The Race for Tech Supremacy between US and China

Implications for the World, US and India

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The unravelling race for tech supremacy, as a microcosm of the macro trade war between US and China, can be depicted as Tech Race 2.0. In some ways, this is akin to the Space Race that unfolded between the US and the erstwhile USSR in the 1950s and 1960s, which eventually turned in favour of the US, given its fundamentals being firmly grounded in democracy, freedom of speech and robust innovation and business ecosystems. Since China shares some of the key elements that the Soviet Union had, it is likely that history can be repeated provided the US is fully aware of the challenges emanating from China and takes necessary steps by investing in the state-of-the-art technologies. The implications of the US losing the race could be far-reaching not only for the US, but also for the entire global order built on the liberal principles and values. The same is applicable for India since it shares a border with China and the border conflict continues

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Note: I would like to thank Dr Cherian Samuel for approaching me to contribute the piece and for being extremely patient in extending the deadlines a few times. I am also grateful to the two anonymous reviewers for their comments and suggestions.

ISSN 0976-1004 (print); 2583-7567 (online)

Journal of Defence Studies, Vol. 19, No. 1, January–March 2025, pp. 232–258

to persist. Therefore, it is imperative to save the global community from the dangers of authoritarian leaders and countries winning the race.

Keywords: *Technology, United States of America, China, India*

Introduction

The global community has been witnessing the unfolding of a major race for tech supremacy between the United States of America (hereafter US) and China in the last few years. This can be described as 'Tech Race 2.0', distinguishing it from the first tech race between the US and Soviet Union in which US maintained its supremacy. This second tech race is likely to intensify further given the American goal of maintaining the lead in the advancement of both high-tech and emerging technologies such as Artificial Intelligence (AI), Internet of Things (IoT), quantum computing, 5G technology and biotechnology. At the same time, China is raring to catch up with the US in the race given the rapid pace of development of diverse technologies since the early 1980s. What is interesting in this race for tech supremacy is that China benefitted quite substantially from the US and many advanced Western and other countries including the UK, France, Germany and Japan.

There are those who posit that the race is going to be quite competitive and yet the US will retain its edge[1] and maintain its supremacy given its fundamental building blocks of research and innovation being robust. But there are others such as Can Huang and Naubahar Sharif,[2] who argue that China is on the path of imminent global technological leadership. In such a context of two contrasting perspectives, what does one make of it and where does the reality lay. Against this backdrop, this article endeavours to explore the contours of the race for tech supremacy.

In some ways, this tech race is akin to an earlier race for tech supremacy between the US and the erstwhile Union of Soviet Socialist Republics (USSR) in the 1950s and 1960s which eventually tilted in favour of the former, given its resilient and tenacious innovation and tech capabilities coupled with a much more conducive and enabling ecosystem. While the endeavour to conquer outer space was at the core of the previous race for tech supremacy, AI is at the heart of the present race between the US and China. 'More than a decade of breakthrough after breakthrough in AI technology has convinced the policymakers in both Beijing and Washington that the leadership in AI technology is foundational to the future of economic and military power'.[3]

Against this backdrop, the article aims to map the trajectory of the tech race between the US and China. In doing so, it is divided into four sections.

The first section contextualises the race for tech supremacy situating it in theory and history. The second section delineates the key contours of the currently unfolding race for tech supremacy between US and China with a focus on their approaches to S&T development, S&T capabilities and some of the frontier technologies. The third section examines the implications for the world, US and India. This race has every possibility to set in motion the development of technology in different parts of the world including several countries in the European Union, Japan, South Korea, Taiwan and India. Losing the race will have major ramifications for the US and the liberal order. The implications of the widening gulf between India and China in the realm of S&T capabilities will be equally serious given the lack of adequate emphasis and commitment to the development of technology. The last section gives the concluding remarks.

Contextualising the Race for Tech Supremacy in Theory and History

To better understand the present race for tech supremacy between the US and China, it is imperative to situate it in the theoretical frameworks of International Relations (IR) wherein technology and IR intersect. In addition, since competition is a key component in the race for tech supremacy, Charles Horton Cooley's analysis of competition is also factored into the present discussion.

Theory

The centrality of technology cannot be undermined given its wide-ranging impact on human life and progress. Highlighting this component, Philip Faulkner and others[4] go on to articulate that technology is not only central to such traditional economic concerns such as economic growth, wealth creation and the alleviation of poverty, but also to wider societal issue ranging climate change, globalisation and the organisation of work, through to education, the provision of healthcare, and the development of media and the arts. For them, theorising technology involves a systematic delineation of the philosophy of technology, technology in social sciences and humanities with the focus on the Social Construction of Technology (SCOT), a framework that Wiebe Bijker, Thomas Huges and Trevor Pinch propounded, that takes into account the key contribution of society in the growth and dissemination of technology.[5] In addition, Bijker's thick conception of technology, which goes beyond just the technical component, and includes elements such

as ideas, institutions and policies that contribute to the advancement of technology.[6]Additionally Eugene Skolnikoff argues, the structure, growth and operation of the scientific and technological enterprises have had their bearing on international affairs leading to a new phase in the evolution of world politics, particularly after the Second World War.[7]

