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Technology, Geopolitics and India's Quest for Tech Self-Reliance

Dr Saroj Bishoyi

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Tel: 011-24121764 | Fax: 011-66173415

E-mail: info@vifindia.org

Website: www.vifindia.org

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Contents

About the Author *7*

List of Abbreviations *8*

Abstract *11*

1. Introduction 13

2. Geopolitics of Technology 15

3. Global Supply Chain Crisis 18

4. India's Quest for Technology Self-Reliance 20

    i) Electronics *21*

    ii) Semiconductor *26*

    iii) Defence Sector *28*

    iv) Space Sector *31*

    v) Digital India *33*

    vi) Technology Startups *34*

5. Establishing STI Ecosystem in India 35

6. Forging Technological Partnerships 38

7. Key Challenges 41

8. Future Prospects 44

List of Graphs

Graph 1: Top Eight Strategic Supply Chain Technology Trends for 2023 19

Graph 2: India's Electronics Goods Manufacturing and Exports from FY 2016 to FY 2023 22

Graph 3: India's Mobile Phones Manufacturing and Exports from FY 2015 to FY 2023 25

Graph 4: Contribution of UPI Transaction in Total Digital Transactions (in Crore) 34

List of Tables

Table 1: India's Roadmap to Manufacture US $300 Billion Electronic Products 23

Table 2: India's Defence Exports from FY 2016-17 to FY 2022-23 29

Table 3: India's Defence Production Segment Wise from FY 2016-17 to FY 2022-23 30

About the Author

Dr Saroj Bishoyi is a Research Fellow with the Centre for Technology and Scientific Studies, Vivekananda International Foundation (VIF), New Delhi where his research focuses on India's capabilities and capacities in technology, and international technology cooperation. His areas of research also focus on USA, India-US Strategic Partnership and Indo-Pacific. He received his PhD degree from Jawaharlal Nehru University (JNU), New Delhi and was ICSSR Doctoral Fellow. Previously, he has worked with the AMS Division, which deals with USA and Canada, Ministry of External Affairs (MEA), New Delhi; Manohar Parrikar Institute for Defence Studies and Analyses (MP-IDSA), New Delhi; Selected Works of Jawaharlal Nehru Unit, JNMF, New Delhi; YC-NISDA, University of Pune, Pune; and, Foundation for National Security Research (NSRF), New Delhi. He has published numerous articles in journals, edited books, magazines, newspapers and academic websites. His recent works include *India's Defence Exports: Recent Trends and the Way Forward; India's Semiconductor Strategy; US Critical and Emerging Technology Strategy; US-China Tech Rivalry: Pentagon Report on China's Emerging Technology Strategy; Growing India-US Ties in Critical & Emerging Tech; India-US Forging Tech Alliance since Long; India-US Peacekeeping Cooperation; and, Role of the United States in the 1971 War: Implications for India–US Relations.*

List of Abbreviations

AI:	Artificial Intelligence
ASPI:	Australian Strategic Policy Institute
AMD:	Advanced Micro Devices, Inc.
ANRF:	Anusandhan National Research Foundation
ASML:	Advanced Semiconductor Materials Lithography
CAGR:	Compound Annual Growth Rate
CES:	Crew Escape System
CETs:	Critical and Emerging Technologies
DDP:	Department of Defence Production
DGFT:	Directorate General of Foreign Trade
DMA:	Department of Military Affairs
DPI:	Digital Public Infrastructure
DPIIT:	Department for Promotion of Industry and Internal Trade
DPSU:	Defence Public Sector Undertaking
DST:	Department of Science and Technology
DUV:	Deep Ultraviolet
EL:	Entity List
EUV:	Extreme Ultraviolet
GII:	Global Innovation Index
GPAI:	Global Partnership on Artificial Intelligence

GVCs:	Global Value Chains
ICEA:	India Cellular & Electronics Association
iCET:	initiative on Critical and Emerging Technologies
IITs:	Indian Institutes of Technology
IMPRINT:	Impacting Research Innovation and Technology
IoT:	Internet of Things
ISM:	India Semiconductor Mission
ISRO:	Indian Space Research Organisation
IUSSTD:	India-US Strategic Trade Dialogue
ML:	Machine Learning
MoU:	Memorandum of Understanding
MRIC:	Mauritius Research and Innovation Council
MSIP:	Modified Semicon India Programme
NIGST:	National Institute for Geo-Informatics Science & Technology
NM-ICPS:	National Mission on Interdisciplinary Cyber Physical System
NQM:	National Quantum Mission
OEM:	Original Equipment Manufacturer
OFBs:	Ordnance Factory Boards
PIL:	Positive Indigenisation List
PLI:	Production Linked Incentive
QKD:	Quantum Key Distribution
QT:	Quantum Technology
R&D:	Research and Development
RRI:	Raman Research Institute
S&T:	Science and Technology
SCOMET:	Special Chemicals, Organisms, Materials, Equipment and Technologies
SELM:	Space Economy Leaders Meeting
SMIC:	Semiconductor Manufacturing International Corp

SMPS:	Service Module Propulsion System
STEM:	Science, Technology, Engineering and Mathematics
STI:	Science, Technology and Innovation
TIHs:	Technology Innovation Hubs
ToT:	Transfer of Technology
TSMC:	Taiwan Semiconductor Manufacturing Company
TTC:	Trade and Technology Council
UPI:	Unified Payments Interface
VAIBHAV:	Vaishvik Bharatiya Vaigyanik
WIPO:	World Intellectual Property Organisation
WSTF:	Water Survival Test Facility

Abstract

Technologies like artificial intelligence (AI), digital platforms, machine learning (ML), data analytics, autonomous vehicles, blockchain, internet of things (IoT), virtual and augmented reality, and robotics have brought profound changes in almost every part of life across the world. More states are competing to develop and deploy these technologies to shape the economic and military power to their advantage, and control their supply chains. The global pandemic and the ongoing geopolitical conflicts have further shaped the Global Value Chains (GVCs) and increased the risks of supply chain disruptions.

In this evolving geopolitical landscape and intensifying rivalry between major powers, India seeks to build a Science, Technology and Innovation (STI) ecosystem in the country to achieve technological self-reliance, position itself among the top manufacturing countries in the world and integrate into the GVCs, which will further drive its economic growth, industrial exports, and create new jobs. Hence, it has been increasingly prioritising to boost the domestic production of electronics, computers, mobile phones, telecommunication equipment, vehicles, defence and space technologies. It is also

deploying its successes in sectors like Digital Public Infrastructure (DPI) and leveraging its growing trade with the Global South. The objective is to shift the GVCs and develop world's dependency on India.

In this endeavour, India achieved several milestones, including in space, defence, and digital sectors, but a lot remains to be done. In this setting, this paper analyses and examines the geopolitics of technology with a focus on the great power competition to develop and deploy emerging technologies; the impact of global pandemic and geopolitical tensions on global supply chains; India's quest for technology self-reliance in critical domains; its efforts to build an STI ecosystem in the country; India's growing technology partnership with friendly foreign countries; key challenges that India faces in its efforts to become technology self-reliant; and, finally, it touches on the future prospects in the field of emerging and disrupting technologies in the evolving geopolitical landscape.

