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China's Pursuit of Emerging and Exponential Technologies

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Chairwoman Stefanik, Ranking Member Langevin, and distinguished members, thank you for inviting me to testify today.

We live in a time of dizzying technological change. The information revolution, which has now been underway for several decades, continues to unfold in surprising ways. The United States was a first-mover in information technology. By leveraging advances in the microprocessor revolution in the 1970s and 1980s, the United States led the world in the development of personal computers, the internet, the Global Positioning System (GPS), and other information-based technologies. Today, information technology has spread to nearly every corner of our lives. It has also spread around the world. While the United States is still the global leader in information technology, other nations are now also significant players. China, in particular, is a major and fast-growing player in information technology.[1]

As the world's third largest economy behind the United States and the European Union and as the most populous nation in the world, China has major structural advantages that make it a key competitor in information technology. China's population, in particular, is a key source of strength because it is a potential source of data on human behavior and genomics. Combined with a more lax cultural attitude towards data protection and personal privacy, this data can help fuel advances artificial intelligence and synthetic biology.[2]

The Information Revolution

There are three broad trends underlying the information revolution: the datafication of our world, increasing networking and connectivity, and increasingly intelligent machines. These trends intersect and reinforce each other in powerful ways, and understanding these trends can help in understanding some of China's structural advantages.

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Datafication of our world: The modern information economy produces over 2.5 exabytes of data daily (an exabyte is one quintillion bytes, or 10^18 bytes).[3] In the past few years the information revolution has generated more data than existed in the entire 5,000 years of recorded human history. This data comes in a variety of forms: mapping data showing patterns of human activity and the locations of people and things; human communications data showing people's networks and the content of their interactions; search, shopping, and entertainment data showing people's preferences and interests; and as gene sequencing becomes cheaper, the digitization of human genetic data. This trend in the datafication of our world is digitizing and quantifying the world around us: our lives, our bodies, and our likes and desires. Much of this data is unstructured and unlabeled, making it a sea of potential information, if one can sort and organize this data to yield useful insights.

Networking and connectivity: The world is increasingly networked, making it possible to transmit and share this new ocean of digital data. In 2017, global internet users topped 3.8 billion people, more than half of the world's population. Nearly 5 billion people use cell phones – roughly two-thirds of the world. Nearly 3 billion people are active social media users. And global connectivity continues to grow at a breakneck pace. Every day more than a million new people join social media.[4] As more people come online, their data comes online as well. They, too, become digitized. People and companies are also sharing this data, sending it over networks that are growing in scale and bandwidth. The number of connected devices is growing even faster than internet users. An estimated 20 billion devices will be connected to this sprawling global network in 2018. Internet of Things (IoT) devices, which include smart meters, medical devices, home appliances, and industrial applications, are growing at the fastest rate and by 2021 are expected to account for over half of all connected devices.[5] These devices create data and share it across a global network that will traffic over 150 exabytes of data per month in 2018. Global internet traffic is growing even faster than connectivity, at a rate of 24% per year. Broadband speeds are increasing to account for this data and are expected to roughly double over the next 5 years.[6] It is not just the amount of connected people, devices, and data and that is increasing, but the volume and speed at which they are communicating.

More intelligent machines: These trends have been made possible because of exponential growth in computer processing power, which enables ever-smaller and more powerful computers, tablets, smartphones, and devices. For the past fifty years, this trend has been encapsulated in a maxim known as Moore's Law, named for Intel co-founder Gordon Moore, which has observed that chip performance has doubled roughly every two years.[7] The rate of advancement of CPU (central processing unit) performance has slowed in recent years. While still improving exponentially, it has been at a markedly slower pace as chips have approached the nanometer scale.[8] At the same time, in the past few years there has been an explosion in deep learning, a powerful machine learning technique used to enable artificial intelligence (AI). This has yielded resulted in tremendous progress on long-standing AI problems such as object recognition and natural language processing. Deep learning draws on large amounts of parallel computer processing, made possible because of advances in graphics processing units (GPUs) driven by the gaming industry; as well as large amounts of data. In deep learning, deep neural networks train on millions of pieces of data to learn how to recognize objects, translate between languages, or perform many other cognitive tasks. Deep learning systems can even learn from unlabeled data, a process known as unsupervised learning.[9] Thus, advances in increasingly powerful computer processors have enabled the production of myriad devices that collect vast quantities of data, which in turn have fueled learning machines that can process and make sense of this data.