For Daniel McCarthy, 'since the inception of IR in the second half of the twentieth century, technology has been of central concern to the field'.[8] However, in complete contrast, Johan Eriksson and Lindy M. Newlove-Eriksson underscore that technology has not received the kind of attention it deserves within the realm of IR including in its theorisation.[9] Arguing that technology has received rather mixed and selective attention within IR and acknowledging that some themes such as information and network society, Internet governance, digital diplomacy have certainly been picked up in IR, they further posit that 'several other technological developments, which arguably impact on the shape and conduct of world politics, have until recently largely gone unnoticed in IR, including: artificial intelligence (AI), autonomous weapon systems (AWS), robotics, nanotechnology, 5G, the Internet of Things (IoT), space technology, bioengineering, neurotechnology, microelectronics, and combinations thereof.' They also map the contours of the place and significance attached to technology in IR theories such as realism, liberalism and constructivism and underscore the imperative of a new paradigm of techno-politics that gives primacy that technology deserves in the theoretical constructs of IR.

Giampiero Giacomello and others underscore that technology has emerged as a new frontier in enhancing global power. If human nature is the constant, technology is the variable that makes historical evolution what it is.[10] Unsurprisingly, technology transformation does influence the relationship among individuals and organisations, not only in domestic politics but also in the international system. For them, technology is a source of empowerment and, at the same time, of concern. They also go on to argue that most IR scholars have considered technology as an exogenous variable that can only have an impact on minor features of international affairs, perhaps with exceptions such as nuclear weapons or the Internet, and not as a central matter of inquiry and methodological debate.

On the theme of competition, Charles Horton Cooley's general theory enunciates that competition is a universal aspect of life, that it is neither good nor bad in itself but may be either, dependent upon its relation to the larger social order and the goals of competition; that it serves useful purposes in any social order; and that, though capable of refinement, it is ineradicable.[11] This

same doctrine may be applied to the smallest social group or to international relations. It involves a vigorous individuality of the respective units, a competitive spirit on the part of each unit, and subordination of the units to a larger social whole, under proper rules governing the competition. Any form of competition, under proper conditions, becomes good. Any form of competition, under other conditions, becomes an evil.[12]

Following Henry Sumner Maine's profound proposition that 'the increase of competition is a characteristic of modern life', the US and China are locked in a major competition for tech supremacy.

While competition, whether among individuals or institutions and industries, is beneficial, it can lead to conflict when it is not managed well. In doing so, it needs to be juxtaposed with cooperation. For Daniel McCarthy, 'competition and cooperation between multiple political communities, the place of foreign policy interests, the norms of international society; all of these are central to the character of technology and science'.[13] In fact, there has to be a balance between competition and cooperation. Given the nature of the development of technology over the centuries, it is imperative to strike a balance between the two.

History

Historically, especially during the ancient period, the development of technology was quite fragmented with a few pockets of bright spots such as Greco-Roman world,[14] India,[15] Egypt,[16] Mesopotamia[17] and China[18] besides a few other countries. In the medieval period, while the evolution of the development of technology stagnated in most countries, it flourished in countries such as China. In the 18th and 19th centuries, the Industrial Revolution opened up new vistas of the development of technology with the UK, US and other Western countries leading from the front. The globalisation of Western technology[19] occurred through the painful process of colonisation[20] which in turn led to the rapid dissemination of technology to the nook and corner of the world. What is uniquely distinctive until the 1940s was that there was no element of competition for tech supremacy.

The aftermath of the Second World War set in motion the first phase of tech competition during which the tech race between the US and Soviet Union began. The ideological divergence between the US and the erstwhile USSR was at the core of the first global race for tech supremacy. The tech race that unfolded between the US and Soviet Union in the 1950s and 1960s is often depicted as the Space Race wherein both contested to conquer the space. While the Soviet Union took the lead initially, the US not only caught

up but overtook by sending a mission to the Moon. Thereafter, as Richard Nelson[21] would argue that the US retained a dominant position because of its depth in mass production industries and substantial investment in science and technology, education and research and development. A subset of the race for tech supremacy, particularly during the 1970s and 1980s was that competition that emerged from Japan. Since both belonged to the liberal democratic order the race did not evolve into a major confrontation, though there were occasional contestations. Interestingly, the US retained its tech supremacy well into the early 1990s. However, in another article, Richard Nelson went on to explicate the rise and fall of the American technological leadership.[22]

In the post-Cold War era, the trajectory of the development of technology has taken an all new dimension, especially with the dissemination and exponential expansion of ICTs wherein not only some of the Western and other Asian countries like Japan and South Korea but also a few developing countries began to witness the advancement of technology. India and China belong to this cohort. Interestingly, this is, in some ways, a revival of the potential they had in history when they contributed to global technology in the form of zero, medical science from India and block printing, paper, compass and gunpowder from China. Moreover, ICTs have not only disseminated and democratised technology but also made it inclusive by facilitating a process of empowering people from all, particularly the poor and the marginalised sections of the society.