1. Introduction

Technology continues to evolve at a rapid pace and plays critical role in all aspects of modern life including social, economic, defence and security. The digital platforms, artificial intelligence (AI), machine learning (ML), rise of big data, autonomous vehicles, blockchain, internet of things (IoT), virtual and augmented reality, robotics and other technological developments have brought profound changes in almost every part of life across the world. More states are competing to develop and deploy these technologies to shape the economic and military power to their advantage. In addition to these transformational technologies, competition and geopolitical rivalry between states are also taking place within the domains of electronics, semiconductor, information and communication, cyberspace, outer space, and defence. The global pandemic and the ongoing geopolitical conflicts have further shaped the Global Value Chains (GVCs) and increased the risks of supply chain disruptions.[1]

In this evolving geopolitical landscape and intensifying rivalry between major powers on technology, India seeks to build a Science, Technology and Innovation (STI) ecosystem in the country

to meet its own growing demand for cutting-edge technologies and also integrate into the GVCs, which will further drive its economic growth, industrial exports, and create new jobs. Its STI policy envisions to achieve technological self-reliance and position India among the top five countries in the world in terms of quality of research outcome by the year 2030.[2]

In this context that India has been increasingly prioritising to boost the domestic production of electronics, computers, mobile phones, telecommunication equipment, vehicles, defence and space technologies. It is also deploying its successes in sectors like Digital Public Infrastructure (DPI) and leveraging its growing trade with the Global South. The objective is to shift the GVCs and develop world's dependency on India. India has recently launched two initiatives, i.e. the Global DPI Repository and a Social Impact Fund for promoting the development of Social Impact Fund to advance DPI in the Global South as they look for equitable access to the benefits of the digital economy.

In this setting, this paper analyses and examines the geopolitics of technology with a focus on the great power competition to develop and deploy emerging technologies; the impact of global pandemic and geopolitical tensions on global supply chains; India's quest for technology self-reliance in critical domains such as electronics, semiconductor, defence, space, digital and tech startups; its efforts to build an STI ecosystem in the country; India's growing technology partnership with friendly foreign countries; key challenges that India faces in its efforts to become technology self-reliant; and, finally, it touches on the future prospects in the field of emerging and disrupting technologies.

2. Geopolitics of Technology

The global technology trends continue to dominate by great power competition and rivalry. The race to develop and deploy Critical and Emerging Technologies (CETs) intensified, especially between the US and China.[3] The two countries are developing and implementing their technology strategies to outcompete each other. The Biden administration under the CHIPS and Science Act, a bipartisan law President Joe Biden signed in August 2022,[4] strengthened the US competitiveness with China by building a strong domestic industrial base for CETs, and brought a range of export control measures to restrict Chinese access to advanced computer chips, data, technologies, software and hardware for reasons of US foreign policy, national security and trade protection.

In addition, Washington rallied its key allies and partners behind its export control measures against China. In this endeavour, leading tech companies have accelerated technological 'de-risking' and diversifying their supply chains. Thus, the Taiwan Semiconductor Manufacturing Company (TSMC), world's largest semiconductor manufacturer, is setting up two fabs in the US, one each in Germany and Japan; Graphcore, a British AI semiconductor firm, pulled out of China citing Washington's export control laws; the Netherlands' Advanced Semiconductor Materials Lithography (ASML) has imposed restrictions on export of advanced lithography machines to China, while ASML and Samsung is jointly investing $762 million to set up a research fab in South Korea to develop advanced semiconductor manufacturing technologies using Extreme Ultraviolet (EUV) equipment;[5] and, Apple Inc., which opened two retail stores in India, is planning to open three more shops by 2027.[6] The US CET strategy primarily aims to secure and enhance its

technological leadership in the world, while making it more difficult for China to use AI computer chips, software and hardware as well as STEM talents for military purposes.

On the other hand, China scaled up its efforts to develop and dominate in the areas of CETs through its 'Made in China 2025', a strategic and industrial policy first announced in May 2015, and 14th Five Year Plan, which the Chinese parliament passed in March 2021. Both the Made in China and the 14th Five Year Plan prioritises on industrial policies and massive technology transfer apparatus in an effort to reduce foreign dependencies, ensure resilience, and become a market leader in emerging and enabling technologies. In fact, China is well on its way to becoming a superpower in important areas of innovation and CETs. The Belfer Center for Science and International Affairs in its report stressed that China has already "displaced the US as the world's top high-tech manufacturer" and "become a serious competitor in the foundational technologies" such as 5G, AI, biotechnology, quantum technology, semiconductors and green energy.[7] The Australian Strategic Policy Institute (ASPI) in its study found that China leads in 37 out of 44 technologies, including advanced materials, AI, biotechnology, defence, energy, key quantum technology, robotics and space[8] while the US leads only in seven of the analysed technologies. Thus, China has already become number one in key areas of emerging technologies.

China's lead is the result of deliberate design and long-term policy planning, as often outlined by President Xi Jinping. Under Xi's leadership, China has adopted a "whole-of-society approach" to develop emerging technologies and become "non-reliant on foreign technology". Consequently, it is driving its domestic industries for indigenous development of CETs that will further strengthen the

military capabilities of the Chinese People's Liberation Army (PLA). In support of its expansionist goals, it is rapidly deploying newly acquired technological and military prowess. The Chinese PLA is using this power to achieve its strategic objectives in the Indo-Pacific region and beyond. China's growing military assertiveness in the region is clearly related to these newly acquired technological and military capabilities.

Amidst stringent export control measures by the Biden administration, China achieved an important breakthrough when Semiconductor Manufacturing International Corp (SMIC), a Shanghai-based chipmaker, supplied 7nm chips, the Kirin 9000s, to Huawei Technologies for its Mate60 Pro phone. The SMIC used the ASML's deep-ultraviolet (DUV) lithography rather than the more advanced EUV lithography to make Huawei's 7nm chip. TSMC and Intel had earlier used DUV to make 7nm chip, so this is not too much of a surprise.

However, it should be noted that the US Department of Commerce in May 2019 had placed the Huawei on its Entity List (EL), expressing national security concerns and Huawei's alleged ties to the Chinese government. This restricted Huawei from purchasing hardware, software and necessary materials from the US. It also required the Netherlands to ban the exports of ASML's most advanced EUV lithography machine, which is used to make 3-7nm chips, to China. In September 2022, the Biden administration asked Nvidia and AMD, America's top chipmakers, to stop selling advanced AI chips to China that can be diverted to a "military end user."[9] In October 2023, the administration updated the rules to close loopholes in the previous restrictions and prevent China's development of AI for military use.[10]

Nevertheless, SMIC's technological breakthrough reflects the failure of United States to control advanced materials and technologies falling into the Chinese hands. The ASPI rightly observed that "Western democracies are losing the global technological competition, including the race for scientific and research breakthroughs, and the ability to retain global talent", that are critical for the development and control of the most important technologies.[11] This is clearly evident from the fact that China's imports of ASML's DUV lithography machines surged in the year 2023.[12] It is now believed that China can make 5nm or smaller chips with self-developed EUV lithography machines in coming years.