China's population is a major structural advantage in this information revolution, as it allows the pooling of large amounts of data. China already has 730 million internet users, a figure that will grow as the country becomes increasingly urbanized and connected. Chinese users also appear more comfortable sharing their data than Western counterparts, which companies can use to train more sophisticated algorithms to understand human behavior.[10]

China also combines a dynamic private sector with a government that plans and executes long-term strategies to increase China's competitiveness in key technology areas. China has used this in recent years to execute plans to leap forward on artificial intelligence, synthetic biology, and quantum computing, all key technologies tied to the information revolution.

Artificial Intelligence

China is a global leader in artificial intelligence, second only to the United States. Baidu, Tencent, and Alibaba – all Chinese firms – are top-tier AI companies, and China also has a vibrant AI startup scene.[11] Since 2014, China has surpassed the United States in the total number of publications and cited publications in deep learning, an important sub-field of AI.[12] The United States still leads the world in AI patents, but China is growing at a faster rate.[13] While the quantity of publications does not necessarily equate to quality, Chinese AI researchers perform well in international competitions.[14] Chinese teams "dominated" the ImageNet visual image recognition competition for the past two years and a Chinese start-up won the Facial Recognition Prize Challenge hosted by the Intelligence Advanced Projects Agency (IARPA).[15] Overall, Chinese AI researchers are not as experienced as U.S. counterparts, but they are improving.[16] In the 2017 meeting of the Association of the Advancement of Artificial Intelligence (AAAI), there were roughly as many papers accepted from China as there were from the United States.[17]

In July 2017, China published a national strategy for artificial intelligence, the "New Generation AI Development Plan."[18] Under this plan, China's goal is to be the "premier global AI innovation center" by 2030.[19] To achieve this goal, China's plan includes improving in areas where China is currently weak, such as human capital, by focusing on the education and recruitment of top AI talent. As one example, Chinese-born and American-educated AI researcher Qi Lu recently left an executive vice president role at Microsoft to become the Chief Operating Officer at Baidu.[20] News reports indicate Chinese firms see the Trump Administration's anti-immigrant policies as an opportunity to draw away top U.S. technology talent, as immigrants are responsible for one-quarter of startups in the United States.[21]

China also has significant advantages in translating private sector advances in AI into national security applications because of its model of military-civil fusion.[22] In the United States, the Department of Defense (DoD) has struggled to break down largely self-imposed barriers to working with non-traditional defense companies that lock the DoD out of crucial innovation in places like Silicon Valley. China has a closer relationship between the public and private sector and is able to more easily "spin in" private sector innovations into the military through their strategy of military-civil fusion. This means that not only is China a significant global player in artificial intelligence – with a plan to be the global leader by 2030 – but that China has major advantages in translating these private-sector gains into national security applications.

Synthetic Biology and Genomics

The information revolution has opened up new opportunities in biotechnology as computers have made genome sequencing increasingly affordable. The cost of sequencing the human genome has been falling exponentially at a rate faster than Moore's Law.[23] In turn, the acquisition of large datasets of human genomes has significant research potential, as these datasets can be mined by data analytics and AI for correlations between genes and health outcomes. A Chinese company, Beijing Genomics Institute (BGI), is the world's largest genetic research center. BGI has a U.S.-based center headquartered in Cambridge and has sequenced the genomes of millions of Americans. BGI has robust support from the Chinese government and partnerships with Chinese military research institutes such as the Academy of Military Medical Sciences.[24]

At the national level, the Chinese government is proactively engaged in developing its biotech sector and has created multiple national-level biotechnology development plans. One of the strategies China uses to advance its biotechnology industry, as in other areas, is "going out" and "bringing in" foreign innovation by investing in foreign companies.[25] For example, in 2013 BGI acquired next-generation genome sequencing technologies by purchasing the U.S. company Complete Genomics.[26]

The importance of genomics is likely to increase as the cost of gene sequencing continues to fall and larger datasets of human genomes are established, making possible large-scale analysis of human genes. Given that the ultimate aim is modifying life itself, it is nearly impossible to overstate the long-term potential of synthetic biology and genomics. As this field matures, China is well-positioned to be a global leader.