Tech Race between US and China

The currently unfolding tech race between the US and China assumes considerable significance given the potential in shaping and taking the global technology architecture to new heights, provided both the countries, particularly China, abide by the globally agreed norms. According to Debin Du and Dezhong Duan, 'whether in relation to overall competitiveness in S&T or to every single dimension containing S&T investment, scientific research, technology innovation, and S&T internationalisation, the gap between China and the United States is still significant.'[23] In contrast, for Gordon Chang, 'the United States and China are locked in a "cold tech war," and the winner will end up dominating the twenty-first century.[24] Beijing was not considered a contender a decade ago. Now, some call it a leader. America is already behind in critical areas.' Given these contrasting and divergent perspectives, it is imperative to assess their S&T capabilities coupled with

their approaches to tech and policies for its development as they play a pivotal role in determining the dynamics of the race.

Ever since China emerged as the second largest economy in 2010, it began to be more confident and reached a tipping point that it is aiming not only to compete with the US, the reigning tech superpower in most fields, but is also striving to overtake and shape the architecture of global technology and politics. Avery Goldstein highlights that

> in contrast to the long-term prospect of a new great power rivalry between the United States and China, which ultimately rests on debatable claims about the intentions of the two countries and uncertain forecasts about big shifts in their national capabilities, the danger of instability in a crisis involving these two nuclear-armed states is a tangible, near-term concern.[25]

Prior to delineating the dynamics of the tech race, it is important to delve into their approaches to the development of S&T and the present tech capabilities as they have a critical bearing on the eventual outcome of who will win the race.

Approaches to S&T Development

Over the years, US and China have evolved quite comprehensive and strategic approaches to develop S&T in their respective national contexts which have facilitated their reach in different parts of the world as the following discussion demonstrates. What stands out in the case of both the US and China is that there has been a steady corporatisation of S&T. However, the state control of private firms is more in China than in the US.

The American approach to the development of S&T is quite variegated given the nature of the public and private institutional structure. The basic approach can be distilled from *The State of U.S. Science and Engineering* which emphasises

> that strengthening the US S&E enterprise is critical to maintaining the US position as a lead performer and collaborator of S&T activities globally…. Currently, the United States leads the world on several S&E fronts…. Globally and within the United States, the business sector both funds and performs the most R&D. However, in terms of share of total R&D funding, the federal government is the single-largest funder of basic research (41 per cent), followed by business (31 per cent), non federal government and non-profits (16 per cent) and higher education (13 per cent). The federal government also funds the greatest proportion of R&D

> performed by higher education institutions (50 per cent). The proportion of US R&D funded by the federal government has declined since 2010 in all sectors and in all research types—basic, applied, and experimental development.[26]

This is a major cause for concern since it will have serious ramifications for maintaining the existing tech supremacy. In contrast, the Chinese approach is constantly refined through various policy frameworks such as *The Medium and Long-Term Plan 2006* and the *Law of the People's Republic of China on the Progress of Science and Technology*, amended on 24 December 2021. The latter envisions to maximise

> the role of science and technology as the number-one productive force (第一生产力) of innovation as the number-one driving force (第一动力), and of talent as the number-one resource (第一资源), promoting the conversion of S&T achievements into practical productive forces, prompting S&T innovation to support and lead economic and social development, and building a modernised socialist country in an all-round way.[27]

The S&T capabilities of the US and China are shaped by these divergent approaches. The following section delineates their respective capabilities.

S&T Capabilities

The S&T capabilities of the US and China are at the threshold of a new paradigm wherein the gulf between the two is narrowing. This is mainly because of the slowing down of the pace of investment in the US and the steady pace of increase in China. The details shown in Table 1 indicate the relative S&T capabilities of the US and China. Of the five selected indicators, the US is leading in three and China in two, denoting that their capabilities are in favour of the US. As of now, the US retains the number one spot in gross expenditure on R&D, researchers per million and patents. Though the US leads China 3:1 pertaining to the number of researchers per million, the output of scientific publications from China is close to twice that of the US. This is mainly because of the Chinese population being three times that of the US. However, the quality of Chinese publications is rather low compared to those from the US. In regard to high-tech exports, China has emerged as the largest exporting country. But this needs to be juxtaposed with George Gilboy's assertion that underscores the compelling reality of the phenomenon of a major number of foreign MNCs behind this exponential

growth of high-tech exports from China. Much has changed in the realm of S&T development in China since 2004 that needs to be factored into our analysis.[28]

Table 1 S&T Capabilities of US and China, 2022

Indicator	US	China
Gross Expenditure on R&D (% of GDP)	3.59	2.56
Researchers in R&D (per million in 2020)	4,452	1,687
Scientific Publications	482,098	925,728
Patents (PCT) for 2017	55,359	47,816
High-tech Exports (US $ billion)	166.4	769.7

Source: 'Main Science and Technology Indicators 2024', OECD; 'World Development Indicators', World Bank.[29]

In terms of ranking in some of the key selected sectors, we find the US leading in most of them, as shown in Figure 1. This is largely because of the historical edge that the US has had. While the US is striving to remain the leading force in the frontier technologies, China is determined to catch up with the US. In the 1980s and 1990s, China was way behind several other Western and other advanced countries in these fields. But now it is behind just the US. What Xi Jinping is aiming to accomplish now is reminiscent of what Mao Zedong wanted to achieve in the 1950s *vis-à-vis* the UK. Mao, in fact, called upon the Chinese to catch up with the UK. While he could not do it in his lifetime, successive regimes managed to do it, particularly in regard to the size of the economy. But China has much to catch up with the UK in terms of per capita income. In fact, the UK's per capita is four times more than China's.

