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Engineering Excellence: China's State-Directed Transformation of Higher Education and Its Implications for Emerging Economies

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Abstract

China's emergence as a global leader in higher education and scientific research over the past three decades represents one of the most consequential transformations in the modern history of knowledge production. This paper argues that China's ascent is neither organic nor accidental, but rather the product of deliberate, state-engineered policy pursued with unusual consistency across successive administrations. Drawing on data from different databases, we document the scale, pace, and strategic logic of this transformation. The paper makes three original contributions. First, it names and theorises the concentration paradox: the counter-intuitive finding that elite targeting with fiscal restraint can outperform the universal-expansion model recommended by mainstream policy orthodoxy. Second, it uses ASPI 2025 data to offer a specific diagnosis of India's technology-research gap as a problem of 'breadth without depth' — India appears in the global top five for approximately 50 of 74 critical technologies but leads in none — and argues this is a structurally different failure mode from simply spending too little. Third, it derives from the China analysis a concrete five-point policy agenda for India, adapted for democratic governance. We also identify significant limitations of China's model: research-integrity concerns, academic freedom constraints, and deep geographic inequality within the Chinese university system.

Keywords: China; higher education policy; research output; university rankings; Double First-Class; concentration paradox; ASPI Critical Technology Tracker; India; emerging economies; R&D spending

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1. Introduction

In the twenty-first century, geopolitical competition has moved decisively into the domain of knowledge. The capacity to train scientists and engineers, to generate original research, to attract global talent, and to translate academic discovery into patented technology and industrial capability has become a core dimension of national power. Universities — once regarded primarily as instruments of domestic human-capital formation — are now understood as strategic assets whose global standing reflects, and shapes, a nation's position in the international order. No country has grasped this logic more clearly, or acted on it more purposefully, than the People's Republic of China.

The trajectory of Chinese universities in global rankings illustrates the transformation with unusual clarity. In 2004, when the inaugural Academic Ranking of World Universities (ARWU) was published, not a single Chinese mainland institution appeared in the top 100; Peking University and Tsinghua University were ranked in the 201–300 band. By 2025, Tsinghua University had climbed to 16th in ARWU and entered the QS top 20, while at least six Chinese universities appear in the ARWU top 100. In the Times Higher Education (THE) World University Rankings 2026, Tsinghua University sits at 12th globally. Over roughly two decades, China has moved from near-absence in elite university tables to systematic presence — a rate of ascent with few historical parallels.

This trajectory poses an intellectual puzzle of considerable importance. China's improvement in global rankings and research output has occurred at a time when the country's higher education spending, measured as a share of gross domestic product (GDP), has remained comparatively modest — hovering between 1.0 and 1.4% of GDP since 2012, approximately half the OECD average for tertiary education. Total public expenditure on education reached approximately 4.2% of GDP by 2023, still below the OECD mean of roughly 5.5%. The question, then, is not merely how China rose so rapidly in university rankings and research metrics, but how it achieved this with what can fairly be described as fiscal restraint.

This paper addresses two related research questions. First: what accounts for the speed and scale of China's higher education transformation? Second: how was this transformation achieved without a commensurate expansion of aggregate public spending on higher education? Our core argument is that the answer lies not in additional resources but in their strategic concentration. China did not attempt to raise all boats simultaneously. Instead, it identified a small cohort of elite universities, channelled a disproportionate share of national research funding toward them, tied that funding to measurable performance targets and periodic re-evaluation, and embedded these institutions within a broader industrial and talent strategy linked to national technology priorities.

The paper makes three original analytical contributions.

- The first is conceptual: we name and theorise what we call the concentration paradox — the finding that a deliberate strategy of elite targeting with aggregate fiscal restraint has produced outcomes superior to those achieved by systems that followed the mainstream policy prescription of broad expenditure expansion. This challenges the dominant World

Bank and OECD orthodoxy that improving higher education in developing countries primarily requires raising the overall public spending ratio.

- The second contribution is diagnostic: we use ASPI 2025 data to characterise India's specific failure mode as 'breadth without depth'. India appears in the global top five for approximately 50 of 74 tracked critical technologies — demonstrating genuine research capability — but leads in none. This is a structurally different problem from under-investment alone, and it calls for a structurally different policy response: not merely spending more, but spending more sharply.
- The third contribution is prescriptive: drawing directly from the China analysis, Section 10 develops a concrete six-point policy agenda for India that is adapted for democratic governance and India's specific institutional inheritance.

The paper proceeds as follows. Section 2 traces the policy architecture from Project 211 through Project 985 to the Double First-Class (DFC) programme. Section 3 analyses China's fiscal model and the 'stable one per cent' approach to higher education spending. Section 4 examines research output and citation impact. Section 5 assesses critical technology leadership using ASPI 2025. Section 6 analyses the governance architecture. Section 7 offers comparative perspectives from the United States, South Korea, and India. Section 8 addresses limitations and critiques of China's model. Section 9 concludes with general policy implications. Section 10 develops the India-specific policy agenda in detail.

2. The Policy Architecture: From Projects 211/985 to Double First-Class

China's success in building world-class research universities cannot be understood in isolation from the broader trajectory of its educational system. China achieved near-universal primary education early in its reform era, reaching a national literacy rate that now exceeds 96.8%. By 2010, nine-year compulsory education — covering primary and junior secondary levels — was effectively universal across all social groups and regions, creating a vast, qualified pool of candidates for higher education. The subsequent 'Great Expansion' of Chinese universities, which saw enrolment grow from fewer than two million students in 1990 to over 45 million by 2022, was made possible by this foundation.

