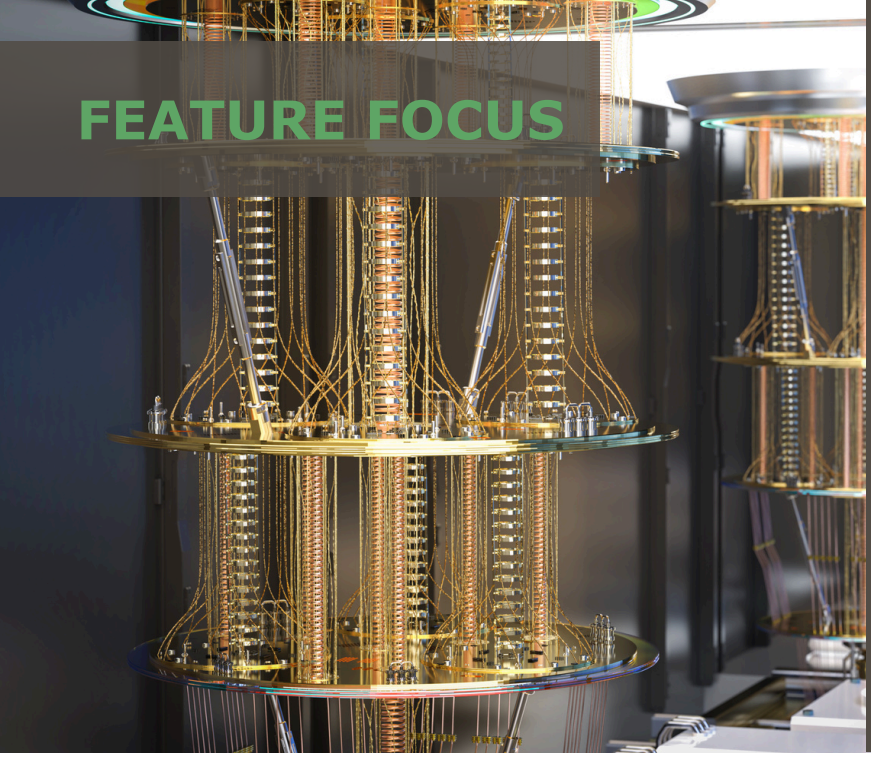

FEATURE FOCUS

AN ASSESSMENT OF THE CHINESE COMMUNIST PARTY'S "MADE IN CHINA 2025" INITIATIVE ON TECHNOLOGICAL ADVANCEMENT AND ECONOMIC DEVELOPMENT IN THE AREA OF QUANTUM COMPUTING

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Unlike in Western countries where bipartisan concept exists in the government, the governments in China, Vietnam, and North Korea follow only one Communist party. The Communist government holds the highest power where they issue laws, collect taxes, and control most of the major industries of the country such as mineral mining, oil drilling, banking, export, and import. Each Communist government often launches 5-year or 10-year initiatives to boost different sectors during a certain period of time. The "Made in China 2025 (MIC 2025) Initiative" is one of China's planned initiatives to help boost their economy and defense system. According to McBride and Chatzky, "Made in China 2025 is the government's ten-year plan to update China's manufacturing base by rapidly developing ten high-tech industries. Chief among these are electric cars and other new energy vehicles, next-generation information technology (IT) and telecommunications, and advanced robotics and artificial intelligence" [1]. This state-led 10-year plan aims to develop the country's industrial base by advancing high-technology production and implementation while strengthening and protecting its economy. While the MIC 2025 focuses on ten key high-tech sectors ranging from bioengineering to maritime engineering, the focus in this paper will be on quantum computing. We have conducted our research, analysis, and completed our writing in collaboration with the U.S. Cyber Command and thus, we will analyze this sector from a cyber environment perspective. The Office of the Director of National Intelligence (ODNI), in its 2024 Annual Threat Assessment, asserts that "China remains the most active and persistent cyber threat to U.S. Government, private-sector, and critical infrastructure networks" [2]. With this in mind, we seek to evaluate the pertinent topic of China's cyber advancement via MIC 2025 on the global geopolitical landscape with the focus on quantum computing capabilities.

Quantum computing is known as supercomputing and are also understood "as specialized computers that can solve specialized problems set at an extremely fast rate such as complex optimization problems or molecular modeling, that current computers cannot" [3]. It uses qubit instead of bit which is used in traditional computing. Even though quantum computing is not fully developed yet, many nations have entered the race to develop their own quantum computing capabilities which can serve in many sectors from medicine, business, science, computing, and communication to national defense systems. According to Penney, "Quantum computers may also be more efficient and faster at highly complex artificial intelligence/machine learning algorithms, but there are also many use cases where classical (or traditional) binary computing delivers faster and more accurate solutions" [3].