Investment is one of the key driving forces that spur the advancement of S&T including the emerging and frontier technologies, provided the larger social, economic and political ecosystems are conducive. The data in Figure 2 indicates the commitment that the US and China have towards the growth of AI, quantum computing, biotech and IoT. Other than quantum computing, the US has been investing much more than China and thus retains tech supremacy in all of them including quantum computing. Even in quantum computing it is a commitment that the Chinese government expressed to invest in the next five years. What is not clear, though, is the actual investment.

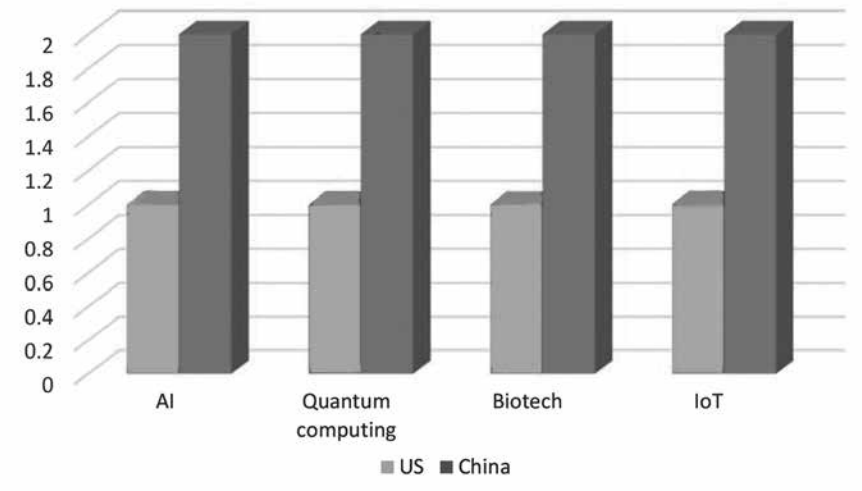

Figure 1 High-Tech: Ranking in Key Sectors[30]

Source: The AI Index 2024 Annual Report; The Quantum Insider 2022; Polaris Market Research Report; Statista.

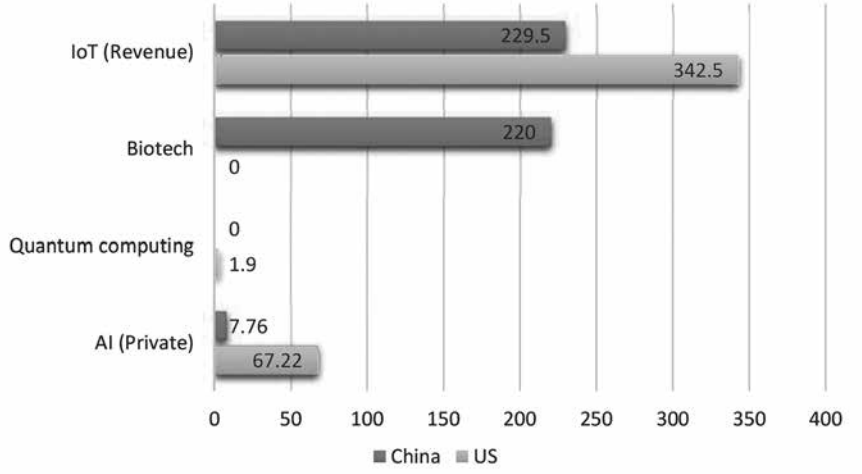

Figure 2 Investment in High-Tech: Select Sectors, 2023 (billion)[31]

Source: Statista 2024; Fortune 2024.

The Emergence of Tech Race

For Jackie Northam, 'The battle for tech supremacy between the world's two largest economies is years in the making'.[32] In fact, there are two distinct

phases of the emergence of the tech race between the US and China. The first phase began with China's entry into the WTO and continued till 2017. During this phase, the race was subtle and invisible. It acquired momentum after the announcement of One Belt, One Road which eventually christened as Belt and Road Initiative (BRI). The second phase began during President Trump's term around 2018 when he took several measures to control transfer of critical technologies to China. Given the potential threat to its present tech supremacy, the next President Joe Biden continued the policy. Pak Nung Wong underscores that 'beneath the US-China trade war, the technology competition between the two powers is actually the more deep-seated structural source of the on-going unsettling rivalry'.[33] In 2018, the US passed two important Acts to contain the growing competition emanating from China and other contenders for tech supremacy. They include Foreign Investment Risk Review Modernization Act (FIRRMA) and Export Control Reform Act (ECRA). The key component of these two Acts involves identifying the companies that pose a threat to the American national and economic security.