The national university entrance examination — the Gaokao — functions as the critical selection mechanism linking this mass secondary system to the elite higher education tier. Access to high-quality senior secondary education thus became the proximate determinant of who could compete for places at the most elite universities, making the quality of the secondary pipeline a strategic concern that compelled parallel investment in school improvement alongside the university excellence programmes. This sequential logic — universal basic education first, then elite university concentration — is an often-overlooked prerequisite of the China model that is directly relevant to policy design in other emerging economies.

The scale of the subsequent higher education expansion was itself remarkable: annual enrolment in regular degree institutions grew from 1.08 million in 1998 to 6.08 million in 2008, a nearly five-fold increase in a single decade, catalysed partly by economic necessity — rising youth unemployment in the aftermath of the 1997 Asian Financial Crisis — and partly by the Ministry of Education's deliberate massification strategy (Huang et al., 2022). Returns to this investment have been substantial: causal estimates using two-stage least squares methods find that additional higher education induced by the Great Higher Education Expansion of 1999 increased adult monthly earnings among urban students by approximately 17% for men and 12% for women (Huang et al., 2022).

The transformation of Chinese higher education did not begin spontaneously with economic growth. It was designed. Three successive state programmes, each building on its predecessor, created a tiered national system in which a small number of elite universities were granted disproportionate resources, autonomy, and prestige — while the mass of Chinese higher education institutions continued to operate on conventional provincial and tuition-fee funding.

Project 211, launched in 1995 under the Ninth Five-Year Plan, was the first systematic attempt to concentrate resources in a defined set of universities. The programme designated 112 institutions — its name derives from '21st century' and '100 universities' — for enhanced central government support, with the stated objective of producing graduates capable of meeting the demands of the post-industrial economy. Project 211 established the institutional precedent for differentiated funding: universities that met performance targets received additional capital for infrastructure, laboratories, and faculty salaries, while others did not. By the early 2000s, Project 211 universities collectively accounted for roughly 70% of national research funding while enrolling a small fraction of total students.

Project 985, announced by President Jiang Zemin at the centenary of Peking University in May 1998, went further. Where Project 211 had defined a broad pool of favoured institutions, Project 985 identified a much tighter elite. The first phase designated nine universities — later expanded to 39 — for special status and substantially enhanced funding. The explicit ambition was world-class status: these institutions were to compete directly with Harvard, MIT, Oxford, and the University of Tokyo. Between 2009 and 2013, Project 985 universities received approximately 70% of total national research funding, an extraordinary concentration given that they enrolled fewer than 5% of Chinese university students (Zhang et al., 2013).

The Double First-Class (DFC) programme, announced in 2015 and formally launched in 2017, represented both a continuation and a refinement of this logic. While DFC formally superseded Projects 211 and 985, its deeper rationale was to introduce performance-based competition into a system where institutional status had begun to ossify. Under the initial 2017 list, 42 universities were designated 'First-Class Universities' and 95 were designated for support in specific 'First-Class

Disciplines', bringing the total DFC5 community to 137 institutions out of approximately 3,000 universities nationwide. The 2022 renewal adjusted the list — notably demoting certain institutions and elevating others — signalling that DFC status was not permanent (Zheng and Li, 2025). The revised list covers 147 universities in 'Category A' and 'Category B' designations, with Category B universities expected to accelerate improvement or face eventual de-listing.

Several design features of these programmes deserves emphasis. First, all three programmes have been explicitly performance-linked: funding is tied to outcomes assessed through periodic reviews, not allocated as entitlements. Second, the programmes have granted participating universities meaningful administrative and academic autonomy relative to other Chinese institutions. Third, and critically, the programmes have operated on long time horizons — Project 985 ran for nearly two decades; DFC is designed as a multi-decade commitment. This temporal depth — the willingness of successive governments to sustain investment across political cycles — is perhaps the single feature most difficult to replicate, and most important to its success.

The sectoral orientation of Chinese elite universities has also been deliberately shaped. The 'C9 League' — China's nine founding Project 985 universities — spans a mix of comprehensive research universities (Peking, Fudan, Nankai), technical universities (Tsinghua, Shanghai Jiao Tong, Harbin Institute of Technology), and regionally embedded institutions (Zhejiang, Xi'an Jiao Tong, University of Science and Technology of China). This configuration was designed to match universities to industrial clusters and regional development priorities, ensuring that the benefits of elite-university investment would diffuse into the broader national innovation system.

Table 1: Top Chinese Universities — Ranking Trajectories, 2004–2026

University	ARWU 2004	ARWU 2010	ARWU 2016	ARWU 2025	QS 2026	THE 2026
Tsinghua University	201–300	151–200	58	16	20	12
Peking University	201–300	151–200	71	17	17	14
Shanghai Jiao Tong Univ.	201–300	151–200	101–150	48	47	102
Zhejiang University	201–300	151–200	151–200	55	44	78
Univ. of Science & Tech. China	201–300	201–300	151–200	72	113	100
Fudan University	201–300	201–300	151–200	89	55	59

Sources: Academic Ranking of World Universities (ARWU) 2004–2025; QS World University Rankings 2026; Times Higher Education World University Rankings 2026. Ranges indicate banded rankings where precise positions were not published.

3. Fiscal Discipline: The 'Stable 1%' Model

The most striking feature of China's higher education transformation, from a comparative fiscal perspective, is what was not spent. Throughout the period of China's most rapid rise in global rankings — from roughly 2005 to the present — higher education spending as a share of GDP remained comparatively low and stable: approximately 1% of GDP in the early 2000s, rising modestly to about 1.4% by the early 2020s. This figure places China below the OECD average for tertiary education expenditure, which hovers around 1.5–1.6% of GDP across member countries, and well below the United States, which consistently spends 2.5–2.8% of GDP on higher education when public and private spending are combined.

