NITI AAYOG DISCUSSION PAPER

Beyond Planning: India's Urgent Need for a 10-Year R&D Vision, Action, and Accountability

(08 April, 2025)

Co-authored by Debjani Ghosh, Distinguished Fellow – NITI Aayog and Sharad Sharma, Founder - ISPIRT

China's R&D Breakthroughs Under "Made in China 2025": A Comparative Analysis with India and Strategic Lessons

China's strategic initiative "Made in China 2025" (MIC 2025) has fundamentally transformed the nation's position in global high-tech manufacturing through targeted research and development investments. This analysis examines China's approach to driving breakthrough R&D, compares it with India's R&D landscape, and identifies strategic lessons for India's industrial and technological advancement.

China's Strategic R&D Investment Approach

China's remarkable ascension in technological innovation stems from a comprehensive and methodical approach to research and development that combines massive funding with strategic direction. The MIC 2025 policy represents a masterclass in coordinated industrial policy.

Scale and Structure of R&D Investments

China's R&D investment has reached unprecedented levels, with total expenditure hitting 3.6 trillion yuan (approximately $496 billion) in 2024, representing an 8.3% year-on-year increase1. This substantial financial commitment underscores China's determination to achieve technological self-reliance. The initial MIC 2025 policy was supported by over $300 billion in funding, followed by an additional $1.4 trillion post-COVID-19 investment to accelerate technological progress.

Basic research investment has seen even stronger growth, increasing by 10.5% to reach 249.7 billion yuan in 2024, constituting 6.91% of total R&D spending1. This emphasis on fundamental scientific exploration demonstrates China's long-term perspective on innovation. The country's R&D intensity (R&D expenditure as a percentage of GDP) reached 2.68% in 2024, an increase of 0.1 percentage point over the previous year, positioning China among the world's leading innovation-driven economies.

The infrastructure supporting China's R&D ecosystem is equally impressive, with 40 dedicated R&D centers and national laboratories established specifically to drive innovation across priority industries1. These research facilities serve as convergence points where academic expertise, industrial know-how, and government priorities align to solve complex technological challenges.

Targeted Focus Areas and Breakthroughs

China's approach differs from broad-based innovation policies by identifying and investing heavily in ten strategic industries that form the foundation of future technological leadership:

1. Electric Vehicles: China has achieved market dominance, with BYD surpassing Tesla as the world's largest EV manufacturer by 20241. This leadership position stems from concentrated R&D in battery technology, power management systems, and autonomous driving capabilities.

2. Renewable Energy: China now controls approximately 95% of global solar panel production and has pioneered innovations in battery technology, including commercial-scale sodium-ion batteries as alternatives to lithium-ion technology1. The country has surpassed its goals for solar panel production and energy storage solutions.

3. Telecommunications: Despite international sanctions, Huawei emerged as a global leader in 5G technology, demonstrating China's ability to overcome external challenges through internal R&D capabilities.

4. Quantum Computing: China's investments in quantum research have yielded significant breakthroughs, including the Micius satellite for quantum communication, positioning China as a leader in this critical emerging technology.

5. Semiconductor Technology: While still facing challenges in advanced chip manufacturing, China's SMIC has managed to develop limited 7nm chip production capabilities without access to state-of-the-art lithography tools, showcasing the resilience of their R&D ecosystem.

6. High-Speed Rail: China has achieved global leadership in railway equipment and infrastructure exports, exemplified by projects like the Jakarta-Bandung High-Speed Rail.

7. Robotics and Automation: By 2024, China had fulfilled all targets in smart manufacturing and robotics sectors, creating a comprehensive ecosystem for Industry 4.0 technologies.