3. Global Supply Chain Crisis

Global supply chains have been reshaped as a result of the Covid-19 pandemic, the ongoing Ukraine war, US-China tech war and the crisis in the greater West Asian region. These global crises continue to disrupt the supply chains in areas of CETs such as semiconductors, AI, quantum technologies, 5G/6G technologies, and advanced materials which are critical to economic growth, as well as in strengthening military capabilities and addressing security challenges. For instance, while the global semiconductor shortage contributed to the supply chain crisis during the Covid-19 pandemic, especially in the electronics and automobile manufacturing sectors. The security of the semiconductor supply chains remains at high risk because of China's actions towards Taiwan, which produces over 90 percent of the world's leading-edge chips. Consequently, the countries and their leading technical companies are revamping their GVCs.

At the same time, it is important to note that these 'strategic, disruptive and unavoidable technologies' will impact their planning processes over the next five years. Accordingly, Gartner Inc., American technological research and consulting firm, predicted the top eight supply chain technology trends that would receive much of investment. These include: i) Actionable AI; ii) Smart operations; iii) Mobile asset optimisation; iv) Industry cloud platforms; v) Employee engagement; v) Composable Application Architecture; vii) Cyber Resilient Supply Chains; and, viii) Supply Chain Integration Services.[13] These eight supply chain technology trends are categorised into three key motivations which underpin their significance: One, to pioneer new forms of engagement; two, scale performance that enables technology to be delivered 'any place and any time'; and three, optimise for resilience (See **Graph 1**).

Graph 1: Top Eight Strategic Supply Chain Technology Trends for 2023

(Source: "Gartner Reveals the Top Supply Chain Technology Trends for 2023", *Gartner*, Press Release, 10 May 2023 at Gartner Reveals the Top Supply Chain Technology Trends for 2023)

The supply chain technology trends will likely to continue in the year 2024. However, technology continues to evolve at breathtaking speed, and it is becoming increasingly difficult in the manufacturing

companies to prioritise the trends, particularly in AI, ML, IoT, data analytics and robotics.[14] These emerging technologies are shaking up the global supply chains, whereas developing and managing a smart supply chain is gradually becoming a 'new normal'.

In this evolving geopolitical and technological landscape, India has emerged as an appealing alternative to the traditional GVCs.[15] India's growing domestic demand for emerging technologies, the demographic dividend, huge talent pool, and the government's initiatives in encouraging global manufactures have put it in a unique position. Government's favourable policy measures and reforms are attracting tech companies for investments, joint development and production of emerging technologies in order to develop alternative GVCs to meet future needs of partner countries. This is expected to assist the country in effectively integrating into the GVCs. In fact, India is seen in a geopolitical sweet spot and its growing strategic partnership with major powers is expected to strengthen its efforts to realise the goal of making India a global manufacturing hub and exporter of advanced technologies. The objective is to shift the GVCs and develop world's dependency on India. In this context, it has renewed its efforts to boost the domestic production of electronics, mobile phones, computers, vehicles, defence and space technologies.

4. India's Quest for Technology Self-Reliance

In its quest to become self-reliance in strategic technologies and reduce the potential risk of global supply chain disruptions, the Indian government has launched a number of initiatives, which include make in India, self-reliant India, digital India and semicon

India programmes, as well as tech startups in various domains. The goal is to become more self-reliant in technology manufacturing by enhancing domestic production of critical technologies, reduce its dependence on imported goods, position itself as the global hub for electronics system, space and defence technologies, and thereby become an integral part of the GVCs. This move is expected to create thousands of new jobs, help achieve economic growth and promote long-term economic stability in the country. This will also address its defence and strategic priorities.

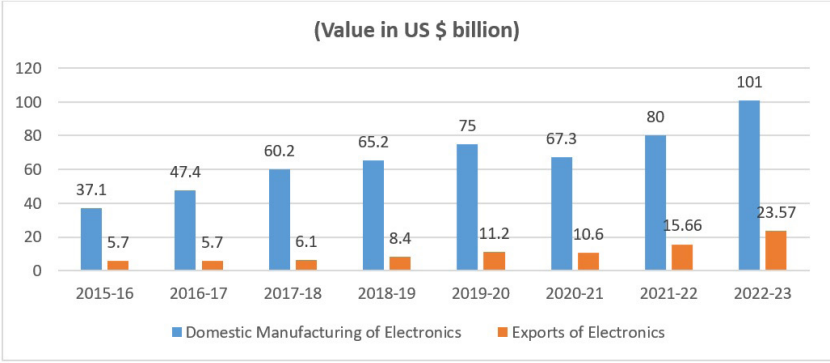
Under the vision of "make in India, make for the world", the government has been increasingly focusing on key areas such as electronics, semiconductor, defence, space, agritech, health tech, green tech, and digital India. As a result, India secured the 40th position in the 2023 Global Innovation Index (GII) among the top global innovative economies.[16] It has improved from being ranked at the 81st in 2015, which shows that India's R&D has the potential to make a global impact. It ranked at 7th position in terms of Resident Patent Filling activity in the world.[17] The ASPI in its 2023 report also highlighted India's significant progress in crucial areas like 5G technology, AI, semiconductors, quantum technology, cybersecurity, space and other cutting-edge technologies. Some of these key sectors are discussed in the following section.

i) Electronics

Invention of transistors and its use in the semiconductor manufacturing revolutionised the production of electronic goods all over the world. This led to the exponential use of PCs, internet, smartphones, cloud and 4G/5G, etc. In India, use of electronic goods has grown significantly, particularly since the outbreak of Covid-19. In the

meantime, domestic manufacturing of electronic goods increased from US $ 37.1 billion in FY 2015-16 to over US $101 billion in FY 2022-23.[18] Meanwhile, exports increased from US $5.7 billion in FY 2015-16 to US $23.57 in FY 2022-23 (See **Graph 2** below).

Graph 2: India's Electronic Goods Manufacturing and Exports from FY 2016 to FY 2023



(Source: Data compiled from *$300 bn Electronics Manufacturing & Exports by 2026: Roadmap and Strategies*, Vision Document Vol. 2, India Cellular & Electronics Association (ICEA), 2022; *Press*

India's electronic sector has transitioned through three phases: during the first phase (2013-15), it imported 78 percent of electronic goods, mostly from China; during the second phase (2016-20), it focused import substitution with its 'self-reliant India' policy; and, during the third phase (2021 onwards) emphasis has been given to export led growth. Within a short period of time, this sector has thus made noteworthy progress from import dependent to self-sufficiency and then self-reliant to export led growth. The electronics sector is also a great job creator; given that it has created over one million jobs since FY 2015. At present, this sector employs two million people. India targets to employ 4.5 million people in this sector in the near future.[19] So this sector has massive opportunity for job creation in coming future.