Total expenditure on education across all levels reached approximately 4.2% of GDP in China by 2023, following the government's 2012 commitment to raise total education spending to 4% of GDP. While this represents meaningful progress from the sub-3% figures of the 1990s, it remains below the OECD average of roughly 5.5%, and below comparators such as South Korea (4.9%), the United Kingdom (5.8%), and the United States (6.1%). The fiscal restraint at the tertiary level is thus not a consequence of overall parsimony in education spending, but a deliberate allocation choice that reflects the concentration strategy.

The R&D picture tells a strikingly different story. China's gross domestic expenditure on research and development (GERD) has grown far more rapidly than higher education spending, rising from approximately 0.9% of GDP in 2000 to 2.68% in 2024 (China NBS, 2025). In absolute PPP-adjusted terms, China's 2024 R&D expenditure of approximately US$785.9 billion surpassed the United States, edging ahead of the US$781.8 billion spent by the US in the same year (OECD, 2025; NSF NCSES, 2025). This milestone — the first time a country other than the United States has led global R&D in absolute terms — passed with surprisingly little public commentary outside specialist circles.

The coexistence of fiscal restraint in higher education with aggressive R&D growth reflects a deliberate policy choice: to invest heavily in applied research through university-industry partnerships and targeted national programmes, without committing to a universal expansion of higher education quality. Universities in the DFC cohort benefit disproportionately from both streams. Tsinghua University alone received approximately RMB 6.8 billion (roughly US$950 million) in direct government grants in 2022 — more than the total public allocation to higher education in many low-income countries. This level of per-institution investment, sustained over years, explains much of the quality differential between China's elite universities and the rest of its system.

Comparing China's model with international peers reveals the distinctiveness of this approach. India spends approximately 0.65% of GDP on R&D — roughly one-quarter of China's ratio — and approximately 1% on higher education, a ratio similar to China's aggregate figure but without the same concentration effect. South Korea, which pursued a broadly analogous elite-university strategy, spends approximately 4.81% of GDP on R&D across public and private sectors. The United States remains the largest single-country spender on higher education in absolute terms, sustaining a broad and deep research university system through federal grants, philanthropy, and tuition fees that China has not sought to replicate.

Table 2: Higher Education Spending and R&D as Percentage of GDP — Country Comparison, 2023–2024

Country	Higher Educ. Spend (% GDP)	Total Educ. Spend (% GDP)	R&D Spend (% GDP)	R&D Spend (PPP US$bn, 2024)
China	~1.4	~4.2	2.68	785.9
United States	~2.6	~6.1	3.45	781.8
South Korea	~1.8	~4.9	4.81	~130
India	~1.0	~3.2	0.65	~70
OECD Average	~1.5	~5.5	~2.7	n/a

Sources: OECD Education at a Glance 2025; China National Bureau of Statistics R&D Communiqué 2025; World Bank World Development Indicators 2025; NSF NCSES Science and Engineering Indicators 2025. PPP figures are purchasing-power-parity adjusted. India and South Korea absolute R&D figures are approximate.

4. Evaluating performance of inflation targeting in India

The fiscal strategy described above has produced measurable outcomes in research output that are now well-documented. China surpassed the United States as the world's largest producer of peer-reviewed scientific publications by volume around 2020, according to Scopus data compiled by Elsevier (NSF NCSES, 2022). In 2022, Chinese authors contributed approximately 23% of global scientific publications by Scopus count, compared with around 17% for the United States.

This volume leadership is remarkable given that China's modern research university system effectively began its transformation less than three decades ago. A measure of the velocity of this rise: China's share of articles in physical sciences, engineering, and mathematics grew from approximately 4% in 2000 to 18.6% in 2016 — at which point it exceeded the United States' total — with the Great Higher Education Expansion (1999–2008) estimated to have increased the annualised probability of publication by a Chinese author by approximately 45% over the reform decade (Piracha et al., 2022).

Publication volume is an imperfect proxy for research quality, and China's critics have long argued that much of its scientific output was characterised by lower average quality than the headline figures suggest. The citation impact evidence is therefore more instructive. China's field-normalised citation impact was estimated at approximately 0.53 in 2003, indicating that Chinese papers received only slightly more than half the citations of the average paper in their field. By 2022, this figure had risen to approximately 1.04, reaching rough parity with the global mean (NSF NCSES, 2025). The improvement over less than two decades is exceptional by any historical standard.

The Nature Index, which tracks publications in a curated set of 82 high-quality natural science journals, provides a particularly rigorous lens on elite research performance. The Nature Index 2025 Research Leaders report reveals that eight of the world's ten most productive institutions in high-quality natural science research are Chinese (Nature Index, 2025). The Chinese Academy of Sciences (CAS) ranks first globally, followed by Harvard University in second place. Tsinghua University, Peking University, Zhejiang University, the University of Science and Technology of China, Shanghai Jiao Tong University, Nanjing University, and Sun Yat-sen University all appear in the top twenty.

Several features of China's publication profile deserve attention. STEM specialisation is pronounced: China's output is concentrated in engineering, materials science, chemistry, physics, computer science, and increasingly life sciences and artificial intelligence, with limited relative output in humanities and social sciences. International co-authorship remains somewhat lower than comparable systems: approximately 27% of Chinese scientific publications in 2022 involved at least one international co-author, compared with over 40% for many European research systems. Additionally, a substantial proportion of citations to Chinese publications — roughly 60% — come from within China itself, a degree of domestic citation-network concentration that raises methodological questions about field-normalised impact calculations.

Despite these caveats, the trajectory is unambiguous. China has moved in two decades from a peripheral position in global science to a central one, particularly in the applied and engineering sciences most directly relevant to industrial competitiveness. It is not that China's 3,000 universities have all improved dramatically, but that its roughly 40 DFC 'First-Class Universities' have achieved genuine world-class research performance, raising China's global profile out of all proportion to the aggregate spending figures.

