing countries to assume the worst of their potential rivals.

Competition in developing AI is underway. Countries around the world are investing heavily in AI, though the United States and China seem to be ahead. Yet even if the space-race analogy is not precise, understanding AI as a competition can still be useful. Such frameworks help people and organizations understand the world around them, from how to evaluate international threats to the potential trajectory of wars.[115] If likening competition in AI to the space race clarifies the stakes in ways that generate incentives for bureaucratic action at the government level, and raises corporate and public awareness, the analogy stands to have utility for the United States.

From a research perspective, one limitation of this article is its focus on the balance of power and international competition, as opposed to specific uses of AI. Future research could investigate particular implementations of AI for military purposes or other critical questions. Specific implementations could include the use of autonomous weapon systems able to select and engage targets on their own. These systems could raise ethical and moral questions about human control,[116] as well as practical issues surrounding war that is fought at "machine speed."[117] The integration of AI into early-warning systems and its ability to aid in rapid targeting could also affect crisis stability and nuclear weapons.[118] In the broader security realm, AI will affect human security missions.[119] By laying out an initial framework for how military applications of narrow AI could structure international competition and the balance of power, this article lays the groundwork for thinking through these questions in the future.

This article also raises a series of policy questions. When thinking about AI as an arena for international competition, one question is whether, in response to China's AI strategy, the United States should launch its own comprehensive AI strategy. In 2016, the Obama White House released an AI policy road map. It acknowledged the importance of U.S. leadership in AI but focused mostly on regulatory policy questions.[120] The transition from Barack Obama to Donald Trump led to a pause in these efforts, though the White House recently announced the creation of a new committee of AI experts to advise it on policy choices.[121]

Some might argue that it is necessary for the United States to develop and announce a formal AI strategy similar to China's.[122] While there are plenty of private-sector incentives for the development of AI technology, only the government can coordinate AI investments and ensure the development of particular implementations that it considers critical for AI leadership.[123]

On the other hand, it is the free market in the United States, and its connections to the global economy, that have made the United States an engine of global innovation. More centrally planned economies have often struggled with innovation. During the Cold War, the Soviet defense industrial base and military proved effective at perfecting existing technologies or adopting technologies.

114 On the security dilemma, see Robert Jervis, "Cooperation Under the Security Dilemma," *World Politics* 30, no. 2 (1978): 167-214, http://www.jstor.org/stable/2009958. This would also make arms control more difficult.

115 Yuen Foong Khong, *Analogies at War: Korea, Munich, Dien Bien Phu, and the Vietnam Decisions of 1965* (Princeton, NJ: Princeton University Press, 1992).

116 Michael C. Horowitz, "The Ethics and Morality of Robotic Warfare: Assessing The Debate Over Autonomous Weapons," *Daedalus* 145, no. 4 (2016): 25-36, https://doi.org/10.1162/DAED_a_00409.

117 On warfare at machine speed, see Robert O. Work, *Deputy Secretary of Defense Remarks to the Association of the U.S. Army Annual Convention*, Oct. 4, 2016, https://www.defense.gov/News/Speeches/Speech-View/Article/974075/remarks-to-the-association-of-the-us-army-annual-convention/. On AI and the speed of war, see Allen and Husain, "On Hyperwar."

118 Horowitz, Scharre, and Velez-Green, "A Stable Nuclear Future?"

119 Heather Roff, "Advancing Human Security Through Artificial Intelligence," *Chatham House*, May 2017, https://www.chathamhouse.org/publication/advancing-human-security-through-artificial-intelligence.

120 Ed Felten and Terah Lyons, "The Administration's Report on the Future of Artificial Intelligence," *White House*, Oct. 12, 2016, https://obamawhitehouse.archives.gov/blog/2016/10/12/administrations-report-future-artificial-intelligence.

121 Aaron Boyd, "White House Announces Select Committee of Federal AI Experts," *Nextgov*, May 10, 2018, https://www.nextgov.com/emerging-tech/2018/05/white-house-announces-select-committee-federal-ai-experts/148123/.

122 For a recent example, see William A. Carter, Emma Kinnucan, and Josh Elliot, "A National Machine Intelligence Strategy for the United States," *Center for Strategic and International Studies* and *Booz Allen Hamilton*, March 2018, https://www.csis.org/analysis/national-machine-intelligence-strategy-united-states.

123 Allen and Husain, "The Next Space Race Is Artificial Intelligence."

The centralized Soviet system, however, made true innovation more difficult.[124]

China is spending much more than the United States on AI research, and Chinese AI researchers are producing more papers on topics such as deep learning than U.S. researchers.[125] How that translates into tangible advances in AI technology is unclear. From a balance-of-power perspective, one could argue that the optimal approach would involve a mixed strategy between market and government development of AI. In the economic arena, central planning can stifle innovation, meaning the role of government should be to fund basic research and then let market incentives do the rest.

