© JUL 2026 | IRE Journals | Volume 10 Issue 1 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV10I1-1719638

# Bridging The Gap: A Comparative Assessment of India's Science and Technology Standing Relative to China and Japan

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***Abstract- India, China, and Japan represent three distinct trajectories of science, technology, and innovation (STI) development in Asia, each shaped by different histories, political economies, and policy choices. This paper offers a comparative, evidence-based assessment of how far India lags behind China and Japan across key STI indicators, including research and development (R&D) expenditure, patent output, scientific publication volume and impact, innovation ecosystem rankings, semiconductor and advanced manufacturing capability, and higher-education research infrastructure. Drawing on data from the World Bank, UNESCO, the World Intellectual Property Organization's Global Innovation Index (GII), and the Clarivate/Institute for Scientific Information G20 Research and Innovation Scorecard, the analysis finds that India has made substantial gains in research output and start-up-driven innovation, rising to third place globally in scientific publication volume and improving steadily in the GII. However, India continues to trail China and Japan by wide margins in R&D intensity (spending as a share of GDP), private-sector R&D participation, high-value patent filings, semiconductor fabrication capacity, and the commercialisation of research into scalable products. The paper argues that India's gap is less a deficit of scientific talent than a structural one, rooted in chronically low R&D investment, weak industry-academia linkages, and a shortfall in translating early-stage research into market-ready technology. The paper concludes with a review of recent Indian policy responses, including the Anusandhan National Research Foundation and the Research, Development and Innovation (RDI) Scheme, and situates these within the broader question of whether India can narrow the gap over the coming decade.***

***Keywords- India Science and Technology; China Innovation Policy; Japan R&D; Comparative Technology Development; Global Innovation Index; Research and Development Expenditure; Patent Filings; Scientific Publications; Innovation Ecosystem; Asia Technology Gap***

## I. INTRODUCTION

Science, technology, and innovation (STI) capability has become a central axis of national competitiveness and geopolitical influence in the twenty-first century. Among Asia's major economies, China, Japan, and India illustrate three markedly different STI trajectories. Japan built a technologically advanced, high-income economy through decades of sustained industrial R&D investment beginning in the postwar era.

China, starting from a much lower base in the late twentieth century, has pursued an explicit state-led strategy of R&D intensification, indigenous innovation, and manufacturing upgrading, and has recently overtaken long-standing leaders in several innovation metrics.

India, the world's most populous nation and fifth-largest economy, has demonstrated notable strength in software services, space technology, pharmaceuticals, and, increasingly, research publication output, yet continues to register R&D spending and innovation-output levels well below those of its two large Asian neighbours.

This paper asks a specific and often politically charged question: how far behind is India in science and technology relative to China and Japan, and along which dimensions is the gap largest or narrowest? Rather than offering a single composite verdict of 'backwardness,' the paper disaggregates the comparison across several measurable dimensions:

R&D investment intensity, publication output and citation impact, patenting activity, innovation ecosystem rankings, and sector-specific capability in

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areas such as semiconductors and advanced manufacturing.

This disaggregated approach is necessary because India's position varies considerably by indicator, appearing globally competitive in some areas (publication volume, digital services exports, start-up ecosystem scale) while lagging substantially in others (R&D intensity, semiconductor fabrication, high-value patents).

## II. LITERATURE REVIEW

A substantial body of comparative development literature has examined the divergent STI trajectories of India and China since economic liberalisation in the early 1990s. Early comparative work framed the two countries as following distinct growth models: China's export-oriented, manufacturing-led, state-coordinated model versus India's services-led, private-sector-driven model.

This distinction has direct implications for R&D: manufacturing-intensive economies tend to generate more applied, patent-generating industrial research, while services-led economies often generate more academic publication output relative to patenting.

Studies of national innovation systems, following the framework developed in the 1990s by scholars such as Richard Nelson and Christopher Freeman, emphasise that innovation capacity depends not merely on R&D spending levels but on the density and quality of linkages between universities, public research institutions, and industry.