Table 3: Scientific Publications — China vs United States, Global Share, 2000–2022

Year	China Pubs (Scopus, 000s)	China Global Share (%)	US Pubs (Scopus, 000s)	US Global Share (%)	China Citation Impact Index
2000	~46	~4.7	~320	~32.4	0.42
2005	~89	~7.3	~345	~28.2	0.50
2010	~195	~12.1	~380	~23.5	0.68
2015	~347	~17.0	~420	~20.5	0.82
2018	~470	~20.4	~440	~19.0	0.95
2022	~558	~23.0	~415	~17.1	1.04

Sources: NSF NCSES Science and Engineering Indicators 2022 and 2025; Elsevier/Scopus data as cited in NSF reports. Citation impact index is field-normalised (1.0 = global average). Publication figures are approximate rounded estimates.

5. Technology Leadership: The Strategic Payoff

The most striking evidence of the strategic payoff from China's higher education investment comes from the domain of critical technology. The ASPI Critical Technology Tracker 2025 assesses leadership across 74 technologies identified as critical to national security, economic competitiveness, and future industrial capacity (ASPI, 2025). China now leads in 66 of the 74 tracked technologies. The United States leads in the remaining eight. China faces no credible competition in 24 of these technologies, a situation the tracker describes as carrying a 'high risk of monopoly', meaning that a single country's dominance could create structural vulnerabilities for all other nations dependent on that technology.

The technologies in which China leads span a wide range: quantum sensors and quantum communications; high-performance and exascale computing; advanced drone and counter-drone systems; synthetic aperture radar; semiconductor design and advanced packaging; space launch systems; advanced batteries and energy storage; hypersonic systems; autonomous underwater vehicles; and multiple domains within advanced materials science. In artificial intelligence, China leads in several sub-domains including natural language processing and AI chip design, though the United States retains advantages in foundation model architecture and certain semiconductor manufacturing technologies. A December 2025 Nature analysis drew on ASPI data to conclude that China leads approximately 90% of technologies considered crucial to future technological and industrial power (Nature, 2025).

The connection between university investment and technology leadership is direct and documented. China's national key laboratory system — approximately 700 laboratories designated by the Ministry of Science and Technology — is almost entirely housed within DFC universities. Tsinghua University alone hosts more than 30 national-level research centres and laboratories. The Zhongguancun Science and Technology Park in Beijing clusters more than 20,000 enterprises within a few kilometres of Tsinghua and Peking University, drawing on their faculties, graduate students, and spinout companies. Tsinghua Tongfang and Founder Group (the Peking University-affiliated conglomerate) are among the most visible examples of the university-enterprise model that has transferred research into commercial and industrial application.

The 2025 ASPI results also illuminate the degree to which China's technology leadership is concentrated in areas directly relevant to its national industrial strategy. The Made in China 2025 (MIC 2025) initiative was explicitly designed to exploit the research capabilities being developed in DFC universities. The alignment between research priorities, university specialisations, and industrial policy targets — quantum, advanced manufacturing, new energy vehicles, biopharmaceuticals, aerospace — is not coincidental. It reflects systematic state coordination of the kind examined in Section 6.

Table 4: ASPI Critical Technology Tracker 2025 — Selected Technologies and Country Leaders

Technology Domain	Global Leader	High Monopoly Risk?	US Position
Quantum Sensors & Communications	China	Yes	2nd
High-Performance / Exascale Computing	China	Yes	2nd
Advanced Drone Systems	China	Yes	2nd
Synthetic Aperture Radar	China	Yes	2nd
Semiconductor Design & EDA	China	No	1st (design tools)
Advanced Batteries & Energy Storage	China	Yes	3rd
Space Launch Systems	China	No	2nd
Hypersonic Systems	China	Yes	3rd
AI — Natural Language Processing	China	No	2nd (English NLP)
Advanced Submarine Technology	US	No	1st
Vaccine & mRNA Platforms	US	No	1st
Semiconductor Manufacturing (EUV)	US	No	1st (with ASML)

Source: ASPI Critical Technology Tracker 2025. 'High Monopoly Risk' indicates the leading country faces no credible second-place challenger. Selected technologies illustrative only; tracker covers 74 domains in total.

6. Governance and State Coordination

The effectiveness of China's higher education transformation cannot be understood without examining the governance architecture that has enabled the state to act as a strategic coordinator rather than merely a funder. China's model combines vertical command — flowing from the State Council through the Ministry of Education (MOE) and the Ministry of Science and Technology (MOST) to individual universities — with horizontal coordination across ministries, subnational governments, state-owned enterprises, and private-sector actors. This combination allows China to align university research priorities with national industrial strategies in ways that more fragmented governance systems find difficult to achieve.

The institutional structure includes:

- The MOE as the primary overseer of university affairs, including the designation of DFC status and the evaluation of performance targets.
- The Ministry of Industry and Information Technology (MIIT) plays a critical coordinating role with technical universities aligned with industrial policy. (Zhejiang University's collaboration with MIIT on advanced manufacturing research under Made in China 2025 is a well-documented example.)
- The National Natural Science Foundation (NNSF) funds basic research through competitive grants distributed predominantly to DFC institutions.
- Provincial governments contribute additional funding — often matching central government grants — and in some cases have established their own elite university programmes modelled on the national DFC design.