Investment and achievements

China has invested billions of dollars in Quantum computing in recent years. They have attracted many physicists and scientists around the world to help them build complete made-in-China quantum computers by heavily funding quantum computing sector. For example, the United States committed to fund an additional $1.8B in quantum computing while China also announced that it would invest $15.3B [4]; however, according to Freedberg, maybe China only invested about $4B [5]. China's actual investment in quantum computing remains unclear until today.

Quantum computing is a new technology race for many nations. Thus, many startups to giant tech firm have entered this field. According to Dargan, there are 9 major quantum computing companies in China such as Baidu Research, Ciqtek, Huawei Cloud, Origin Quantum, Qasky, Quantumctek, Qudoor, Tencent Quantum Lab, ZTE. They focus on applying quantum computing in "search engines, cloud computing, online business platforms, software solutions, network security, quantum cryptography communications, quantum AI, quantum algorithms and quantum architecture" [6].

The U.S. surpass China in both the number of quantum computing companies and patents: "12 public and 78 private start-up quantum computing companies with over 1086 patents" versus "a dozen companies and 384 patents in China;" and the U.S. has closed 110 quantum computing deals while China only has closed 30 deals [7]. Giant technology firms such as Google, Microsoft, Intel, and IBM have invested dramatically in this field. According to Pichai, the CEO of Google, Google was "the first company" to launch a strong complete quantum computer in 2019 after "13 years of research and development" [8]. For example, "Google recently achieved quantum supremacy by solving a problem in 200 seconds that would take a classical computer 10,000 years to solve" [9]. In response to this event, China claimed that they have successfully built two complete quantum computers which is much stronger than the one Google built; however, China did not provide any evidence to support their claim.

Quantum computing potential application

Quantum computing has vast promising future applications varying from medical field, business services to national defense system. According to Amerongen, a co-author of NATO's White Paper on Quantum Technologies, the focus of quantum computing will be on "quantum sensing, quantum communication, quantum computing, implications for defense and security" [10].

First, quantum sensing can increase the precision of medical imaging and diagnosis which helps detect any ailment in the early stage, so medical physicians deliver more accurate treatment schedules and medication to shorten the treatment time and save more lives. For instance, "… quantum sensors can detect subtle brain activity changes, aiding in the diagnosis and monitoring of neurological disorders [20]. Similarly, in cardiology and oncology, quantum-enhanced imaging techniques provide valuable insights into heart conditions and cancer detection" [11].

Second, quantum communication used qubit which is more secure than bit in optical fiber cables in traditional internet. According to Amerongen, when hackers try to steal data by interrupting data during its transmission, quantum communication channel will collapse which means hackers cannot steal data since "quantum computing is extremely sensitive to external disturbances" [10]. Quantum communication opens the door for ultra-secure data transmission via the internet since data becomes un-hackable in quantum communication which creates a much safer channel for transferring data in the future.

Third, quantum computing can simulate drug discovery and new materials, solve complicated optimal solutions in logistics and finance. Additionally, it combines artificial intelligence for advanced machine learning and applies to asymmetric encryption algorithm for secure data transmission. "Big technology companies like IBM, Google and Microsoft are racing for 'quantum supremacy', which is the point where a quantum computer succeeds in solving a problem that no classical computer could solve in any feasible amount of time" [10].

Fourth, implications of quantum computing for defense and security are extremely important in any defense system. For instance, according to Smith-Goodson, "Once fully developed, quantum radar could threaten the US lead in stealth technology. That translates into the increased vulnerability of US stealth aircraft such as the B-2 Spirit, F-22 Raptor, F-35 Lightning II, and allied stealth aircraft. Quantum radar might also be able to determine the type of aircraft or the weapons the plane is carrying. It could also compromise US domination over the electromagnetic domain in combat environments" [9].

However, during the 118th Congress Hearing on Current and Emerging Technologies in U.S.-China Economic and National Security Competition, Thursday, February 1, 2024, Freedberg Jr. stated that the U.S. ruled out quantum radar and quantum key distribution (QKD) technologies while China has invested heavily on them. Experts predicts that this could be bad bets for China since "the U.S. military has publicly identified quantum radar as impractical" [5]. He wrote "My own assessment largely agrees with the U.S. DoD's position that QKD and quantum radar are unlikely to deliver significant military operational advantage" [5].