Analyses of China's innovation system consistently point to sustained state investment, beginning with the 863 Program in the 1980s and continuing through the Medium- and Long-Term Plan for Science and Technology Development (2006–2020) and subsequent Five-Year Plans, as the central driver of its rise in patent filings and R&D expenditure.

Comparable analyses of Japan's innovation system emphasise the historical role of keiretsu-linked corporate R&D laboratories and a stable, high-intensity national R&D-to-GDP ratio maintained since the 1980s.

India-focused STI policy literature, including assessments by the Department of Science and Technology and independent economists, has repeatedly identified the same structural weakness: gross expenditure on R&D has remained close to 0.6–0.7 percent of GDP for over a decade, a level roughly one-fifth of Israel's or South Korea's and well under half of China's.

Scholars attribute this gap primarily to weak private-sector participation, with Indian industry contributing a substantially smaller share of national R&D than is typical in China, Japan, the United States, or South Korea.

Recent literature, including the Economic Survey of India 2025–26, has introduced the concept of research 'valley of death' in India, describing a systemic failure to move technologies from early-stage laboratory research (technology readiness levels 1–3) into prototyping, piloting, and commercial deployment (levels 7–9), even where foundational research is internationally competitive.

A separate strand of literature, most notably the annual Global Innovation Index produced by the World Intellectual Property Organization and the G20 Research and Innovation Scorecard produced by Clarivate's Institute for Scientific Information, provides longitudinal, indicator-based comparisons rather than qualitative case studies.

This literature consistently finds that India is an 'innovation overperformer' relative to its income level, meaning its innovation outputs exceed what would be predicted from its GDP per capita alone, even as its absolute levels remain below China's and Japan's.

This dual finding, structural underinvestment alongside output overperformance, is a recurring theme this paper draws upon in constructing its comparative assessment.

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## III. METHODOLOGY

This paper adopts a comparative descriptive-analytical approach rather than a novel empirical model.

It synthesises the most recent publicly available data (2024–2026) from four principal sources: the World Bank's World Development Indicators and UNESCO Institute for Statistics data on R&D expenditure; the World Intellectual Property Organization's Global Innovation Index 2025; the Clarivate Institute for Scientific Information's G20 Research and Innovation Scorecard 2025; and government and parliamentary data from India's Department of Science and Technology and the Economic Survey of India 2025–26.

Indicators were selected to capture both input measures (R&D spending, researcher density) and output measures (publications, citation impact, patents, innovation cluster rankings), since input–output disaggregation is essential to avoid conflating investment levels with realised innovation performance.

## IV. COMPARATIVE FINDINGS

### 4.1 R&D Expenditure as a Share of GDP

R&D intensity, gross expenditure on R&D as a percentage of GDP, is the most widely cited input indicator of national STI commitment. On this measure, the gap between India and its two neighbours is the starkest of any indicator examined in this paper.

India's gross expenditure on R&D has remained close to 0.6 to 0.65 percent of GDP for well over a decade, a level the Economic Survey 2025–26 describes as significantly below the 2.5 to 5 percent range typical of innovation-led economies.

By contrast, Japan has sustained R&D spending above 3 percent of GDP for decades, and China, though starting from a much lower base in the 1990s, surpassed the 2 percent threshold in 2013 and has continued climbing since, with WIPO estimating that China became the world's largest single national R&D spender in absolute terms in 2024.

A further structural distinction is the composition of R&D funding: in India, private industry contributes only around 36 percent of gross R&D expenditure, whereas in China, Japan, and other high-R&D economies, private-sector contributions typically exceed 70 percent.

This indicates that India's shortfall is concentrated less in public scientific institutions and more in the comparative absence of large-scale corporate research investment.