The talent pipeline that the Thousand Talents Plan would later formalise has roots that predate the formal university excellence programmes by nearly two decades. In June 1978, Deng Xiaoping delivered a landmark speech calling for thousands of Chinese students — rather than the small numbers then being sent — to study abroad, declaring they would be a 'vital force' for China's transformation. Deng's approach was characteristically pragmatic: he observed that even if a small proportion of students chose not to return, the policy would still succeed because of the knowledge they would eventually bring back. He urged students to 'love their own motherland' and return, while simultaneously arguing that China must improve its own living and working conditions to attract them back naturally — a logic that anticipated the incentive-based return programmes of later decades.

The scale of what followed far exceeded initial expectations. Between 1978 – when opening-up and reform began – and 2024, an estimated 8.88 million Chinese students have studied abroad. Return rates, initially modest — approximately 32% by 1997, as many students chose to remain in the West for better professional opportunities — surged as China's economy and universities improved. The return rate evolved dramatically over time: at the start of the 2000s it stood at approximately 14%, but following sustained government incentive programmes it rose to 78% by 2018 (Piracha et al., 2022), and to approximately 86% by 2024 as measured by official Chinese government statistics (Ministry of Education, China, 2024).

These returnees, known colloquially as haigui ('sea turtles'), now lead over 70% of China's key national research projects and hold the majority of senior positions in universities and hospitals. Their impact on China's publication profile has been equally measurable: the Great Higher Education Expansion (1999–2008) increased the annualised probability of publication by a Chinese author by approximately 45%, with productivity rising most strongly among Chinese authors based in North America, the United Kingdom, and Asia who maintained collaborative links with China-based institutions (Piracha et al., 2022).

The talent dimension of state coordination has been particularly significant. The Thousand Talents Plan, launched in 2008, was designed to attract high-calibre overseas Chinese researchers back to Chinese universities through substantial salary supplements, research funding, and housing allowances. By 2016, the programme had recruited approximately 5,208 scholars in its main category, with many thousands more through affiliated sub-programmes such as the Young Thousand Talents and the Thousand Foreign Experts schemes (CSET Georgetown, 2022). The Changjiang (Yangtze River) Scholars Programme similarly provides high-level salary support to outstanding researchers at Chinese universities. These programmes collectively reversed what had been a severe brain drain in the 1980s and 1990s, returning research talent trained at leading Western institutions to the domestic system.

Beyond formal repatriation, China has more recently embraced a 'brain circulation' model that does not require overseas scholars to return permanently. The government shifted from a policy of 'return and serve' to one of 'serve the homeland' regardless of physical location — a pragmatic recognition that global mobility cannot easily be reversed and that collaborative ties across borders may be more valuable than insisting on relocation. This model generates measurable research dividends: papers co-authored by diaspora scholars and China-based researchers receive approximately twice as many citations as papers authored exclusively within China, significantly boosting the global profile of Chinese institutions (SciDev.Net, 2024). The 111 Project, administered by the Ministry of Education, specifically targets this mechanism: it aims to establish innovation bases in Chinese universities by recruiting thousands of overseas scholars from the world's top 100 universities to work collaboratively with domestic faculty. At elite institutions such as Peking University, haigui faculty are actively prioritised for appointments not only for their own research productivity but for the 'spillover effects' their presence generates — raising the productivity and international orientation of their domestic colleagues.

Internationalisation mandates have been another feature of state coordination, though with important limits. Major Chinese research universities have been encouraged to establish joint institutes, exchange programmes, and dual-degree arrangements with leading international partners: the Tsinghua–MIT programme in urban design, the Fudan–Washington University partnership, and the Zhejiang University–University of Edinburgh joint institution are among the most visible. These partnerships serve multiple purposes: they accelerate faculty development, provide benchmarks for quality assessment, and enhance global visibility and legitimacy.

It is important to acknowledge that state coordination since approximately 2015 has had a more contested dimension. The tightening of the Chinese Communist Party's presence in university governance — including Party secretary roles that in many institutions formally outrank university presidents, the expansion of mandatory ideological courses, and heightened monitoring of classroom content — has created tensions with the academic freedom norms that characterise research productivity in liberal university systems. The question of whether authoritarian governance can sustain world-class frontier research, which typically requires the freedom to pursue unexpected results and challenge established ideas, remains unresolved.

7. Comparative Perspectives: United States, South Korea, and India

Situating China's higher education strategy within a comparative frame illuminate both its distinctive features and the degree to which it represents a synthesis of successful models from other contexts. Three comparators are particularly instructive: the United States, whose research university system established the global benchmark that China explicitly sought to match; South Korea, which pursued an analogous elite-university strategy in a smaller economy with chaebol-anchored industrial policy; and India, which shares many structural features with China — large population, rapid economic development, strong STEM tradition — but has achieved substantially different higher education outcomes.

The United States model is characterised by institutional diversity, decentralised governance, and deep public-private partnership in research funding. Federal agencies — DARPA, NIH, and NSF — provide competitive grants for foundational research, while universities retain intellectual property rights that incentivise commercialisation and spin-out formation. The outcomes include transformative technologies — the internet, GPS, modern semiconductors, the human genome project, mRNA vaccine platforms — that have shaped global society. The US model is deeply path-dependent: it works because of a dense ecosystem of venture capital, entrepreneurial culture, immigration policy that attracts global talent, and a legal framework for intellectual property that is difficult to disaggregate and transplant. China studied this model carefully and borrowed specific elements — particularly the national laboratory concept and the competitive grant mechanism — while adapting them to a centralised governance framework.

South Korea's route to research excellence has been qualitatively different. The Korea Advanced Institute of Science and Technology (KAIST, founded 1971) and Pohang University of Science and Technology (POSTECH, founded 1986) were created as greenfield elite technical universities with explicit industrial missions, tightly linked to the major chaebol conglomerates (Samsung, POSCO, Hyundai). R&D investment in South Korea, at approximately 4.81% of GDP — the highest ratio in the OECD — is overwhelmingly private-sector driven, with firms accounting for roughly 75% of total R&D expenditure. South Korea's elite universities are better understood as nodes in a chaebol-anchored innovation system than as autonomous research institutions. China's model is broader in scope and more state-directed, but the underlying logic of elite concentration linked to industrial champions has clear parallels.