The defense sector may be different, however. For the United States, it will be up to the Department of Defense to clearly outline what types of AI technologies are most useful and to seed research and development to turn those technologies into a reality. For any strategy, for both the United States and China, a principal challenge will be translating basic research in programs of record into actual capabilities. As Cummings writes about government agencies working on AI systems around the world, "[T]he agencies developing these technologies are struggling to make the leap from development to operational implementation."[126]

More broadly, if investing in and appropriately utilizing AI is critical to military power in the 21st century, the U.S. approach is a mixed bag. Optimists can point to investments in connecting cutting-edge research to U.S. military forces through institutions such as the Defense Innovation Unit – Experimental (DIUx), the Strategic Capabilities Office, and the Defense Advanced Research Projects Agency (DARPA). From discussions of the "Third Offset" to "Multi-Domain Battle," senior military and civilian leaders are also taking the challenge of AI seriously.[127]

Meanwhile, a great deal of bottom-up innovation is happening in the U.S. military, both in terms of developing technologies and experimenting with novel concepts of operation. It is possible that the research and smaller, experimental programs that the United States is funding will become part of mainstream U.S. military programs, enabling the United States to stay ahead and sustain its military superiority. If narrow AI continues to develop, adopting the technology will require sustained attention by senior leaders.

Pessimists, however, can point to a gap between rhetoric and unit-level experimentation on the one hand and budgetary realities on the other.[128] There is a lot of discussion about the importance of artificial intelligence and robotics, as well as a clear desire among senior uniformed leadership to make the U.S. military more networked, distributed, and lethal by taking advantage of AI, among other technologies.[129] This rhetoric has not yet caught up to reality in terms of U.S. military spending on AI. When faced with a choice of investing in a next-generation drone, for example, the U.S. Navy used its available programmatic dollars for the MQ-25 air-to-air refueling platform, which will support inhabited aircraft such as the F-35. The MQ-25 program was chosen over an advanced armed system — based on the X-47B demonstrator — with stealthy potential that could operate in dangerous conflict environments.[130] The MQ-25 decision may be seen as the canary in the coal mine if the U.S. military falls behind in the coming decades — especially if a failure to appropriately adopt advances in AI and robotics turns out to be a key reason for that relative military decline.

At the end of the day, however, AI's effect on international politics will depend on much more than choices about one particular military program. The challenge for the United States will be in calibrating, based on trends in AI developments, how fast to move in incorporating narrow AI applications. This will be true whether those applications are dual-use or based in exclusively-military research. And that challenge to leadership in AI in general, as well as in military power,

124 Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies* (Ithaca, NY: Cornell University Press, 1988).

125 Cade Metz, "As China Marches Forward on A.I., the White House Is Silent," *New York Times*, Feb. 12, 2018, https://www.nytimes.com/2018/02/12/technology/china-trump-artificial-intelligence.html.

126 Cummings, 9.

127 Tom Simonite, "Defense Secretary James Mattis Envies Silicon Valley's AI Ascent," *Wired*, Aug. 11, 2017, https://www.wired.com/story/james-mattis-artificial-intelligence-diux/; Gopal Ratnam, "DARPA Chief Touts Artificial Intelligence Efforts," *Roll Call*, Mar. 1, 2018, https://www.rollcall.com/news/politics/darpa-chief-touts-artificial-intelligence-efforts.

128 On bottom-up innovation, see Grissom, "The Future of Military Innovation Studies." On innovation inhibitors, see Adam M. Jungdahl and Julia M. Macdonald, "Innovation Inhibitors in War: Overcoming Obstacles in the Pursuit of Military Effectiveness," *Journal of Strategic Studies* 38, no. 4 (2015): 467-499, https://doi.org/10.1080/01402390.2014.917628.

129 Adm. Harry B. Harris Jr. et al., "The Integrated Joint Force: A Lethal Solution for Ensuring Military Preeminence," *Strategy Bridge*, March 2, 2018, https://thestrategybridge.org/the-bridge/2018/3/2/the-integrated-joint-force-a-lethal-solution-for-ensuring-military-preeminence.

130 Sam LaGrone, "Navy Releases Final MQ-25 Stingray RFP; General Atomics Bid Revealed," *USNI News*, Oct. 10, 2017, https://news.usni.org/2017/10/10/navy-releases-final-mq-25-stingray-rfp-general-atomics-bid-revealed.

is complicated by the movements of China and other competitors, all of which seem interested in leveraging AI to challenge U.S. military superiority.

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