Table 1: India's Roadmap to Manufacture US $300 Billion Electronic Products

Sl. No.	Product Segment	FY 2020-21 (Value in US $ billion)	FY 2025-26 (Value in US $ billion)
1	Mobile Phones	30	126.9
2	IT Hardware (laptops, Tablets)	3	25.4
3	Consumer Electronics (TV and Audio)	9.5	23.1
4	Strategic Electronics	4	11.5
5	Industrial Electronics	10.5	25.4
6	Wearables and Hearables		8.1
7	PCBA	0.5	11.5
8	Auto Electronics	6	23.1
9	LED Lighting	2.2	16.2
10	Telecom Equipment		11.5
11	Electronic Components	9	17.3
	Total	74.7	300.0

(Source: *$300 bn Electronics Manufacturing & Exports by 2026: Roadmap and Strategies*, Vision Document Vol. 2, ICEA, 2022)

Today, a lot of trade takes place in electronic goods. But India's overall share in global trade is just about two and half percent. In FY 2022-23, India's overall goods and services exports reached to a 'new height' to $770 billion, which is just 2.4 percent of global trade that stands at $32 trillion.[20] Though India's share in global manufacturing of electronics has grown from 1.3 percent in 2012 to 3.75 percent in FY 2021-22, the share of electronics trade to its top trading partners such as US and the EU remains very low while it imported US $ 73.46 billion of electronic goods in FY 2022-23. For increasing its share in global trade, India needs to expand its consumer goods including electronics by building competitive electronics manufacturing companies. Therefore, India aims to manufacture US $300 billion of electronic products by FY 2025-26 (See Table 1 above) and export US $120 billion electronic products by 2025-26.[21] It aims to become US $5 trillion economy by 2025-26,

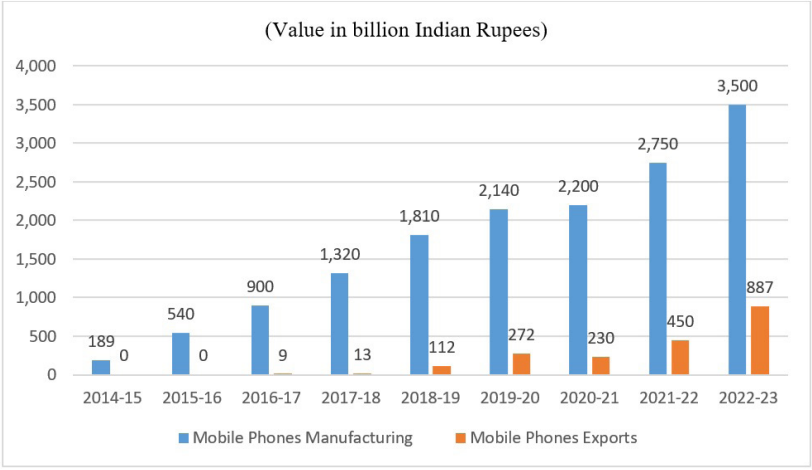
and targets to export $600 billion merchandise goods by 2025-26. Its vision is to make electronics as India's top three export category by 2025-26.

So far as the mobile phone production, domestic use and export is concerned, India is a big market for mobile phones. The demand for mobile phones will further increase as it plans to digitally connect 400 million people more from current 800 million, taking this to 1.2 billion in near future. In terms of value, India's mobile phone production had increased from 5.8 crore units valued at about Rs. 18,900 crore in FY 2014-15 to 31 crore units valued at over Rs. 2,75,000 crore in FY 2021-22.[22] The value of mobile phone production reached to an all-time high of Rs 3,50,000 crores in FY 2022-23 (See Graph 3),[23] which is an impressive increase in production by more than 1,700 percent from FY 2014-15.

A closer look at the mobile phone production in India reveals that it increased from Rs 2,200 billion in FY 2020-21 to Rs 2,700 billion in FY 2021-22 despite the impact of the coronavirus pandemic. In fact, it became the second largest manufacturer of mobile phones in the world and electronic exports have become the 6th largest export commodity group for March 2023. Notably, mobile phone production constituted US $ 44 billion of the US $101 billion total electronics production in FY 2022-23, including US $11.1 billion as exports, which constituted 47 percent of electronics exports. The mobile phone export was almost zero percent in FY 2014-15. It attained this landmark achievement as a result of various initiatives that were launched to boost local mobile phone manufacturing, including the Phased Manufacturing programme (PMP), which helped build a robust indigenous mobile manufacturing ecosystem in India and incentivised large-scale manufacturing under the

Production Linked Incentive (PLI) scheme. The government also exempted customs duty on imports of certain parts such as camera lens and concessional duties on lithium ion cells for battery.[24]

Graph 3: India's Mobile Phones Manufacturing and Exports from FY 2015 to FY 2023



(Source: Data compiled from Vision Document Vol. 2, ICEA, 2022; PIB, GoI, Delhi and MeitY, GoI, Delhi)

So far as the import of mobile phone is concerned, only 0.8 percent of total volumes of mobile phones sold in India were imported in the FY 2022-23. Currently, 99.2 percent of mobile phones sold in India are made in India. So it has almost reached self-sufficient in mobile phone sector. In terms of value, from 78 percent of total market value were imported in the FY 2014-15, now it imports only 4 percent of total value.

Building on the success of the PLI scheme for mobile phones, the government in May 2023 approved PLI Scheme 2.0 for IT Hardware with a budgetary outlay of Rs. 17,000 crore, which is valid for six years.[25] The scheme covers laptops, tablets, all-in-one-PCs, servers, and ultra-small form factor devices. The applications

of 27 IT hardware manufacturers were approved in November 2023 and the brands such as Acer, Asus, Dell, HP, Lenovo, etc. will be manufactured in India. This is expected to generate about 50,000 direct and 1.5 lakh indirect jobs.[26] It will also expand the investments in the component ecosystem to develop the supply chain.

The global electronics manufacturers such as Apple, Micron, Foxconn are also coming to India. This will further strengthen the electronics manufacturing ecosystem in the country and reinforce the vision of 'self-reliant India'. So, there is a great opportunity for India to become a global hub for electronics manufacturing and build exports led supply chains. The opportunities are arising out of the changing geopolitical realignments on the one hand, and politics of technology on the other hand. At present, from decoupling to de-risking is taking place which reflects the changing world order. The geopolitics is driven by not just military factors, but also trade and electronics. Nevertheless, it is building a global manufacturing ecosystem in the country and it is emerging as a trusted supply chain partner.

ii) Semiconductor

Semiconductors have become building blocks of electronic devices and have applications in almost all sectors including mobile phones, computers, automobiles, defence, space, and communication devices. The semiconductor industry continuous to expand driven by key factors such as AI, defence, clean energy initiatives, digital transformation, advanced data generation, and transfer systems. Meanwhile, the demand for semiconductor chips continued to increase in India because of the increasing use of electronic goods.[27] India's semiconductor market, which was at $27 billion in 2021,

projected to reach $64 billion by 2026 with a healthy CAGR of 16 percent. Demand for semiconductors will further increase as it targets to achieve US $300 billion worth of domestic electronics manufacturing and US $ 120 billion in exports by FY 2025-26 from US$23.57 billion in FY 2022-23, to realise the goal of a US $ 1 trillion digital economy by 2025. The government launched the 'Semicon India' Programme with PLI scheme of Rs 76,000 crore (about US $10 billion) to build the semiconductor manufacturing ecosystem in the country to meet its growing demand for semiconductor.

To achieve this goal, the government in May 2023 announced the 'Modified Semicon India Programme' (MSIP). It offers a fiscal incentive of 50 percent of the project cost to set up semiconductor fabs in India of any node (including mature nodes). The Programme has been modified in view of the enhanced incentives offered by the countries such as the US, Taiwan, South Korea, Japan and China, which already have an established semiconductor ecosystem, while Taiwan and South Korea have advanced node technologies. The MSIP is expected to facilitate more industry players to make semiconductors in India.