Contours

One of the major distinctive features of the ecosystem that sustains tech supremacy in the US is its liberal social, political and economic fabric. In contrast, the Chinese technological capabilities are driven by a statist element with a very restrictive ecosystem. Though there has been an exponential growth of private enterprises with deep pockets to invest in R&D, they are under the state control. A case in point is the crisis that the Ant Group that Jack Ma dreamed to develop went through besides his forced disappearance for three months. In many ways, it is akin to the Soviet style and top-down. However, there are certain differences between the Soviet style development of S&T and the Chinese style. One of them pertains to the FDI-driven component that was absent in the Soviet model. In addition, China used technology transfer or rather technology acquisition from the Western and other advanced countries in transforming its technology base.

The race for tech supremacy is a key component of the larger contestation between the established superpower and the rising great power that is aiming to challenge the existing balance of power. In fact, China is attempting to challenge the US, the reigning superpower, in the realm of advanced technology by increasing investment and coaxing private enterprises to step up their role in the process. The battle for tech supremacy is spreading to different parts of the world, including Europe.[34]

What is most confounding is that China immensely benefitted from American technology besides technology from other countries including Japan, France, Germany and the UK during the 1980s and 1990s. It is often argued that 'after forty years, China has gradually transformed itself from being a mere pupil of the West to a formidable competitor in some key technological sectors'.[35] This could be possible primarily because China used its massive size of the market to coax the developed countries to transfer their advanced technology in a way that it would have the license to use and export it. China also acquired advanced technology through acquisitions and mergers. A case in point is the acquisition of the computer segment of IBM. At the same time, we must not be oblivious to the assertion that Ana Manual, Pavneet Singh and Thomason Paine make *vis-à-vis* the fact of China's unfair practices in acquiring technology from the advanced countries.[36]

Richard Robert argues that

> as China became a more confident technological power, it began to realise that it could use its growing capabilities to shape the international arena.[37] In areas of cyber-governance and cybersecurity, China has realised that if they can establish their technology standards as the global ones, they can then use their overwhelming manufacturing power and economic reach to become globally dominant in key areas … There is also the military dimension. China has been working hard to become a credible competitor to the USA and is on its way to achieving this goal. It is indeed ahead in some areas of military technology such as hypersonics. There is also a huge advantage for China in terms of intelligence as it rolls out its digital "Silk Road," which is a subset of a much wider global strategy.

The present race for tech supremacy is essentially between a liberal order and a state and party-led order. The winner in the race will determine the future dynamics of the global order.

Innovation

US has been a major innovation[38] hub during the latter half of the 19th century and most of the 20th century. It still remains the most innovative country in the world with its cutting-edge technologies in several domains. In contrast, China has been envisioning the need to promote innovation since 1997, which eventually culminated in May 2006 when the Chinese government set an important goal to become an innovation nation by 2020. The central thrust of this plan is to strengthen indigenous innovation. Thereafter the Chinese government initiated the 'Made in China 2025' programme to

further strengthen the architecture of innovation. The cumulative impact of these initiatives is that innovation in China has become more robust. In the last few years, China's goal has been endeavouring to make a paradigm shift from being a factory of the world to a frontier innovation hub. While its manufacturing capabilities may help in the process to a certain extent, it lacks what one might call Innovation Quotient that is pivotal for the expansion of knowledge economies and information societies to flourish. More recently, digital innovation came to occupy centrestage given its increasing contribution to economic prowess.[39]

Table 2 Innovation Rankings and Scores of US and China, 2024[40]

Indicator	**US**	**China**
Institutions	17 (74.9)	44 (57.6)
Human Capital and research	12 (56.7)	22 (50.3)
Infrastructure	30 (52.3)	5 (62.5)
Market Sophistication	1 (81.5)	16 (55.8)
Business Sophistication	2 (70.6)	11 (58.0)
Knowledge and Technology Outputs	4 (60.2)	3 (61.7)
Creative Outputs	8 (54.9)	14 (50.0)

Source: Soumitra Datta, Bruno Lanvin Lorena Rivera Leon and Sacha Wunsch Vincent, 'Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship', WIPO, Geneva, 2024, pp. 106, 243.
Note: The figures in brackets indicate scores.

The rankings and scores of innovation in the US and China, as shown in Table 2, do indicate the gap that exists between the two. Of the seven indicators, except in two—knowledge and technology outputs and infrastructure—the US is ahead of China. While in most indicators there is considerable gulf, in the realm of creative outputs and business sophistication China is fast catching up with the US. The US, particularly the Federal Government, has to invest more in these two areas which are crucial for innovation which in turn are critical for steady economic growth.

