



## Advancing the Growth of Core Technologies

*This editorial is based on "[How do we develop 'core' technologies?](#)" which was published in The Hindu Business Line on 02/01/2025. The article brings into focus the critical need to address India's persistent challenge of translating scientific innovations into commercial success, emphasizing stronger academia-industry-government collaboration as the key to building a technology-driven developed economy.*

**For Prelims:** [Raman effect](#), [Semiconductor tech](#), [Artificial Intelligence](#), [Quantum Computing](#), [Cybersecurity](#), [Space Technology](#), [Telecommunications](#), [PLI scheme](#), [Semicon India](#), [Digital India Mission](#), [e-Sanjeevani](#), [Green hydrogen](#), [India's EdTech sector](#), [Startup India](#), [iCET \(Initiative on Critical and Emerging Technologies\)](#), [Make in India](#), [National Research Foundation](#).

**For Mains:** Importance of Core Technology for India, Key Issues Hindering the Growth of Core Tech in India.

From the [Raman effect](#) in 1930 to modern [semiconductor tech](#), India has repeatedly demonstrated its capability to develop groundbreaking '**core technologies**'. However, the nation has consistently struggled to commercialize these breakthroughs, often losing market advantages to foreign competitors. The **historical disconnect between academia, industry, and government** has resulted in India remaining dependent on imports for critical technologies, despite having the intellectual capacity to develop them. This gap in **translating scientific excellence into commercial success remains a crucial challenge** that must be addressed for India to achieve its vision of becoming a technology-led-developed economy.

### What does the term Core Technology mean?

- **About: Core Technology (Core Tech)** refers to the **foundational, advanced, and critical technologies** that form the backbone of innovation and drive growth across industries, economies, and national priorities.
- **Key Characteristics of Core Tech**
  - **Foundational Nature:** Core tech serves as the building blocks for other technologies and applications.
  - **Wide Applicability:** These technologies find applications across multiple domains such as defense, healthcare, education, and manufacturing.
  - **Strategic Importance:** Core tech often determines a nation's economic, military, and geopolitical power due to its critical role in security, governance, and innovation.
- **Examples of Core Tech**
  - **Semiconductors:** Chips used in electronics, computing, and AI.

- **Artificial Intelligence (AI)**: Technologies for machine learning, natural language processing, and automation.
- **Quantum Computing**: Advanced computing leveraging quantum mechanics for unparalleled processing power.
- **Cybersecurity**: Tools to protect digital infrastructure and data from threats.
- **Space Technology**: Satellites, launch vehicles, and space exploration tools.
- **Advanced Manufacturing**: 3D printing, robotics, and Industry 4.0 technologies.
- **Green Technologies**: Renewable energy solutions like solar panels, wind turbines, and green hydrogen.
- **Telecommunications**: Core technologies enabling 5G, fiber optics, and next-generation communication systems.