Table 1. R&D Expenditure as a Share of GDP (most recent available year) Table 1. R&D Expenditure as a Share of GDP (most recent available year)

| Country | R&D Spend (% of GDP) | Approx. Year |
|---|---|---|
| Japan | 3.4% | 2022 |
| China | 2.6% | 2022 (est. ~2.7% by 2024) |
| India | 0.6% – 0.65% | 2023–24 |

### 4.2 Scientific Publication Output and Citation Impact

India's position is markedly stronger on research publication volume than on R&D spending. According to the Clarivate G20 Research and Innovation Scorecard 2025, India rose from ninth place in global publication output in 2013 to fifth by 2016 (overtaking Japan), and by 2024 had climbed to third place globally, behind only mainland China and the United States, having overtaken the United Kingdom.

India's output roughly doubled between 2015 and 2024. However, the scorecard notes an important pace differential: China took only five years to grow its annual output from 100,000 to 200,000 papers, whereas India has taken seven years to grow from roughly 100,000 toward 180,000 papers, indicating that China's publication growth trajectory has been steeper even though both countries started R&D intensification from comparatively low bases.

Citation impact, a proxy for research quality rather than sheer volume, has improved steadily for India but still lags both China and Japan on a per-paper basis, reflecting earlier-stage development of India's research ecosystem, less mature peer-review and doctoral training pipelines in some fields, and lower average research funding per scientist.

Japan, despite lower publication volume growth, maintains strong citation performance in areas such as materials science, robotics, and precision engineering, reflecting its long-established research infrastructure.

4.3 Global Innovation Index Standing

The WIPO Global Innovation Index 2025, which benchmarks 139 economies on roughly 80 indicators spanning institutions, human capital, infrastructure, market and business sophistication, and innovation outputs, places the three countries far apart.

China entered the GII top 10 for the first time in 2025, ranking 10th overall, overtaking Switzerland in knowledge and technology outputs, ranking second in R&D expenditure, and leading the world in patent filings. Japan rose to 12th place, its best ranking since 2011, excelling particularly in patent families (2nd) and business-performed R&D (3rd). India ranked 38th globally in 2025, retaining its position as the top-ranked economy in the Central and Southern Asia region.

Notably, India is repeatedly described in the GII literature as one of the world's longest-running innovation 'overperformers,' meaning its innovation outputs exceed what its income level would predict, and it has climbed roughly ten places in the ranking over the preceding decade.

India performs particularly strongly on ICT services exports (ranked first globally), domestic market scale (third), late-stage venture capital deals (fourth), and unicorn valuation (eleventh), reflecting the strength of its digital and start-up economy. It performs comparatively weakly on institutional quality indicators and on the translation of research into scaled industrial output.

4.4 Innovation Clusters and Patent Filings

At the sub-national level, China and Japan dominate the WIPO top global innovation cluster rankings. The Shenzhen–Hong Kong–Guangzhou cluster ranks first globally, followed by Tokyo–Yokohama in second place, with China hosting 24 of the world's top 100 innovation clusters for a third consecutive year, more than any other country.

India has made recent progress, with Bengaluru and Delhi entering the global top 30 clusters for the first time in 2025, ranked 21st and 26th respectively, while Mumbai (46th) and Chennai (84th) also feature in the top 100, giving India four clusters overall.

Japan maintains three clusters in the global top 100 (Tokyo–Yokohama, Osaka–Kobe–Kyoto, and Nagoya). On raw patent volume, China leads the world by a wide margin, and Japan ranks highly in patent families, a measure of internationally protected, higher-value inventions, while India's patent filings, though growing quickly in percentage terms, remain a small fraction of China's or Japan's absolute totals.

4.5 Semiconductors, Advanced Manufacturing, and Deep Technology

Beyond the aggregate indices, sector-specific capability gaps are especially pronounced in semiconductor fabrication and advanced electronics manufacturing. Japan retains globally significant capability in semiconductor materials, precision manufacturing equipment, and robotics.

China has built substantial domestic capacity across the semiconductor value chain, supported by sustained state investment, though it continues to depend on foreign equipment and design tools for the most advanced process nodes.

India, by contrast, has historically had negligible domestic semiconductor fabrication capacity, and its current efforts to build fabrication plants under the India Semiconductor Mission remain in early stages relative to the mature ecosystems in East Asia.