Key Innovations out of China – 2020 to 2025

Year	Sector	Innovation/Breakthrough Exampls	Impact
2020	Biotechnology	Development of mRNA vaccine platforms by Synthea Biotech during COVID-19.	Strengthened domestic biotech capabilities and reduced reliance on Western pharma.
2020	Artificial Intelligence	Launch of Baidu's Ernie Bot, one of the first Chinese LLMs competing with GPT-3.	Positioned China as a leader in AI-driven language models.
2021	Renewable Energy	CATL introduced sodium-ion batteries, reducing EV battery costs by 30%.	Made EVs more affordable, boosting adoption globally.
2022	Quantum Computing	Micius Satellite enabled quantum communication over 4,600 km (Beijing to Vienna).	Established leadership in secure quantum communication.
2022	Semiconductors	SMIC achieved limited production of 7 nm chips despite US sanctions.	Reduced dependency on foreign chipmakers and bolstered domestic supply chains.
2023	Space Exploration	Tiangong Space Station became fully operational.	Expanded China's presence in space research and international collaborations.
2023	High-Speed Rail	Shanghai launched the world's fastest maglev train (600 km/h).	Enhanced global competitiveness in transportation infrastructure.
2023	Advanced Materials	Commercialization of condensed matter batteries by CATL for electric vehicles.	Improved EV range and energy density, accelerating green energy transitions.
2024	Biotechnology	First gene-edited pig-to-human heart transplant using CRISPR technology.	Advanced organ transplantation and regenerative medicine fields globally.
2024	Space Exploration	Chang'e-6 mission retrieved lunar samples from the Moon's far side.	Strengthened China's lunar exploration program and scientific research capabilities.
2024	Infrastructure	Completion of Jakarta-Bandung High-Speed Rail, Southeast Asia's first high-speed rail project.	Expanded Belt and Road Initiative influence in infrastructure development abroad.
2025	Advanced Materials	Peking University announced gallium oxide-based semiconductors with 10x efficiency over silicon chips.	Revolutionized semiconductor efficiency for next-gen electronics and energy systems.
2025	Renewable Energy	Completion of the world's largest hybrid solar-wind farm (16 GW) in the Gobi Desert.	Accelerated renewable energy adoption and reduced carbon emissions at scale globally.

Patent Output and Intellectual Property

The tangible results of China's massive R&D investments are evident in its rapidly growing patent portfolio. By the end of 2024, China had accumulated approximately 4.76 million valid domestic invention patents, representing a 16.3% increase compared to 20231. This remarkable patent growth reflects both the quantity and quality of China's innovation ecosystem, with many patents focused on emerging technologies like artificial intelligence, quantum computing, and advanced materials.

Integration Model for Innovation

China's R&D success rests heavily on its unique integration model that connects multiple stakeholders in a coordinated innovation ecosystem. This triple-helix approach brings together:

1. Academic Institutions: China's top universities are directly involved in applied research aligned with national priorities.
2. State-Owned Enterprises (SOEs): These organizations provide scaled manufacturing capabilities and implementation pathways for new technologies.
3. Private Technology Firms: Companies like BYD, Huawei, and numerous startups bring market responsiveness and entrepreneurial drive.

This integration model creates feedback loops where theoretical research rapidly transitions to commercial applications, accelerating the innovation cycle significantly. The collaboration

between academia, SOEs, and private firms has been instrumental in accelerating technological breakthroughs in sectors like semiconductors and AI-driven robotics.

Comparative Analysis: China vs. India R&D Landscape

The research and development ecosystems of China and India show significant divergence in scale, focus, and integration, leading to notably different outcomes in technological innovation and industrial competitiveness.

Investment Scale and Priorities

China's R&D investment has reached 2.68% of GDP as of 2024, with plans to continue increasing this proportion1. In contrast, India's R&D spending has historically hovered around 0.7% of GDP, creating a substantial funding gap that impacts the ability to drive breakthrough innovations at scale.

The absolute difference is even more striking: China's annual R&D expenditure of approximately $496 billion dwarfs India's investment, which is estimated to be less than $100 billion1. This massive disparity in funding translates directly to research capacity, infrastructure development, and the ability to attract top talent.