Moreover, India Semiconductor Mission (ISM) organised the three-day SemiconIndia 2023 conference in Gujarat in July 2023 on the theme 'Catalysing India's Semiconductor Ecosystem.' Prime Minister Modi in his special address at the conference expressed India's commitment to the programme of building the semicon manufacturing ecosystem in the country.[28] The conference saw the participation of industry leaders from leading global companies such as Micron Technology, Foxconn, Applied Materials, Cadence, AMD, Western Digital, and the industry association, SEMI.

On 29 February 2024, the government approved the setting up of three semiconductor units which will start construction within next 100 days.[29] India already has capabilities in chip design. These three units will establish the semiconductor ecosystem in India. This is expected to propel innovation and develop domestic capacities to make India a global hub for high-tech production, increase the share of manufacturing in the economy, create high-tech jobs, and integrate the country to the global semiconductor value chain. In its desire to build a semiconductor ecosystem in the country, thus, the government has made a renewed effort and brought proactively policy initiatives including facilitated cooperation between the government, industry, and academia. With the presence of a pool of semiconductor talent, global tech companies, and the ongoing digital India transformation, India is poised to play a big role in the growth of semiconductor sector.

iii) Defence Sector

In the year 2023, India made a notable progress towards its goal of becoming self-reliant in defence and armed forces modernisation. Its defence exports surged ahead with a record exports of nearly Rs 16,000 crore (US $ 1.94 billion) in FY 2022-23, almost Rs 3000 crore increase from the previous financial year (See Table 2).[30] It represents a notable ten-fold increase from the FY 2016–17, when exports were merely ₹1,521 crore (US $184.59 million). At present, about 100 Indian industries are exporting defence items to over 85 countries.[31] This is a significant step towards India's stated goal of exporting ₹35,000 crore (US $ 5 billion) worth of aerospace and defence equipment by FY 2025-26. While India continues to remain the largest importer of arms in the world, its emergence on the world

stage as an exporter is a major development and will help achieve its strategic priorities and become self-reliance in the defence sector. There is huge potential for further progress, given that only about 15 percent of India's total defence production are exported presently that constitutes only 0.2 percent of the global arms market. There is growing demand for Indian arms, including LCA-Tejas, Aircraft Carriers, Light Combat Helicopters, BrahMos missiles, MRO services, among others.

Table 2: India's Defence Exports from FY 2016-17 to FY 2022-23

Sl. No.	**Financial Year**	**Export Authorisations to Private Companies (Rs Cr)**	**Export by DPSU/ 7 New OF Companies (Rs Cr)**	**SCOMET Issued by DGFT (Rs Cr)**	**Contract Value(Rs Cr)**	**Total Export Value** (Rs in crores)
1	2016-17	194.35	1327.51	0.00	0	1521.86
2	2017-18	3163.16	1519.20	0.00	0	4682.36
3	2018-19	9812.91	932.86	0.00	0	10745.77
4	2019-20	8007.81	904.74	203.00	0	9115.55
5	2020-21	7271.25	984.64	178.94	0	8434.83
6	2021-22	5965.03	386.19	6.70	6456.60	12814.52
7	2022-23	9050.84	385.78	351.28	6130.26	15918.16
	Total					**63,233.05**

(Source: "Dashboard", Department of Defence Production (DPP), Ministry of Defence, Government of India, figures are as on 17 May 2023 at https://ddpdashboard.gov.in/DefenceExport/Defence_Exports)

Note: Export by Defence Public Sector Undertaking (DPSU) or seven new defence companies, carved out of the erstwhile 41 Ordnance Factory Boards (OFBs) in October 2021. DGFT: Directorate General of Foreign Trade; SCOMET: Special Chemicals, Organisms, Materials, Equipment and Technologies.

The value of defence production also reached all-time high of Rs 1,06,813 crore in FY 2022-23 (See Table 3 below).[32] While the

contribution of private companies in defence production is only 19 percent, their contribution to India's total defence export is more than 70 percent. In FY 2022-23, the total export value of Defence Private Companies was ₹9,050.84 crore of their defence production of ₹19,925 crore, which make up over 45 percent. In fact, the private sectors defence exports value ranged from 68 to 98 percent in the last seven years. While Defence PSUs export value ranged from 4 to 10 percent during the same period. Thus, the substantial rise in defence exports is the result of increased partnership with the private sector.

This is a significant achievement for the private sector, which was not part of the defence production until 2001. It was because of the present government, which accorded greater emphasis on the private sector's involvement in the defence sector and brought supportive policy measures, helped achieve this milestone in the defence export. Importantly, it has created a conducive atmosphere for the defence companies, especially for the private companies to play a larger role for making India self-reliant in the defence sector under the vision of "make-in-India" and "make for the world". The domestic import ratio has also significantly improved. A degree of trust has been built with the private sector and its participation in the defence production and export. This resulted in the remarkable rise of private sector in defence manufacturing and has immense potential to further expand its footprint in the international defence market.

Table 3: India's Defence Production Segment Wise from FY 2016-17 to FY 2022-23

Sl No.	Financial Year	DPSUs (in Rs Cr)	OFB (in Rs Cr)	Other PSUs/JVs (in Rs	Defence Private Companies (in Rs Cr)	Total Production (in Rs Cr)
1	2016-17	40,427	14,825	4,698	14,104	74,054
2	2017-18	43,464	14,829	5,180	15,347	78,820
3	2018-19	45,387	12,816	5,567	17,350	81,120

4	2019-20	47,655	9,227	6,295	15,894	79,071
5	2020-21	46,711	14,635	6,029	17,268	84,643
6	2021-22	55,790	11,913	7,222	19,920	94,845
7	2022-23	63,107	16,998	6,783	19,925	106,813

(Source: "Dashboard", Department of Defence Production (DPP), MoD, GoI, at https://ddpdashboard.gov.in/DefenceProduction/Defence_Production)

The fifth Positive Indigenisation List (PIL) of Department of Military Affairs (DMA) consisting of 98 items was released which includes high complex systems, sensors, weapons and ammunition.[33] The DMA had earlier promulgated four PILs consisting of 411 military items and the Department of Defence Production (DDP) has separately notified four PILs comprising of 4,666 items. As per the provisions given in Defence Acquisition Procedure 2020, all these items will be procured from indigenous sources in staggered timeline. Importantly, the government has brought a range of reforms for making self-reliant India in defence and a net defence exporter by FY 2025-26. Consequently, greater government-industry-academia collaborations are now taking place. For instance, under 'Impacting Research Innovation and Technology' (IMPRINT) programme in the domain of 'security & defence', an innovation was made in design and development of textile-based metamaterial absorber for RADAR stealth in a government funded project executed by the Indian Institutes of Technology (IITs), Kanpur. This invention has stealth applications in defence.

iv) Space Sector

In the space sector, India achieved major successes in 2023 and the sector increasingly demonstrates India's growing technical heft to the world. India became the first country to land its Chandrayan-3 on the Moon's South Pole in August 2023.[34] It's first Solar Mission,

Aditya-L1, was launched to study the Sun in September 2023. As part of the preparation for the *Gaganyaan* mission, India's first human space flight scheduled for 2025, the Indian Space Research Organisation (ISRO) conducted a number of tests including initial recovery trials of Crew Module in the Water Survival Test Facility (WSTF) along with the Indian Navy in February 2023, the Gaganyaan Service Module Propulsion System (SMPS) in July 2023, and the first Developmental Fight of Test Vehicle (TV-D1) was accomplished with the in-flight abort demonstration of the Crew Escape System (CES) in October 2023. More such tests are expected to be conducted throughout the year 2024 to ensure readiness for the mission.