India's case is the most instructive comparator for emerging economies, both because of structural similarities with China and because of the nature and magnitude of the gap in outcomes. India's Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISc) in Bangalore represent a world-class but insufficiently scaled elite university cohort. India appears in the ASPI top five for approximately 50 of the 74 tracked critical technologies — demonstrating genuine research capability across a broad front. Yet India leads in none. This is not simply a story of insufficient investment; it is a story of a specific failure mode that we term 'breadth without depth'. India's research system has achieved wide presence in global science without achieving primacy in any single critical domain. China's strategy did precisely the opposite: it sacrificed breadth for depth, concentrating resources in priority domains until first-mover advantages became self-reinforcing.

India's 'breadth without depth' profile is consistent with a system where research effort is spread thinly across a large number of institutions and topics without the concentrated investment that converts frontier presence into technology leadership. The translation gap — from research to patent to product to industrial capability — remains India's defining challenge, reflecting weak university-industry linkage, inadequate research infrastructure in most of the system, and an R&D/GDP ratio of 0.65%, less than a quarter of China's.

India also possesses one of the world's largest scientific diasporas — estimated at over three million Indian-origin scientists and engineers working abroad, including a substantial cohort in senior academic and research positions at leading global universities — yet has no systematic mechanism analogous to China's Thousand Talents Plan, 111 Project, or brain circulation framework to leverage this resource for domestic research productivity. China turned its diaspora into a structured national asset; India has largely allowed its diaspora to remain an untapped one. Compounding the structural problem is a growing disconnect between doctoral education and innovation. India has significantly expanded PhD enrolments across public and private universities, but this quantitative expansion has not been matched by a corresponding rise in research quality or innovation outcomes. In many institutions, the pursuit of a doctorate has become, as one recent commentary observes, 'an academic credential rather than a pathway to discovery', with theses frequently focusing on theoretical or repetitive topics of limited commercial relevance, and publications accumulating in low-impact journals rather than contributing to a stock of useful knowledge (Uppal, 2026). The lesson from China is that the true measure of a nation's academic strength is not the number of degrees it awards, but the impact its research creates.

The structural comparison between India and China across key indicators is shown in Table 5. The differentials are stark: no Indian university appears in the ARWU top 200, compared with six Chinese universities in the top 100; China's R&D/GDP ratio is four times India's; China's Scopus publication volume is roughly five times India's; and China leads in 66 ASPI technologies versus India's zero. These are not primarily differences of economic size — South Korea, with a GDP approximately one-sixth of India's, has three universities in the ARWU top 100. They are differences of strategic commitment, concentrated investment, and governance effectiveness in translating research investment into research outcomes. Section 10 develops the India policy implications in detail.

Table 5: India vs China — Key Higher Education and R&D Indicators, 2024–2025

Indicator	China	India
Top university — ARWU 2025 rank	16 (Tsinghua)	501–600 (IISc)
Universities in ARWU top 100	6	0
Universities in THE top 200	7	0
R&D expenditure (% of GDP, 2024)	2.68%	0.65%
R&D expenditure (PPP US$bn, 2024)	~786	~70
Scopus publications (approx., 2022)	~558,000	~110,000
Global share of publications (2022)	~23%	~4.5%
Field-normalised citation impact (2022)	1.04	~0.84
ASPI tech tracker: #1 in domain (2025)	66/74	0/74
ASPI tech tracker: top 5 in domain (2025)	74/74	~50/74
International co-authorship share (2022)	~27%	~31%
Talent return programme (cumulative)	~5,200+ (TTP)	No equivalent

Sources: ARWU 2025; QS World University Rankings 2026; THE World University Rankings 2026; ASPI Critical Technology Tracker 2025; NSF NCSES 2025; OECD 2025; China NBS 2025; World Bank 2025; Department of Science & Technology, India (2024). TTP = Thousand Talents Plan. IISc Bangalore ARWU band is approximate.

8. Limitations and Critiques

An honest assessment of China's higher education transformation requires attention to its significant limitations and the critiques that have been raised by scholars within and outside China. These fall into four broad categories: research integrity concerns; systemic bias in quality metrics; academic freedom constraints; and internal geographic inequality.

Research integrity has become an increasingly visible issue as China's publication volume has grown. Paper mills — commercial services that produce fraudulent or fabricated research for payment — have been a documented problem in several Chinese-language and English-language academic communities. In 2023, retraction counts in major databases included approximately 177 papers attributed to Chinese authors in a single Wiley journal cluster alone (The Lancet, 2026). While China is by no means unique in experiencing research fraud, the scale of its publication output means that a given fraud rate produces a larger absolute number of problematic papers. The domestic citation-inflation dynamic noted earlier adds a further methodological concern: if Chinese papers disproportionately cite each other within a self-reinforcing network, field-normalised citation scores may overstate genuine international influence.

International faculty ratios present a further constraint. Tsinghua University's international faculty ratio is estimated at approximately 17.6%, compared with 93.5% at MIT — a differential that reflects both language barriers and, increasingly, concerns among international scholars about academic freedom and political risk in China. As China's geopolitical tensions with the United States and Europe have intensified since 2017, the practical difficulty of sustaining the deep international partnerships that characterised the 2005–2015 period has grown.

The academic freedom dimension is structurally important. World-class research productivity — particularly in frontier sciences, social analysis, and technology policy — typically requires the freedom to challenge established consensus, pursue unexpected results, and engage openly with international peers. Post-2015 tightening of Party oversight in Chinese universities — including expanded requirements for ideological education, monitoring of classroom speech, restrictions on foreign textbooks, and in some fields explicit guidance on acceptable research topics — creates an environment in tension with these norms.