Artificial Intelligence, Quantum Computing and Big Data

Both the US and China consider AI as one of the most important technologies that can change the trajectory of their hold over global politics. For quite

some time, US has been at the forefront of the development of AI wherein its private firms such as Microsoft and Google set global benchmarks. Realising the potential of this technology, China began to factor this into its framework. According to Parmy Olson (2024), the New Generation Artificial Intelligence Development Plan (AIDP) that the Chinese government approved in 2017 provides a roadmap for the development and growth of AI in China.[41] The government aims to invest billions of dollars in the next few years. More recently, China initiated a plan to develop as a major global AI innovation hub. If this is taken to its logical conclusion in China, it will pose a major threat to the American edge in Generative AI. Manya Koetsa captures the development and growth of AI in the US and China. For her,

> China emphasises a balance between economic growth and political stability. The central government's tight control over digital developments has meant the emphasis is on cyber sovereignty, collective support, "national harmony" and maintaining power with the party. In contrast, the west places a stronger emphasis on AI applications that promote individualism, personal autonomy, decentralisation, and globalisation—bringing with them their own set of debates over how to find the balance between individual rights and broader societal interests.[42]

Given the growing significance of quantum computing in the ever-deepening and expanding digital economy and society, there has been a major focus on its development and extensive use. Consequently, the race in the realm of quantum computing has been heating up between the US and China. The US has been a dominant player in quantum computing for quite some time. Recognising its current and future potential, recently China announced 15 billion dollars' investment in the next five years, which is eight times more than what the US is planning to invest, which may have a major impact on the growth and application of quantum computing in the years to come.[43]

The remarkable growth and expansion of the digital economy, coupled with online banking and digital payment platforms such as Google Pay and Alipay, there has been a renewed emphasis on big data, which is crucial in promoting big businesses. Big data covers a wide range of technologies including data storage, data analytics, data mining and data visualisation. The tech giants from the US and China have been taking the lead in pouring billions of dollars to further their businesses.

Green Technology

The growing concerns of climate change and the increasing importance accorded to green technologies such as wind turbines, solar energy and biofuels have propelled the global community to enhance their share in the energy basket. In this regard, China has been investing quite substantially and emerged as one of the large investors.

China's rise as a major player in promoting green technology is deeply connected to its emergence as the largest polluter in the world and mission-oriented approach to benefit from scaling it up. As a result, several countries began to lag behind China. For Joanna Lewis, the United States in many ways is sort of falling behind China in the clean energy technology manufacturing space, with repercussions also for our positioning in clean energy technology innovation more broadly.[44] She further says that '(h)istorically, the technologies that China has really been able to adopt were initially innovated in other countries, primarily Europe or the United States, including the wind turbine and particularly solar photovoltaic technology. China was able to have that technology transfer it and then really scale up manufacturing at home.' At the same time, there is hope that '(T)he United States has a chance to flip that script in low-carbon technology, leveraging deep ecosystem connections to catch up with China in low-carbon technologies where Chinese firms are dominant, while also accelerating innovation globally.'[45]

Space Technology

The US has been a dominant player in space technology for more than seven decades. Having woken up to the initial lead that the Soviet Union had in the 1950s, the US made some of the most impressive strides in the development of space technology including the notable Mission to the Moon. This is largely due to substantial public investment in the space industry. Though China joined the Space League late, it is making considerable progress in catching up with the US. In 2023, while the US invested about 100 billion dollars, China managed to invest about 12 billion dollars. More recently, the entry of private firms has changed the trajectory of space technology and industry both in the US and China. This scenario might change as China opened the doors of space technology for private and commercial entities in the last few years with an explosion of space companies and industries being set up.[46] Though there are no Chinese counterparts of SpaceX and Blue Origin that can compete with them, China seems to be determined to carve a niche for itself in this segment.

According to Jean-Frédéric Morin and Eytan Tepper,

> United States holds significant structural power thanks to its thriving commercial space sector and extensive international network. This has enabled the global diffusion of its preferred norms while simultaneously constraining China's space cooperation network. Despite its remarkable technological capabilities, China has not been able to translate them into substantial global structural power.[47]

However,

> China's space capabilities have made significant strides in recent years. In 2003, it launched its first crewed spacecraft, becoming the third country to independently send humans to space…. In addition, China has launched its own modular space station and is currently developing plans for a permanent lunar base. These developments suggest that China is narrowing the gap with the United States in terms of outer space capabilities.[48]

Military Technology

In most components of military technology, the United States has an edge over China given its longstanding commitment to R&D and investment in advanced technologies. Seong Hyeon and Hayley Wong posit 'that while the US still has an edge over China in military strength, the gap is shrinking, and in future this balance is likely to be determined by advanced technology and Washington's cooperation with its Indo-Pacific allies.'[49] This is mainly because, as Elsa B. Kania underscores, 'as technological competition emerges as an ever more prominent element of great power rivalry, it is clear the Chinese military and defense industry have undertaken active initiatives in research, development, and experimentation.'[50]

Echoing a similar view, Gregory Allen argues that

> as the United States' principal peer competitor in the field of technology, China has sought to expand in many emerging technology areas, foremost among them is the field of AI. As military competition with China gains increasing salience in our national security policy, US leadership in the realm of military AI is not at all guaranteed. While the United States has important advantages, China may be able to quickly take the lead in government and military adoption of AI capabilities. This is an outcome that the United States should seek to prevent.[51]

A more recent study by Sarah Harting and others underscores that 'In this era of strategic competition between the United States and the People's Republic of China (PRC), emerging critical technologies present both countries with the possibility of disrupting the current balance of forces to achieve significant military advantages.'[52]