Moreover, ISRO participated in Aero India 2023 where it showcased key space technologies and equipment leveraging the defence space.[35] It launched a Capacity Building Programme on 'Geospatial Technologies and Applications' in tandem with objectives of National Geospatial Policy 2022. Notably, the government approved India's Space Policy 2023 and signed the Artemis accord in June 2023,[36] which has significant technological and strategic value.

Meanwhile, the number of Space Startups have increased from just one in 2014 to 189 in 2023 and have attracted private investment amounting to more than Rs. 1,000 crore in 2023.[37] India's success in the space sector has accelerated its space economy, and it is becoming an important component of India's economy. At present, the size of the Indian Space Economy is estimated around $8.4 billion (around 2-3 percent of global space economy), which is expected to reach $44 billion by 2033. In the space sector, thus, India is well positioned to utilise the arising opportunities to further strengthen its space programme.

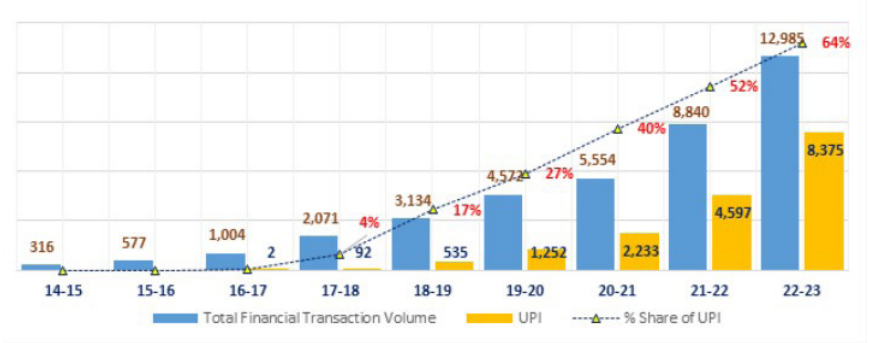
v) Digital India

The 'Digital India' Programme was launched in July 2015 with the vision of providing digital infrastructure as a core utility to every citizen, governance and services on demand, and digital empowerment of citizens. In the process, India has emerged as one of the pre-eminent countries to use technology to transform the lives of its citizens. In 2023, the government reinforced its efforts to further transform India into a digitally empowered society by infusing digital technologies into the public service ecosystem, creating investment and employment opportunities, and making India adept at emerging technologies in order to transform the country into a leading knowledge economy. In pursuit of this goal, in August 2023, the government approved the extension of the Digital India Programme with a total outlay of Rs. 14,903.25 crore during the period 2021-22 to 2025-26.[38]

Notably, several initiatives have been launched such as 'DigiLockers', where citizens can store their documents free of charge, has now more than 13.7 crore users; over 135.5 crore residents have enrolled with the 'Aadhaar' scheme which facilitates targeted delivery of financial and other subsidies, benefits and services; 'E-Hospitals', which connect patients, hospitals and doctors through a single digital platform - 753 Hospitals have been on-boarded; 'Co-Win' has so far facilitated administration of 220 crore doses of vaccinations; 'E-Pathshala' showcases and disseminates all educational e-resources; and 'BHIM' app which makes payment transactions simple, easy and quick using Unified Payments Interface (UPI) - about 458 on-boarded as of November 2023. The UPI, India's fastest payment system which was launched in 2016, has recorded phenomenal growth both in terms of volume

and value of transactions in recent years (See Graph 4).

Graph 4: Contribution of UPI Transaction in Total Digital Transactions (in Crore)



(Source: Rise of a New Era in Digital Payments, Ministry of Information and Broadcasting, Government of India, Delhi, 2023 at doc2023427188301.pdf .pib.gov.in)

In terms of volume, UPI transactions have grown from 92 crore in FY 2017-18 to 8,375 crore in FY 2022-23 at a Compound Annual Growth Rate (CAGR) of 147 percent. Similarly, UPI transactions in terms of value has grown from ₹ 1 lakh crore in FY 2017-18 to ₹ 139 lakh crore in FY 2022-23 at a CAGR of 168 percent.[39] The UPI has thus emerged as the most popular and preferred payment system in India. All these digital initiatives have brought faster changes and helped build new economic structures in the country.

vi) Technology Startups

The Startup India initiative was launched in January 2016 with an intent to build a strong ecosystem for nurturing innovation, startups and encouraging investment in startup ecosystem of the country. Since then, various programmes have been implemented under the initiative for achieving specific objectives. This has led to significant increase in number of startups in India. As of 31 December 2023,

there are 1,17,254 startups in India, recognised by the Department for Promotion of Industry and Internal Trade (DPIIT).[40] The Action Plan for startups comprising of schemes and incentives such as simplification and handholding, funding support and incentives, industry-academia partnership and incubation, and credit guarantee fund for the startups have been created which led to the growth of startups in India.

As a result, the startups are making substantial contributions in diverse sectors, ranging from FinTech, AgroTech, SpaceTech, DefenceTech, EdTech, FoodTech, HealthTech, MedTech to the drones and aviation sector. More than 4000 recognised startups are now increasingly focusing on new technology areas such as AI, quantum technology, IoT, robotics, and semiconductor technology. The interface between the government, industry and academia has increased significantly.

Consequently, India is now home to 111 unicorns with a combined valuation of over US $349 billion. The startups are not only developing innovative solutions and technologies in these sectors, but also have created over 12.42 lakh direct jobs, contributing substantially to Indian economy. Thus, the startups are playing pivotal role in India's journey towards becoming technology self-reliant and a developed nation by 2047, the 100th year of India's independence.

5. Establishing STI Ecosystem in India

In pursuit of its vision of establishing STI ecosystem in the country, the government brought a series of major policies and announced big investments in a range of sectors. The Indian Parliament passed the 'Anusandhan National Research Foundation Act 2023' to establish

Anusandhan National Research Foundation (ANRF) with aims to provide high level strategic direction for research, innovation and entrepreneurship in the field of natural sciences including mathematical sciences, engineering and technology, environmental and earth sciences, health and agriculture. It will be implemented with a total budget of Rs 50,000 crores from 2023-28, out of which a major share of around 70 percent is estimated to come from non-government sources.[41]

The *National Quantum Mission* (NQM) was launched with a total budget of over Rs. 6,000 crores for eight years from 2023-24 to 2030-31 to seed nurture and scale up scientific and industrial R&D and innovation ecosystem in Quantum Technology (QT).[42] The NQM focuses on four main areas such as quantum computing, quantum communication, quantum sensing & metrology, and quantum materials & devices. Meanwhile, the Raman Research Institute (RRI), Bangalore, has achieved a major milestone of free space quantum communication between a moving source and a stationary observer using Quantum Key Distribution (QKD).[43] IIT Delhi has also demonstrated secure quantum communication upto a distance of 380 km in a standard telecom fiber.[44] These are important steps towards India's efforts in developing secure quantum communications using satellites and optical fiber. The significance of QT in the defence and security sectors has increased significantly, particularly because of its ability to process and transmit vast amounts of unhackable data, navigation capabilities, improved sensing and metrology has the potential to revolutionise the nature of future warfare.[45]

Under the *National Mission on Interdisciplinary Cyber Physical System* (NM-ICPS), 25 Technology Innovation Hubs (TIHs) have been established in the areas of new and emerging technologies

such as AI, ML, QT, Robotics, Cybersecurity, Data Analytics & Predictive Technologies, and Technologies for Agriculture, Water, Mining, & Advanced Communication Systems.[46] The Government-Industry-Academic collaborations are its main foci which carry out their activities under four major categories, i.e. Human Resource Development, Technology Development, Entrepreneurship Development and Industrial Collaboration. The mission has developed 63000+ Human Resource, 1200 jobs creation, 311 technologies, 549 technology products and nearly 124 international collaborations. Its Hub Collaborative activities has made the Mission's impact even bigger.