Finally, geographic concentration of gains within China is severe. China's higher education transformation has in practice been a story about Beijing, Shanghai, and a handful of other coastal cities. DFC 'Category A' universities are disproportionately located in Beijing (8 institutions) and Shanghai (4 institutions). The approximately 2,850 Chinese universities that are not DFC-designated operate in relative resource scarcity. The Great Higher Education Expansion, while dramatically increasing total enrolment, exacerbated rather than reduced the urban-rural divide in educational attainment: students with rural hukou (household registration) were systematically disadvantaged relative to urban peers due to the inferior quality of compulsory and upper secondary schooling available to them (Huang et al., 2022). The concentration strategy thus produced a two-tier outcome:

world-class research at the top, while large segments of the population — particularly rural youth — remained unable to access meaningful higher education opportunity. China's 'stable one per cent' model works, in part, because it does not attempt to raise average quality: a sobering caveat for emerging economies considering how to adapt the model.

9. Conclusion

China's transformation of its higher education system constitutes one of the most consequential policy experiments in the modern history of science and technology governance. In less than thirty years, China has moved from the periphery to the centre of global knowledge production — leading 66 of 74 critical technologies tracked by ASPI, hosting eight of the world's ten most productive research institutions by Nature Index measure, and in 2024 surpassing the United States in absolute R&D expenditure for the first time. This has been achieved through what this paper terms the concentration paradox: an approach that combined aggressive concentration of elite university investment with relative aggregate fiscal discipline, holding higher education expenditure at roughly 1–1.4% of GDP while directing R&D spending to 2.68% of a rapidly growing economy. The conventional policy prescription — raise aggregate spending, expand access, and quality will follow — does not account for China's experience. The more accurate description of China's model is: spend less overall, but concentrate what you spend with extraordinary intensity on a small, performance-managed elite.

These five pillars rested, however, on two prior foundations that are equally important but less often acknowledged in the literature. The first is a sequential investment in universal basic education: China achieved near-universal primary and lower-secondary schooling before launching its elite university programmes, ensuring a large, qualified national talent pool from which the Gaokao and DFC universities could select. The second is a long-term overseas-study strategy originating in Deng Xiaoping's landmark 1978 speech, which dispatched successive waves of students to the world's leading universities. Deng's philosophy was characteristically pragmatic: even if only a small fraction returned immediately, the knowledge they acquired and the networks they built would ultimately serve China. The 8.88 million students who have studied abroad since 1978 — 86% of whom had returned by 2024 — were not simply a product of policy; they were themselves a form of long-term strategic investment that took four decades to compound fully.

The architecture of China's higher education achievement thus rests on five reinforcing pillars: disciplined and concentrated investment channelled through successive programmes (211, 985, DFC); performance-linked funding with genuine consequences for underperformance; effective state coordination aligning university research priorities with national industrial strategy; university-industry integration through science parks and enterprise linkages; and a ranking strategy calibrated to the methodologies of ARWU, QS, and THE. Several features carry important caveats. The tightening of Party oversight post-2015 is a structural constraint on frontier research independence.

The paper-mill problem and domestic citation concentration suggest that quality assurance has not kept pace with volume growth. And the geographic concentration of gains creates inequality (that China is beginning to address through the DFC Category B mechanism).

For emerging economies, the concentration paradox offers a reframing of the policy challenge: the question is not simply 'how much should we spend on higher education?' but 'where should we spend it, and with what consistency over time?' It is this reframing that makes China's model potentially instructive for countries like India, which already has the foundational institutions, the talent pool, and the research presence — but not yet the concentrated, directed investment that converts presence into primacy. The choice before India, as one recent commentator has observed, 'is not whether to produce more PhDs, but whether those PhDs will matter' (Uppal, 2026). The specific policy agenda that derives from this analysis is developed in Section 10.

10. A Policy Agenda for India: From Breadth to Depth

India occupies an unusual position in the global science and technology landscape. It is simultaneously one of the world's most prolific producers of engineering graduates, a significant presence in the global scientific literature, a country with demonstrable research capability across a wide range of critical technologies — and a country with no university in the global top 200 by any major ranking, an R&D/GDP ratio of 0.65%, and zero technology domains in which it leads the world. This combination is not a paradox; it is a precise diagnosis. India has breadth without depth. It has built a system capable of producing large volumes of competent research across many domains, but has not built the concentrated excellence in any domain that converts research presence into technology leadership.

The policy implication is equally precise: India does not primarily need to spend more across the board. It needs to spend more sharply, in defined institutions and defined domains, with the consistency of purpose that China has demonstrated over three decades. In the terms of one recent commentary on the India-China research divergence, the shift required is 'from degrees to discoveries, from isolation to integration' (Uppal, 2026) — a formulation that maps precisely onto the structural deficiencies identified by the China comparison. Six policy pillars follow from the analysis.

First, an India First-Class (IFC) programme. India should formally designate a cohort of eight to ten institutions — for instance, IISc Bangalore, IIT Bombay, IIT Delhi, IIT Madras, IIT Kanpur, IIT Kharagpur, IISER Pune, TIFR Mumbai, CCMB, and potentially one or two regionally embedded universities — for a fifteen-year concentrated funding commitment, explicitly modelled on the DFC architecture. Each institution in this cohort should receive a multi-year block grant of the order of Rs. 2,000–3,000 crore annually — significantly above current levels — with the grant tied to a performance compact reviewed every five years. The compact should set specific targets for Nature Index position, patent output, international faculty ratio, and industry research income, not merely publication counts. The programme should be administered by a dedicated autonomous body insulated from annual budget cycles, analogous to how China's Ministry of Education administers DFC with multi-year funding security.