The allocation patterns also differ significantly:

Parameter	China	India
R&D % of GDP (2024)	2.68%	~0.7%
Total R&D Expenditure (2024)	$496 billion	<$100 billion
Basic Research (% of R&D)	6.91%	Higher proportion
Government vs. Private R&D ratio	Increasingly private-led	Government-dominated
Focus on applied vs. basic research	Strong emphasis on applied research with commercial outcomes	Greater proportion on basic research with fewer commercial applications
Industrial concentration	Focused on 10 strategic sectors	More dispersed across multiple sectors

China's approach emphasizes strategic concentration of resources in priority sectors, with clear commercialization pathways. The Chinese government allocated over $300 billion initially for the MIC 2025 initiative, with an additional $1.4 trillion invested post-COVID-19 to accelerate progress. India's approach tends to be more diffuse, with less concentrated investment in specific industries.

Infrastructure and Ecosystem Development

China has systematically established 40 dedicated R&D centers and national laboratories focused on priority industries, creating concentrated innovation hubs with critical mass1. India has created institutions like IITs and CSIR laboratories, but these often function with greater independence and less industrial integration.

The Chinese model actively promotes knowledge transfer between research institutions and industry through formal mechanisms and incentives. This integration across stakeholders—academia, SOEs, and private firms—has been critical to China's rapid technological advancement1. India's academic-industry gap remains wider, with fewer structured pathways for commercializing research.

Outcomes and Technological Position

The divergent approaches have led to measurable differences in global technological positioning:

1. Patent Output: China's patent portfolio has grown to 4.76 million valid domestic invention patents by the end of 2024, a 16.3% increase from the previous year. India's patent filings, while growing, remain at a fraction of China's output.
2. Global Market Share: In key sectors like EVs, solar panels, and telecommunications equipment, Chinese firms have captured dominant global market shares. BYD has surpassed Tesla as the largest EV manufacturer globally, and China controls approximately 95% of global solar panel production. Indian firms have achieved similar dominance only in select legacy niches like generic pharmaceuticals and IT services.
3. Self-Reliance: China has significantly reduced dependency on foreign technology in multiple sectors, with MIC 2025 targeting 70% self-sufficiency in core technologies by 2025. India continues to heavily import technology in many high-value areas, particularly in electronics, advanced materials, and precision manufacturing.
4. Supply Chain Control: China has built comprehensive supply chains in strategic industries, while India remains dependent on imported components and materials for many high-tech products.

Strategic Lessons for India's R&D Transformation and Implications:

Some of the key takeaways from India are:

- Strategic Sectoral Focus: Identifying and prioritizing high-impact sectors for funding with clear commercialization roadmaps.
- Robust R&D Investment: Committing substantial financial resources, as evidenced by the MIC 2025 and post-COVID-19 investments.
- Integrated Innovation Ecosystems: The Chinese model actively promotes knowledge transfer between research institutions and industry through formal mechanisms and incentives. This integration across stakeholders—academia, SOEs, and private firms—has been critical to China's rapid technological advancement.
- Performance Tracking and Measurement: Meticulous monitoring of progress, evidenced by the rapid growth of China's patent portfolio. By the end of 2024, China had accumulated approximately 4.76 million valid domestic invention patents, representing a 16.3% increase compared to 2023. This remarkable patent growth reflects both the quantity and quality of China's innovation ecosystem, with many patents focused on emerging technologies like artificial intelligence, quantum computing, and advanced materials.
- Policy Continuity and Long-Term Vision: Maintaining consistent policy direction to build investor confidence.
- Rigorous Accountability: China's success is not just about planning, but disciplined execution. A key learning for countries is the need for a dedicated National Industrial Strategy Task Force to track progress, enforce accountability, and ensure that plans are not just made, but realized. This task force will be responsible for providing regular, transparent reports on key performance indicators, addressing bottlenecks, and adjusting strategies as needed.

In sum, there is an urgent need to reimagine India’s R&D ambition and impact. To drive this transformation, we must start with a bold vision of where we want to be. Recognizing that successful change starts with strategic foresight, NITI Frontier Tech Hub (NITI FTH) is establishing a core group of experts to craft the Vision for R&D in India in 2035. This initiative will also lay out a concrete roadmap for achieving global leadership in key technologies. Crucially, this effort must prioritize effective implementation, strong accountability, and sustained policy continuity to ensure real impact and secure our future.