Complexities

It is in this unraveling context of the development of various technologies that the present competition for tech supremacy between US and China assumes significance and is paving the way for confounding complexities. As per James A. Lewis,

> The end of the Cold War and its bifurcated trade system led to a profusion of interconnections. The connection between the US and China is one of the most important, but it is not unique and if it were to be severed both would be damaged, but China would currently suffer more damage, given its dependence on Western technology.[53]

Given this plausibility, the Chinese government has been determined to increase R&D spending on some of the frontier and high technologies such as quantum computing, semiconductors, AI, Robotics, IoT, Blockchain, as has been pointed out in the discussion earlier. One of the consequences of such a phenomenon is that there has been an increasing element of the statization of tech, which involves a degree of use of technology by the Chinese state to tighten its iron grip on the people and civil society, a phenomenon which has often led some scholars like Josh Chin and Liza Lin to describe the Chinese state as a surveillance state.[54] This is a major cause for concern. The antidote for this is that China is in dire need of fifth modernisation of democracy which can put checks and balances in using technology to stifle freedom.

Techno-nationalism is at the heart of the Chinese strivings to not only catch up with the US but also to win the race. Following the vision to develop tech architecture, Chinese Premier Li Qiang went on to underscore that 'We will fully leverage the strengths of the new system for mobilising resources nationwide to raise China's capacity for innovation across the board.'[55] In fact, the underlying objective is 'to harness the entire nation's resources to speed homegrown scientific breakthroughs, reaffirming a central priority to become self-reliant in spheres from AI to chipmaking to wrest technological supremacy from the US.'[56] While this may contribute to the furtherance of

technology like it did in the earlier edition, it can lead to more competition and complexities.

In addition, the issue of national security is one of the fulcrums of the race for tech supremacy especially in the wake of the increasing sophistication and wider use of telecommunication technology, particularly 5G technology[57] that is often touted as one of the path-breaking technologies. The American request for the extradition of the Chief Financial Officer of Huawei, Meng Wanzhou is a classic case in point of the extent to which the US is willing to go to safeguard its national security. In this context, Dave Altavilla posits that the

> ban on Chinese-manufactured telecommunications and video surveillance equipment was enacted to secure network infrastructure and monitoring systems here in the US. These bills date back to the US Secure and Trusted Communications Networks Act of 2019, the 2019 Supply Chain Order, and more recently the bipartisan Secure Equipment Act of 2021. These bans even included the "rip and replace" of telecom and networking equipment, with US government subsidies to assist communications and other companies to cover the cost of such an effort.[58]

In addition,

> the US has taken a number of measures to restrict China's access to strategic technologies, citing national security concerns. China is responding in kind, imposing extensive export and investment restrictions on US companies. This ongoing rivalry has also fueled a subsidy race as the US and China both seek to shore up to their capabilities in critical technologies such as semiconductors.[59]

Similarly, Alan Patterson highlights how

> the Biden administration revived Cold War-like sanctions aimed at blocking China's advancement with chip technology that is critical for both economic development and military superiority. Those measures banned exports of Nvidia and AMD GPUs destined for supercomputers in China, as well as sales of chipmaking tools and design software. Months later, the US followed up by blacklisting Chinese memory maker YMTC and banning US exports to Huawei.[60]

Given the increasing competition to dominate the architecture of global technology, the strategy of decoupling is factored into their bilateral trade relations. Decoupling is not going to be easy as the US is dependent on China

for manufactured goods and China is dependent on the US for advanced technology. Both are adopting strategies to address this complexity.[61] While the US is determined to get a number of its companies back into its territory, China is trying to be independent in developing and advancing its technologies indigenously. The US is also focusing, particularly on specific sectors where the gulf between US and China is narrowing. This sentiment is reflected in the articulations of Klon Kitchen who underscored that

> the race for dominance in cloud computing and artificial intelligence (AI) is heating up, and China is pulling ahead with aggressive tactics. If the U.S. doesn't step up now, we risk losing our technological edge and compromising national security.[62]

Moreover, there has been a concerted attempt by the Chinese state to weaponise technology in general and AI in particular by developing the Autonomous Weapons System (AWS) in order to gain military tech supremacy. This will make the race more complex leading to debilitating repercussions for the global community unless certain checks and balances are not put in place.

Implications

The implications of the race for tech supremacy between US and China are quite far-reaching for the global order as well as for US and India. They range from challenging the global order established by the US in the aftermath of the Second World War that has, despite a few setbacks, not only served the global community but also provided stability in the last 80 years paving the way for a new and stable dispensation.

For the World

As it occurred in the first tech race between the US and erstwhile Soviet Union, there is every possibility of the global community benefitting from the present race with more sophisticated technologies. As long as the competition is healthy and under the established global norms, the tech architecture will witness a new tectonic paradigm. If there is any misadventure, it will be calamitous for the world.

Much of what China has been aiming to do in global politics after it joined the World Trade Organization (WTO) in 2001 indicates an attempt to restructure the international system.