A *National Geospatial Policy* 2022 was also launched to make India a world Leader in global geospatial space. A tripartite Memorandum of Understanding (MoU) has been signed between Department of Science and Technology (DST), National Institute for Geo-Informatics Science & Technology (NIGST), the TIH, and IIT Tirupati for the establishment of a Geospatial Innovation Hub to create a robust geospatial innovation ecosystem in the country.

Furthermore, the 'Make in India' initiative continues to facilitate investment, foster innovation, build best in class infrastructure, enhance skill development, and to make India a hub for innovation, design and manufacturing through cutting-edge technologies. The initiative has registered significant achievements and currently it focuses on 27 strategic sectors of manufacturing and services under 'Make in India 2.0'. It encourages potential investors and partners all over the world to participate in the growth story of 'New India'. With the vision of 'Make in India, Make for the World' theme, it continues to ensure that the business ecosystem is conducive for investors doing business in India and in contributing to growth and

development of the country.

6. Forging Technological Partnerships

In the midst of ongoing great power competition for technology dominance, the geopolitical realignments are taking place where India is seen in an advantageous position. In this fast evolving geopolitical landscape, the government has made renewed efforts in building technology cooperation with leading powers. In February 2023, India and Singapore launched the UPI-PayNow linkage, which enables the people of the two countries to transfer remittances instantly, conveniently and securely by using their mobile phones.[47] This marked a major milestone in forging fintech cooperation that immensely benefits the people of the two countries. Earlier in January 2023, India and the US launched the 'initiative on Critical and Emerging Technologies' (iCET) to strengthen outcome oriented cooperation in emerging technologies such as 5G/6G, AI, quantum, defence, space, and semiconductor technology in addition to nurturing STEM talents. The iCET framework also includes General Electric's proposal for joint production of jet engines in India. In March 2023, the two sides launched a new India-US Strategic Trade Dialogue (IUSSTD), which focuses on aligning the two countries' export control systems for enhancing high technology trade and facilitating transfer of technology (ToT) between the two countries.

Meanwhile, the government approved the proposal of Micron Technology for setting up a semiconductor unit in India with capital investment of Rs 22,516 crore (US $2.75 billion), with providing 50 percent fiscal support. Construction of the unit is going on in full swing in Sanand, Gujarat and is expected to be completed by

the end of 2024. The memory and storage products manufactured in this unit will cater to domestic consumption and also be exported globally. It is expected to create up to five thousand direct and 15 thousand indirect job opportunities in the next five years. Applied Materials has also announced to invest $400 million for establishing a 'Semiconductor Centre for Commercialisation and Innovation' in India to strengthen the semiconductor supply chain diversification; and, for Lam Research to train 60,000 Indian engineers through its 'Semiverse Solution' to accelerate India's semiconductor education and workforce development goals. AMD is investing US $400 million in India over the next five years to establish world's largest design center for AMD. Most recently, Foxconn won approval to invest at least US $1 billion more in a plant it is building in India that is to make Apple products.[48] It plans to spend that amount in addition to nearly US $1.6 billion it earlier set aside for the 120-hectare site close to Bengaluru's airport.

Besides, India and the European Union held their first ministerial meeting of the Trade and Technology Council (TTC) in May 2023, which is a key forum to deepen the India-EU strategic partnership on trade and technology. Under the Quad mechanism, India along with Australia, Japan and the US have set up the Quad CET Working Group which facilitates cooperation on innovation technologies and international standards. The Quad countries have organised their work around four areas of CETs: technical standards, 5G diversification and deployment, horizon-scanning, and technology supply chains. In a significant development, G20 countries under India's presidency reached groundbreaking consensus on how to effectively shape Digital Public Infrastructure (DPI) of the future. In the meantime, India has signed agreements with a number of countries, especially with the global south countries in management

and deployment of DPI for the larger benefit of the people of the world.

The first India Stack Developer Conference was held in January 2023 where more than 100 digital leaders from industry associations, industry, system integrators and startups discussed to increase access and adoption of India Stack for countries that are keen to adopt and integrate it. The *Vaishvik Bharatiya Vaigyanik* (VAIBHAV) Summit was held in October 2023 to connect Indian STEM diaspora with Indian academic and R&D institutions.[49] Under its Chairmanship, India hosted the annual Global Partnership on Artificial Intelligence (GPAI) summit in New Delhi in December 2023. The representatives from 28 member countries and the European Union participated in the deliberations on the urgent matters shaping the fast-evolving landscape of AI. One of the major outcomes of the summit is the GPAI New Delhi Declaration, which built consensus among its members on advancing safe, secure, and trustworthy AI.

Under India's G20 presidency, the fourth edition of the Space Economy Leaders Meeting (SELM) was also orgnanised by Department of Space, where the Heads of Space Agencies and Representatives from 18 G20 member nations and eight friendly countries participated to deliberate current issues and opportunities in global Space. In a significant step towards international space collaboration, ISRO and Mauritius Research and Innovation Council (MRIC) signed a Memorandum of Understanding (MoU) in November 2023 for development and deployment of a Joint Small Satellite at cost of Rs 20 crore in 15 months.[50] The MoU also establishes a framework for cooperation on the use of the ground station at Mauritius, which is critical for India's launch vehicle and satellite missions in future. Some of the subsystems for the satellite

will be developed through the participation of Indian industries. So, this will enhance industrial capabilities and generate employment opportunities within the country.

India's technology diplomacy thus helped elevate and expand technology cooperation with a large number of countries involving the governments, private companies and academic institutions. Such technology partnerships will shape the evolving GVCs, where India is positioned to play an important role.

7. Key Challenges

While the world is undergoing rapid technology enabled transformations, new societal and security challenges such as epidemic, food, energy, climate change, increasing level of pollution, depleting natural resources, cyber, etc. are coming up with having major implications. Revolution in technologies like AI have created immense potential for transformation of human life, at the same time it threatens human extinction, unless regulated well. It is thus believed that CETs would help address these challenges. However, technology itself cannot solve these problems. There is need of greater international cooperation. But developing international collaboration has become increasingly challenging because of the growing geopolitical rivalry between major powers, which are in race to develop and deploy CETs to shift the balance of economic and military power in their favour.