Quantum computing technologies help increase the security and ability of detecting objects in air, land, and water. These technologies will have a huge impact on future economy and defense systems for any nation.

Current Challenges

Quantum computing chips get very hot during their operations. Chinese companies have successfully developed a device called EZ-Q Fridge, which "is designed to provide an ultra-low temperature environment, nearing absolute zero Celsius, crucial for the optimal performance of quantum computing chips" [12]. Chinese companies enjoyed the success of their research and development as it performed well in testing and those companies have begun deliveries of this refrigerators to their customers starting in the second quarter of 2023; however, there is no evidence about how effective the EZ-Q Fridge are yet.

The U.S. researchers are in testing phase for a new cooling technology for quantum computing. According to Toon, "A new cooling technique that utilizes a single species of trapped ion for both computing and cooling could simplify the use of quantum charge-coupled devices (QCCDs), potentially moving quantum computing closer to practical applications" [13]. This promising technology can be used to produce a cooling system for any device or system that uses quantum chips.

Economic and technology prediction

Although quantum computing is still in its infancy stage, investors around the world have already started investing in quantum computing companies varying from start-ups to giant tech firms. According to Williams, the investment in this market was nearly $500M in 2021 but it is expected to reach nearly $1.7B by the end of 2026 [14]. Quantum computing seems to set the run for the fifth industrial revolution. In addition, Bogobowicz et al. predicted that "… the four industries likely to see the earliest economic impact from quantum computing—automotive, chemicals, financial services, and life sciences—stand to potentially gain up to $1.3Tin value by 2035" [4].

Quantum computing application in medical field may lead to advance technologies in treatment and medicine which would draw people to the U.S. for medical tourism. According to Precedence Research, the global medical tourism market is predicted to grow very fast from about $116B in 2022 to more than $346B in 2032 [15]. It triples this market value within a 10-year period. Medical tourism has become very popular in the last decade since wealthy people still want to get advanced medical care such as high technology, advanced medicine, and better services. It is one of the most attractive markets that contributes a good revenue to a nation's economy which helps boost other sectors of the economy such as retail, other services, hospitality, and tourism industry.

According to Liu, "In 2022, GlobalData said the U.S. was about five years ahead of China in the quantum computing race. Now, in 2024, the firm considers the two countries as "nearly equal" in the arena" [16]. The quantum computing race is now nearly tied between the U.S. and China; however, the U.S. is behind with around 45 thousand versus China with nearly 58 thousand when it comes to the number of quantum computing talents [4]. Still, we are not sure about the quality of Chinese quantum talents yet.

The post-quantum cryptography (PQC) algorithms standard may be released in 2024. The National Institute of Standards and Technology (NIST) is in its final process to finalize a new standard for PQC communication encryption which cyber experts believe would provide long-term security for cyberspace communication. According to NIST, "The agency has begun the process of standardizing these algorithms — the final step before making these mathematical tools available so that organizations around the world can integrate them into their encryption infrastructure" [17].

Quantum computing threatens our nation's safety. The ability of combining two quantum computers to increase their power imposes a threat to our national defense system. According to Sanzeri, China has proven the "ability of entanglement sub-atomic particles and maintain them over twelve kilometers" which also means that quantum power can be used as a threat to crack standard encryption that our current defense system uses [18].

Recommendations

As mentioned, China surpasses the U.S. in the number of quantum computing talents which means China has more scientists and physicists than the U.S. Therefore, the U.S. should attract more quantum talents starting with nurturing the next generation. For instance, we should distribute more funding to high schools, colleges, and universities by providing excellent mathematics and science education programs to attract more students in this field.

In addition, we should facilitate visa program for quantum talents around the world who are currently studying in the U.S. or planning to come to the U.S. for studying and research in this field. Work permits should be granted to quantum talents so they can stay in the U.S. for work after their graduation.

According to Kitchen and Drexel, the U.S. should establish "stricter patent protections and more aggressive repercussions for domestic and international offenses in IP theft" [19]. The U.S. Department of Defense should maintain partnerships with private sectors as they have been doing in the last decade along with collaboration with our allies around the world in quantum computing research and development.

The U.S. should monitor the supply chain of exporting critical components and materials of quantum computers and also create an ecosystem where the government pays attention to the financial health of small, specialized quantum computing firms.

In conclusion, the U.S. should closely monitor quantum computing sector which means they have to set quantum computing standards and create an ecosystem where the government supports both public and private quantum computing companies. This will help the United States stay ahead in quantum computing race which support both the country's future economy and national defense system.

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