## Why Investing in Core Technologies is Crucial for India?

- **Economic Growth and Global Competitiveness**: Investment in core technologies like **Artificial Intelligence (AI), semiconductor manufacturing, and quantum computing** is crucial for boosting India's economic growth.
  - These technologies drive **innovation, improve productivity, and create high-value jobs**.
  - For instance, the **global AI market is projected to reach \$900 billion by 2030**, and India's share is expected to grow with its AI investments through **the National AI Mission**.
  - Similarly, the **PLI scheme for semiconductors aims to establish India as a global chip manufacturing hub**, addressing the **\$110 billion semiconductor market deficit by 2030**.
- **Strengthening National Security**: Core tech like **cybersecurity, drone technology, and AI-driven surveillance** are critical for addressing modern security threats, including cyberattacks and border management.
  - For example, AI-enabled tools can be used for **real-time monitoring of the Line of Actual Control (LAC)**.
  - CERT-In tackled over **1.39 million cybersecurity incidents in 2022**, making indigenous cybersecurity development imperative.
  - Additionally, the **Defence Ministry's collaboration with private firms under IDEX** has led to advances in drone and anti-drone systems, enhancing security readiness.
- **Reducing Technological Dependence**: India's reliance on imports for critical technologies like **semiconductors and high-end electronics hampers strategic autonomy**.
  - Investing in indigenous R&D ensures self-reliance in critical sectors like **telecom (5G), defense, and space**.
  - The inauguration of the **Semicon India program in 2023** aims to make India self-sufficient in chip production.
- **Building a Knowledge-Based Society**: Core technology investments enhance education, healthcare, and governance by fostering innovation and improving access.
  - Initiatives like the **Digital India Mission** have brought rural households online, boosting e-learning and e-health services.
  - For example, AI tools are being used to predict disease outbreaks, while platforms like **e-Sanjeevani** have facilitated over **276 million teleconsultations** in rural India.
  - Similarly, **India's EdTech sector, currently valued at \$7.5 billion**, highlights how digital tools are transforming education.
- **Driving Climate Resilience and Sustainability**: Advanced technologies like **renewable energy tech, smart grids, and climate modeling** are critical for India's energy transition and climate action goals.
  - India has committed to achieving **500 GW of non-fossil fuel capacity by 2030** under its Nationally Determined Contributions (NDCs).
  - Investment in **green hydrogen and solar power tech** will help in fulfilling its commitments,
  - Furthermore, the **use of AI in crop monitoring** has improved agricultural productivity while conserving resources.
- **Boosting Startups and Entrepreneurship**: A robust tech ecosystem nurtures **startups and fosters entrepreneurship**, driving economic diversification and innovation.

- With over **100 unicorns** and a thriving community of more than **157,000 startups**, the country is shaping the future of global business.
- Programs like **Startup India and the DPIIT's support for tech startups** are instrumental in positioning India as a global innovation hub.
- **Geopolitical Leverage:** Investments in core technologies enhance India's strategic positioning and global partnerships.
  - India's partnership with the US under the **iCET (Initiative on Critical and Emerging Technologies)** highlights the role of tech in bilateral ties.
  - Additionally, India's role in **semiconductor alliances like the Quad Semiconductor Supply Chain Initiative** positions it as a key player in countering China's dominance in tech supply chains.

## What are the Key Issues Hindering the Growth of Core Tech in India?

- **Inadequate R&D Investment and Ecosystem Support:** India's low investment in **research and development (R&D)**, at just **0.65% of GDP**, constraints innovation and technological advancement, especially in critical fields like **AI, semiconductors, and robotics**.
  - This underfunding also **discourages private sector participation and collaboration with academia**, which are essential for breakthrough technologies.
  - In comparison, countries like Israel and South Korea have robust tech ecosystems due to significantly higher R&D investments.
- **Shortage of Industry-Ready Workforce:** India lacks an **adequately skilled workforce** capable of meeting the demands of emerging technologies like **blockchain, quantum computing, and AI**, limiting industrial innovation and global competitiveness.
  - Only **51% of graduates are employable**, reveals **Economic Survey 2023-24**.
  - Roles such as data analysts and AI specialists are expected to see high demand, with projections indicating employment for **2.5 to 2.8 million professionals** by 2030, yet existing training programs fail to address this requirement adequately.
- **Dependence on Imports for Strategic Technologies:** India's reliance on imports for critical technologies such as **semiconductors, lithium-ion batteries, and advanced machinery undermines** self-reliance and exposes the economy to global supply chain disruptions.
  - Currently, **India imports 95% of its semiconductors** from countries like **China, Taiwan, South Korea, and Singapore**.
  - The global semiconductor shortage during the pandemic severely affected India's automobile and electronics industries, costing billions in lost output and highlighting the need for domestic capacity under initiatives like **Make in India**.
- **Policy Inconsistencies and Bureaucratic Delays:** Frequent shifts in government policies and **lengthy approval processes discourage investments in core technologies**, stalling projects in critical areas like chip manufacturing and green tech.
  - For instance, while the government announced ₹76,000 crore for semiconductor manufacturing in 2021, **no large-scale fab facilities have become operational** due to procedural delays and lack of clarity.
  - India ranks **63rd in the World Bank's Doing Business Report (DBR), 2020** published in October, 2019 before its discontinuation by the **World Bank**, underscores the regulatory challenges in attracting FDI for tech innovation.
- **Weak Collaboration Between Academia and Industry:** India's innovation ecosystem **suffers from limited partnerships between academic institutions and industries**, leading to isolated research efforts without scalable outputs.
  - India witnessed a **record 31.6% increase in patent applications in 2022**, but despite world-class research from premier institutes like IITs, only a small fraction of these patent were successfully commercialized.
  - In comparison, the **US fosters tech transfer through programs like the Bayh-Dole Act**, which mandates the commercialization of federally funded research, creating a thriving innovation ecosystem.
- **Limited Deep-Tech Startup Funding:** India's startup ecosystem is skewed towards **consumer tech and e-commerce**, with insufficient venture capital for deep-tech sectors like AI, quantum computing, and space tech, which require long gestation periods.
  - Nasscom reports a surge in Indian deep-tech startups in 2023, but funding dropped by **77%**.