India's strength in this domain lies predominantly in chip design services and IT-enabled engineering support rather than in fabrication or advanced materials science.

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## V. DISCUSSION: WHY THE GAP EXISTS

The comparative evidence suggests that India's STI gap relative to China and Japan is not primarily a deficit of scientific talent, ideas, or publication capacity, areas where India has demonstrated strong and improving performance, but rather a structural gap in investment intensity and commercialisation capacity. Four structural factors recur across the literature and data reviewed in this paper.

- Chronically low R&D intensity: India's R&D spending has remained near 0.6 percent of GDP for over a decade, compared with over 2.6 percent in China and over 3.4 percent in Japan, limiting the scale of laboratories, equipment, doctoral funding, and long-horizon research programmes India can sustain.
- Weak private-sector R&D participation: Indian industry funds only around a third of national R&D, compared with more than 70 percent in China, Japan, and other high-R&D economies, reflecting a smaller base of large domestic technology and manufacturing conglomerates willing to fund in-house research at scale.
- The prototyping and commercialisation 'valley of death': India's Economic Survey 2025–26 explicitly identifies a systemic gap between early-stage research (TRL 1–3) and market-ready deployment (TRL 7–9), meaning strong academic output does not reliably translate into scaled domestic technology products or globally competitive firms.
- Later-starting, narrower industrial R&D base: unlike Japan's decades-old corporate research laboratories or China's state-coordinated industrial upgrading programmes dating to the 1980s, India's private industrial R&D base is younger, smaller, and more concentrated in IT services and pharmaceuticals than in advanced manufacturing or deep technology.

At the same time, the data caution against an undifferentiated narrative of Indian 'backwardness.' India's rise to third place globally in research publication volume, its leadership in ICT services exports, its expanding venture-capital-backed start-up ecosystem, and its emergence as a top-performing innovation economy relative to its income level all indicate a research and innovation base that is expanding rapidly, even if it remains smaller in absolute and intensity terms than China's or Japan's.

## VI. POLICY RESPONSES AND OUTLOOK

India's government has responded to these structural gaps with several recent initiatives. In November 2025, the government operationalised a Rs. 1 lakh crore Research, Development and Innovation (RDI) Scheme aimed explicitly at incentivising private-sector innovation investment, reflecting recognition that public research funding alone cannot close the gap with China and Japan.

The Economic Survey 2025–26 further proposes the establishment of Translational Research Centres intended to reduce the cost and risk of prototyping and piloting for start-ups, small and medium enterprises, and academic institutions, directly targeting the commercialisation gap identified above.

Earlier reforms, including the establishment of the Anusandhan National Research Foundation to coordinate and scale research funding across disciplines, similarly aim to increase both the volume and translational quality of Indian research.

Whether these measures narrow the gap with China and Japan over the coming decade will depend substantially on whether they succeed in mobilising private capital at a scale comparable to that seen in China's state-industry innovation coordination or Japan's long-standing corporate research culture, rather than on public science funding or research publication output alone, both of which India has already demonstrated it can grow rapidly.

## VII. CONCLUSION

This comparative review finds that India is substantially behind China and Japan in science and technology when measured by R&D investment intensity, private-sector research participation, high-value patenting, semiconductor and advanced manufacturing capability, and overall innovation ecosystem ranking. India ranks 38th in the 2025 Global Innovation Index against China's 10th and

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Japan's 12th, and spends roughly a quarter of China's and a fifth of Japan's share of GDP on R&D.

However, India is not uniformly behind: it now ranks third globally in scientific publication output, is recognised as a long-running innovation overperformer relative to its income level, and leads the world in specific domains such as ICT services exports.

The overall picture is one of a rapidly maturing but still under-invested research and innovation system, whose principal constraint is not scientific capability but the scale of financial commitment, particularly from private industry, and the institutional capacity to translate research into scaled, commercially deployed technology.

Closing the gap with China and Japan will likely require India to sustain R&D spending growth well above its historical trend and to succeed in mobilising private-sector research investment at a scale it has not yet achieved.

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