> Besides acquiring technology, it now also has ambitions concerning the regulations of international trade and global governance generally. In other words, China is challenging the liberal order out of which it emerged as a global player. Just what a China-led order would look like is still unclear and the uncertainties are even more significant since the technology sector has rules of its own. The inherent dangers of technology need to be meticulously assessed, as they have the potential to alter the core values of modern societies, with which they are inextricably entwined'.[63]

The economic implications for the world are visible in 'reshaping relationships and supply chains the world over. And its costs are mounting. Estimates vary, but the IMF reckons that the elimination of high-tech trade across rival blocs could cost as much as 1.2 per cent of global GDP each year—about $1trn'.[64]

In the event that the present race for tech supremacy tilts in favour of China, a major implication will be that it might undermine and undercut the liberal global order and pave the way for an authoritarian international order on the lines of its domestic model. This is going to be disastrous for global politics because the domestic model of authoritarian state and weak civil society, which is being emulated in some of the developing countries, would permeate all across the world.

Though the liberal order is not without imperfections, it is still the best bet and hope for the stability of the international order. Therefore, it is incumbent on the part of the scholarly community, the fulcrum of the civil society, to continue to shed light on the trajectory of the unravelling tech race.

For the US

There are two distinct plausible outcomes of the race for tech supremacy for the US. First, if the US takes the necessary steps to maintain the lead, it will continue to retain credibility and moral authority to promote the liberal order. Second, if the US loses the race, it will lose the hold over the liberal order. The race for tech supremacy is, therefore, a high-stakes race because it can redraw the architecture of the global order.

Graham Allison and Eric Schmidt 'sound an alarm over China's rapid progress and the current prospect of it overtaking the United States in applying AI in the decade ahead' besides pointing out 'the dangers of an unconstrained AI arms race between the two digital superpowers' and underscore that 'this is a race the United States can and must win'.[65] Similarly, Xuan-Thao cautions

the United States about the possible danger of losing the tech war to China.[66] She highlights that

> With the United States turning its attention to the war and humanitarian crisis in Europe and increasing its defense budget, China marches feverishly and confidently forward towards new frontiers of scientific and technological progress. The gap is narrowing between the United States and China on many fronts, but it will close entirely if there is no serious response from both U.S. businesses and the government on all levels.[67]

Alessandra Zimmermann captures for us the unfolding reality when she underscored that the

> U.S. continues to remain dominant in terms of R&D expenditures, but that dominance is not as strong anymore. Other countries, namely China, are catching up to R&D expenditures as their governments put a focus on research and innovation as national priorities. In all other metrics, the production of researchers, publications, and patents, the US has fallen to second or third place in recent years…. if U.S. science and technology leadership is to be maintained, policymakers must take a proactive approach to its federal R&D investment policy, which is very complicated to achieve in a time of fiscal conservatism, and especially after the cuts to science spending that we saw in the U.S. with the latest fiscal year 2024 budget.[68]

For India

A major implication of the tech race between US and China is that the existing gap between India and the US, and between India and China is going to widen in the near future. This possibility can be mitigated by envisioning a clear roadmap for the development of STI in India by increasing the R&D budget from the present dismal 0.67 per cent to 2 per cent in the next few years and continue to increase thereafter. Overconcentration of R&D investment and expenditure in a few institutions and universities, though may be helpful in the short-term, must be dispersed all across the country for a long-term impact on the innovation ecosystem.

Moreover, the profile of the Ministry of Science and Technology needs to be radically enhanced with a visionary leader who can lead and facilitate the development of STI from the front. He or she must ensure that the academic freedom and budget allocation for education in general and S&T in particular are upgraded to the global standards.

In addition, the government must incentivise private investment in R&D. Regrettably, most of the well-established private enterprises have not been investing in proportion to their potential. For instance, among the top 14, and in some cases top 15 global corporate R&D spenders, in each sector such as ICT hardware and electrical equipment, Software and IT services, Pharmaceuticals and biotechnology, Automobiles, Construction and industrial metals, Industrial engineering and transportation, Travel, leisure and personal goods, and other, only one Indian company figures. Contrast this with China, which has more than 18.[69]

At the same time, India needs to strengthen its multilateral and bilateral initiatives to acquire some of the most sophisticated technologies available in the global market, including the US. The mutually agreed initiative on critical and emerging technologies (iCET) between India and the US, if taken to its logical conclusion, will have a major bearing on the advancement of technology in India.[70]

Conclusion

The race for tech supremacy between the US and China is likely to witness intense competition given the American determination to retain the edge of supremacy and the Chinese aim to catch up with the US. The impending ramifications in the event of China gaining upper hand are going to be debilitating not only for the global technology architecture but also for the global community. However, as the history of tech race during the Tech Race 1.0 has demonstrated, tech supremacy under either totalitarian and authoritarian regimes does not last long given the inherent elements of the possibility of implosion. Technology in the hands of democratic leaders and institutions is safer and secure. But technology in the hands of authoritarian leaders and tyrannical institutions wherever they emerge, in the West or East or South, is dangerous and debilitating. It remains to be seen whether the US would repeat its feat of retaining supremacy during the Tech Race 2.0. This would ultimately depend on its innovative individuals and the liberal institutions, including public and private.

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