- For example, space-tech companies like **Agnikul Cosmos** have struggled to **secure funding for scaling operations** despite their pioneering achievements in India's private space sector.
- **Fragmented Approach to Climate-Tech Innovation:** India's climate-tech innovation is limited by a lack of coordinated policy and investment despite the **pressing need for sustainable technologies like green hydrogen and advanced battery storage**.
  - For instance, while India committed to 500 GW of renewable capacity by 2030, investments in **energy storage technologies remain insufficient**.
  - In contrast, **countries like Germany and Japan have made significant strides in hydrogen technology** by investing heavily in R&D and creating public-private partnerships.

## What Measures can India Adopt to Enhance the Development of Core Tech?

- **Increase R&D Investment and Public-Private Collaboration:** India must increase R&D spending to at least **2% of GDP**, aligning with global leaders like South Korea and the US, to foster breakthrough innovations.
  - A dedicated **National Core Technology Fund** could finance advanced research in AI, quantum computing, and semiconductors, with incentives for private sector contributions.
  - Linking programs like **Semicon India** with academia and industry under the **National Research Foundation** can bridge research and commercialization gaps, creating a cohesive innovation pipeline.
- **Establish World-Class Infrastructure for Core Tech:** India must prioritize building cutting-edge infrastructure such as semiconductor fabs, quantum labs, and AI testbeds.
  - Special incentives for technology parks like the **Bangalore Technology Cluster** could attract global tech giants to set up facilities.
  - Integrating **PLI Schemes** with **Smart Cities Mission** can help build advanced industrial zones with sustainable infrastructure, ensuring a steady supply chain and streamlined logistics.
- **Develop a National Talent Strategy:** A nationwide strategy focusing on **skilling and reskilling** must be implemented to meet the demand for an industry-ready workforce in core tech sectors.
  - Programs like **Skill India** should partner with global firms to provide **hands-on training in AI, robotics, and blockchain**.
  - Additionally, **reforming STEM curricula to include emerging technologies can close the skill gap**; for instance, embedding AI and data analytics courses in all engineering programs.
- **Boost Domestic Manufacturing with Strategic Investments:** India should invest in high-tech manufacturing sectors like semiconductors, lithium-ion batteries, and advanced machinery to reduce import dependency.
  - The **National Manufacturing Policy** must integrate with the **Atmanirbhar Bharat** initiative to support startups and MSMEs in these domains.
  - For example, aligning **FAME(Faster Adoption and Manufacturing of Electric Vehicles)** with domestic **lithium-ion battery production** can create a sustainable EV ecosystem, reducing reliance on Chinese imports.
- **Create a Unified Innovation Ecosystem:** Strengthen collaboration among academia, startups, and industries to foster innovation and commercialization of technology.
  - Programs like the **Startup India** initiative can be expanded to provide funding and mentorship to core-tech startups.
  - Connecting **IITs and NITs** with industrial hubs through an **Innovation Exchange Platform** could replicate the success of **Silicon Valley-style ecosystems**, leading to more effective tech transfer and scalable solutions.
- **Focus on Cybersecurity and Indigenous Solutions:** India must prioritize building indigenous cybersecurity infrastructure to safeguard critical sectors amid rising cyber threats.
  - Programs like **Cyber Surakshit Bharat** need expansion to include **real-time threat monitoring tools** and robust AI-driven defense systems.
- **Leverage Global Partnerships for Technology Transfer:** India should deepen collaborations with global tech leaders through initiatives like the **India-US iCET (Initiative on Critical and Emerging Technologies)** to acquire advanced expertise in semiconductors and AI.