Second, a domain prioritisation strategy derived from ASPI data. India's approach to research priority-setting has historically been diffuse, spread across CSIR laboratories, IITs, central universities, and sectoral research organisations without a unifying logic of competitive advantage. The ASPI data offers a sharper framework. India is already in the global top five for approximately 50 of 74 critical technologies. Rather than treating this as evidence of adequate performance, policymakers should identify twelve to fifteen of these domains — particularly quantum computing, advanced materials, biotechnology, space systems, and AI — and concentrate IFC programme resources in those domains with the explicit goal of achieving global leadership within ten years. The selection should be made against criteria of industrial applicability to India's priority sectors (semiconductors, clean energy, defence, pharmaceuticals), existing institutional strength, and depth of the global talent pool India can access.

Third, a structural PLI–IIT research pipeline. India's Production-Linked Incentive (PLI) scheme, which provides fiscal incentives to firms scaling up manufacturing in priority sectors, is the closest India has to an industrial policy instrument of the kind China deployed through Made in China 2025. But the PLI scheme has no structural linkage to university research: it funds production, not innovation. China's MIC 2025, by contrast, was explicitly built on the research capabilities of DFC universities, with national key laboratories in MIC-priority sectors housed within leading technical universities and funded jointly by MIIT and MOST. India should create an analogous mechanism: a requirement that firms receiving PLI benefits above a defined threshold in technology-intensive sectors must commit a proportion of revenues to joint research agreements with IFC institutions. This would create a demand-pull for university research in commercially relevant domains, and would build the university-industry proximity that is currently India's weakest link in the innovation chain.

Fourth, a National Research Laboratory (NRL) system within IFC institutions. India's current national research infrastructure is dispersed primarily across CSIR laboratories, DRDO establishments, and DAE institutes — organisations structurally separated from university-based research and training. China's 700-laboratory national key laboratory system is housed within DFC universities, ensuring that graduate students and faculty work alongside cutting-edge research infrastructure and that laboratory outputs feed directly into teaching. India should designate thirty to forty National Research Laboratories in the IFC institutions, co-funded by the central government and relevant ministries (DST, DBT, DPIIT, MeitY), with a mandate to work on the priority domains identified under the second pillar. This would also facilitate the kind of ministry-university coordination — analogous to China's MOE–MIIT–NNSF horizontal governance — that is currently absent from India's innovation architecture.

Fifth, a Pravasi Vidwan programme — a democratic Thousand Talents equivalent. India has produced one of the world's largest scientific diasporas, with thousands of world-class researchers at leading universities in the United States, United Kingdom, Germany, Australia, and Singapore. A well-designed, adequately funded, and — critically — politically-insulated repatriation programme could recover a significant proportion of this talent for Indian institutions. The key lessons from the Thousand Talents Plan are transparency in selection, competitive salary parity with international peers, guaranteed research infrastructure funding, and protection from bureaucratic interference. The success of China's haigui programme — which achieved an 86% return rate among overseas-educated students by 2024, with returnees now leading over 70% of national research projects — demonstrates that diaspora repatriation at scale is achievable when the domestic research environment is sufficiently attractive. Moreover, China's subsequent shift to a 'brain circulation' model offers India an even more pragmatic template: rather than demanding that diaspora researchers abandon established careers abroad, India could offer structured research partnerships, visiting faculty appointments, and co-investigator roles in IFC institutions that allow Indian scientists to contribute substantively without requiring permanent relocation. India has attempted versions of formal return programmes — the SERB Vajra Faculty scheme, Ramalingaswami Re-entry Fellowships — but at scales and funding levels that are inadequate to shift the equilibrium. A programme offering five hundred appointments annually at compensation competitive with mid-career US or UK academic salaries, housed specifically in IFC institutions and tied to priority research domains, could meaningfully alter the talent landscape within a decade.

Sixth, strengthening the secondary-to-elite pipeline. An often-overlooked lesson from the China model is that the success of elite universities was predicated on an earlier achievement: near-universal, high-quality primary and secondary education that created a large, standardised national talent pool. China's Gaokao system — imperfect in many respects — nonetheless ensures that elite universities draw from a nationwide, meritocratically selected pool that is not restricted to urban or socioeconomically advantaged students. India faces an analogous structural challenge: the quality of senior secondary (Class 11 and 12) STEM education in government schools outside major metropolitan centres limits the size and diversity of the talent pool available to IFC institutions. Targeted investment in science and mathematics education in Jawahar Navodaya Vidyalayas, Kendriya Vidyalayas, and state government science schools — combined with a national scholarship pathway analogous to China's provincial selection schemes, specifically designed to route high-potential students from government schools into IFC institutions — could meaningfully widen the recruitment pool. Without deliberate pipeline investment, the IFC programme risks becoming an elite within an elite: outstanding institutions drawing from a narrow socioeconomic band, replicating the very bottleneck that limits India's research capacity at scale.

A **final** observation on institutional design. The concentration paradox implies that what distinguishes successful elite university programmes from unsuccessful ones is not primarily the scale of investment, but its governance: specifically, whether the programme can be insulated from short-term political pressures, whether performance accountability is genuine rather than nominal, and whether funding is sustained across electoral cycles. In a parliamentary democracy with federal complexity, this is harder than in China's unitary state. But it is not impossible. India's success with the IIT system itself — built in the 1950s and 1960s under conditions of fiscal austerity, with a clear mandate and protected autonomy — demonstrates that democratic India can, when the political will exists, create world-class institutions. The question for the coming decade is whether India will apply that lesson at the scale that China has demonstrated is both necessary and achievable.

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