Quantum Computing

Quantum computing is another important area of information-related technologies and one in which China has shown striking recent advances. Quantum computing is an entirely different method of computing from current approaches and relies on the unusual properties of quantum physics. Quantum technology has many potential national security applications, including cryptography, remote sensing, and secure communications.[27] Chinese researchers have made recent strides in quantum technology, demonstrating a 10-qubit quantum processor and a quantum communications satellite in 2017.[28] China is following up on these advances with national-level investments in quantum technologies. China recently launched the Jinan Project, a plan to build a secure quantum computer network, and is building a $10 billion National Laboratory for Quantum Information Sciences.[29]

Conclusion

As the world's third-largest economy and most populous nation, China has many inherent structural advantages in competing in high-technology areas. China has a dynamic private sector, with both large established firms and dynamic start-ups, and a large pool of potential talent to draw upon. In places where China has weaknesses, such as the quality of human capital in some fields, China is actively working to improve by recruiting top talent from abroad. China's population, increasingly networked and digitized, is a major source of potential data, which is a critical resource for information-enabled innovation. One of China's biggest strengths relative to the United States, however, is the government's willingness to develop and follow through on large-scale long-tem investment plans in key technology areas. China has repeatedly demonstrated an ability, in multiple technology areas, to acquire foreign expertise by investing in foreign companies and then using that to improve Chinese indigenous capabilities. China's capacity for executing long-term strategies for technology development should not be underestimated, and Chinese plans to become the global leader in critical technology areas such as artificial intelligence should be taken seriously.

Further Reading

For further reading, see:

Michael J. Biercuk and Richard Fontaine, "The Leap Into Quantum Technology: A Primer for National Security Professionals," War on the Rocks, November 17, 2017, https://warontherocks.com/2017/11/leap-quantum-technology-primer-national-security-professionals/.

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From 2008-2013, Mr. Scharre worked in the Office of the Secretary of Defense (OSD) where he played a leading role in establishing policies on unmanned and autonomous systems and emerging weapons technologies. Mr. Scharre led the DoD working group that drafted DoD Directive 3000.09, establishing the Department's policies on autonomy in weapon systems. Mr. Scharre also led DoD efforts to establish policies on intelligence, surveillance, and reconnaissance (ISR) programs and directed energy technologies. Mr. Scharre was involved in the drafting of policy guidance in the *2012 Defense Strategic Guidance*, *2010 Quadrennial Defense Review*, and Secretary-level planning guidance. His most recent position was Special Assistant to the Under Secretary of Defense for Policy.

Prior to joining OSD, Mr. Scharre served as a special operations reconnaissance team leader in the Army's 3rd Ranger Battalion and completed multiple tours to Iraq and Afghanistan. He is a graduate of the Army's Airborne, Ranger, and Sniper Schools and Honor Graduate of the 75th Ranger Regiment's Ranger Indoctrination Program.

Mr. Scharre has published articles in the *New York Times, Foreign Policy, Politico, Proceedings, Armed Forced Journal, Joint Force Quarterly*, *Military Review*, and in academic technical journals. He has presented at the United Nations, NATO Defence College, Chatham House, National Defense University and numerous other defense-related conferences on robotics and autonomous systems, defense institution building, ISR, hybrid warfare, and the Iraq war. He has appeared as a commentator on CNN, MSNBC, NPR, the BCC, and Swiss and Canadian television. Mr. Scharre is a term member of the Council on Foreign Relations. He holds an M.A. in Political Economy and Public Policy and a B.S. in Physics, cum laude, both from Washington University in St. Louis.

Notes

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