- Expanding such partnerships with **Japan (for robotics) and Germany (for green hydrogen tech)** can fast-track India's capabilities.
- For example, linking the **Quad Semiconductor Initiative** with domestic efforts under **Semicon India** can help build resilient supply chains.
- **Enhance Tech Accessibility in Rural Areas:** To bridge the rural-urban divide, India must ensure core technologies like AI and IoT reach underserved areas.
  - Programs like **BharatNet** should be accelerated to provide broadband connectivity to all rural regions, enabling digital inclusion.
  - Linking this with the **Digital India Initiative** can promote **AgriTech solutions like AI-driven crop monitoring and precision farming tools**, enhancing rural productivity.
- **Adopt a Circular Economy for Sustainable Tech Development:** India must integrate sustainability into its core tech development by focusing on **recycling e-waste and reducing resource-intensive practices**.
  - Establishing **Green Technology Zones** in collaboration with the **National Green Hydrogen Mission** can promote eco-friendly innovation.
  - For example, **combining solar energy with battery recycling plants** can support the EV sector sustainably, creating a circular economy for clean energy technologies.
- **Strengthen Intellectual Property (IP) Framework:** India must **simplify its IP filing process** and enhance enforcement to encourage innovation and attract foreign investments.
  - Establishing **fast-track IP courts and IP awareness campaigns** can ensure quicker commercialization of innovations.
  - Linking this with **Startup India** can provide startups with subsidized patent filing assistance, fostering a culture of protecting and monetizing innovations.
- **Encourage Gender Diversity in Tech:** India must focus on increasing the participation of women in STEM and core tech roles to enhance its talent pool.
  - Initiatives like **Women in STEM** should be expanded to provide scholarships, mentorship, and leadership training for women in AI, quantum, and robotics.
  - Linking these with programs like **Digital Saksharta Abhiyan (DISHA)** can ensure grassroots participation by women in tech innovation.
- **Build Strategic Reserves of Rare Earths:** India must invest in exploring and mining rare earth minerals domestically to reduce dependence on imports for semiconductors and EV batteries.
  - The **National Mineral Exploration Trust** should integrate with the **Make in India** program to incentivize private firms to develop rare earth processing facilities.
  - For example, building partnerships with **Australia, the fourth-largest rare earth mining country in 2023**, can secure India's supply chains.

## Conclusion

To achieve its vision of becoming a technology-driven developed economy, India must address the **critical gaps in the commercialization of core technologies**. By fostering stronger collaboration between academia, industry, and government, and **significantly increasing investment in research and development**, India can create a thriving innovation ecosystem. Strengthening these efforts will not only drive economic growth but also contribute to **national security, sustainability, and global competitiveness**.

### **Drishti Mains Question:**

India has consistently demonstrated its capability to develop cutting-edge core technologies, yet struggles to commercialize them effectively. Analyze the reasons behind this gap and suggest measures to strengthen the linkages between academia, industry, and government

## UPSC Civil Services Examination, Previous Year Question (PYQ)

### **Prelims:**

**Q. Atal Innovation Mission is set up under the (2019)**

- (a) Department of Science and Technology
- (b) Ministry of Labour and Employment
- (c) NITI Aayog
- (d) Ministry of Skill Development and Entrepreneurship

**Ans: (c)**

**Mains:**

**Q.** COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was sought to aid management of the pandemic. **(2020)**

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