At the same time, India remains in a vulnerable position as the largest importer of arms in the world whereas real transfer of technology, joint research, development and production of emerging

technologies are not happening. One of the major challenges faced by the STI sector is low investment in the R&D and negligible private investment in sectors such as defence. Research is also done in silos and the existing linkages between the government, industry, researcher and academia are not good enough. The interface between the knowledge creator, industry and user community also inadequate. As a result, converting scientific ideas into commercial products and processes faces a big challenge.

India, with the current defence expenditure and defence R&D plan, faces major challenges in catching up with China's growing military capabilities. The power asymmetry between India and China, its main adversary, has grown over the last two decades, with Chinese having substantial advantage. According to SIPRI 2023 data, India ranked fourth with total military expenditure of about $82 billion in 2022, which constituted 3.6 percent of global military spending.[51] Whereas China accounted for 13 percent of global spending and ranked second in absolute terms with military spending of $292 billion. The US ranked first with expenditure of $877 billion, which constituted 39 percent of global spending. The continuous increase of China's military expenditure and its plan to increase nuclear warheads from the current operational stockpile of more than 400 nuclear warheads to over a thousand nuclear warheads by 2030 pose grave threats to India's security and strategic interest. In addition, China has capabilities in the domain of space, cyber, intelligence, surveillance and reconnaissance (ISR) and building new capabilities by using AI, quantum technologies, big data to strengthen its concept of the 'intelligentised' warfare.

India will find very difficult to build parity with China, given the huge economic and technological gap that have devolved over the

years but even then, it needs to sharpen its focus on areas where it needs to invest to strengthen its military capabilities to counter the major threats and challenges. It also needs to further strengthen and deepen defence cooperation with the Quad and other likeminded countries who share security and strategic interests vis-à-vis China. Moreover, though Russia is still the largest supplier of arms to India, its share has declined from 64 percent to 45 percent during the period 2013-17 to 2018-22, that is from $ 11.004 billion to $ 6.964 billion in terms of total value. Russia's position as the largest arms supplier to India is 'under pressure' due to several reasons, including competition from other suppliers; India's indigenous arms production efforts; prioritised supplies to its own army; and finding a payment mechanism that doesn't violate US sanctions.[52] By shifting India's major arms imports from Russia to either France or US may be useful, but that will not support India's cause. So, there is need for joint research, development and production of advanced technologies which will greatly support its efforts to build effective military capabilities, strengthen its deterrence against China and help fight future wars.

Electronics is one of the world's largest traded commodities with a total value of over US $2.3 trillion.[53] India aims to export US $120 billion of electronics goods by FY 2025-26 and make electronics as its top three export category. To achieve this target, it needs to reach global scale in production, increase its exports and shift the GVCs. This requires enhancing competitiveness of India's electronics sector, without which GVCs will not shift. It needs to fill the gap between what the world buys and what India exports at present. However, achieving this target in a short-time frame appears to be a big challenge, given that it has no big electronics manufacturing companies. Large scale investment are also not coming to this field

though India's big companies like TATA Group have announced big investments in electronics.

India's R&D in innovation is also meagre in comparison to other leading electronics manufacturing countries including defence electronics. So, building an entire electronic manufacturing ecosystem in the country will remain a challenge for foreseeable future. Moreover, though India has huge STEM talent base, developing IP rights is a big challenge. Currently, the Indian semiconductor engineers are designing chips for the leading foreign companies without having Original Equipment Manufacturer (OEM) players in the country.

Nevertheless, the government has been making several S&T interventions to address these challenges as mentioned in the preceding section for building a STI ecosystem in the country. Consequently, major technology companies such as Micron, Apple, Foxconn are coming to India to set up facilities. However, there is need to do more. In this regard, the private sector has a big role to play in transforming India in the areas of emerging technologies.

8. Future Prospects

The world has increasingly become multipolar and interconnected where technology plays important role. In the year ahead, competition and geopolitical rivalry between states are expected to further intensify, especially between the US and China. While the United States will continue to battle to keep the advanced technology, software and materials from falling into the Chinese hands, the latter is fast deploying its newly acquired technologies

to achieve its defence and strategic priorities. Consequently, critical technology and material supply chains would remain at high risk. Particularly, Taiwan's TSMC, which makes over 90 percent of all high-end semiconductors, remains vulnerable to geopolitical rivalry and natural disasters. Countries are thus expected to step up the de-risking efforts by building their own chip industries and also diversify their supply chains.

Despite the prevailing challenges, the Government of India, with people centric approach, has brought a paradigm shift in bridging the gap between the government and its people, where new technologies are playing critical role. The S&T based development models also contributed to India becoming the world's fifth largest economy. India is now targeting to launch its *Gaganyaan* mission, first manned mission to the space, by 2025. It aims to build a space station by 2035 that is accessible for Indians to go there for research purpose and build Indian presence on the moon by 2040. It is poised to broaden and deepen its role in global semiconductor supply chain and facilitate setting up a world class semiconductor manufacturing ecosystem in the country, including creation of IP rights. It is also expected to increase public investment and encourage private investment in R&D, especially in the areas of emerging and disrupting technologies such as AI, ML, IoT, blockchain, big data and cyber security. In fact, the private sectors, who have been risk averse so far, have already begun to contribute big way in various sectors such as defence and space under Make in India and Self-reliant India programmes.

Importantly, India aims to become US $ 1 trillion digital economy by 2025 by empowering every citizen with access to digital information, knowledge and services. It strives to achieve inclusive growth in

areas of electronic services, manufacturing and job opportunities. It has already begun connecting rural areas with high-speed internet networks such as 4G/5G to bridge the digital divide and improve digital literacy. At present, India has more than 800 million active internet users. With 5G and the largest rural broadband connectivity network project at 'Bharat Net', it aims to connect more than 400 million users in the near future and bring the number of people having access to the internet to 1.2 billion.

Moreover, strategic opportunities for India at the global level are increasing and it is making vigorous efforts to deepen and expand technology partnerships with friendly foreign countries. It is expected to further leverage the mechanisms such as iCET, Quad and India-EU Trade and Technology Council (TTC) to initiate collaborative R&D in emerging and disruptive technologies. India's vigorous efforts to indigenously design develop and manufacture advanced technologies, and to strengthen international technology partnership would support it become a part of the GVCs, and create India brand products. There is huge potential for expanding this in coming years. Given the global supply chains realignment, it has opportunities to build its manufacturing ecosystem. In the next decade, many countries in the world would prefer to buy Indian products.

Under the 'make-in-India, make for the world' vision, India is expected to further strengthen the indigenous development and production of advanced defence weapons and equipment to meet the full range of 'short-of-war' activities. At the same time, as the fast-growing and the fifth largest economy, the expectations from India have increased over providing S&T inputs to address the socio-economic, industrial and strategic challenges. In fact,

as a responsible stakeholder, India is already sharing technology solutions through innovation and entrepreneurship, such as the India Stack, for the larger benefits of the people of the world. Thus, it has acquired a key place in the comity of nations and given that there is no shortage of knowledge, skill, vision and strategy on CETs in India. Indeed, India is set to play a global role and is on a right path to become a developed nation by 2047.

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VIVEKANANDA INTERNATIONAL FOUNDATION
3, San Martin Marg, Chanakyapuri, New Delhi – 110021
Phone: +91-11-24121764, 24106698
Email: info@vifindia.org,
Website: https://www.vifindia.org
Follow us on twitter@vifindia