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Research in Higher Education Institutions: A Comparative Study of Select Countries

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Research in Higher Education Institutions: A Comparative Study of Select Countries

Abstract
Innovation has a crucial role in driving growth and development across the world. The present study explores the research and development (R&D) architecture of five diverse economies – India, China, the United States, Japan and South Korea - to assess the degree of R&D capacity and regulatory complexity in R&D within the higher education ecosystem of these countries. The study measures the innovation capacity in terms of state funding for tertiary education, higher education expenditure on research and development (HERD) and gross expenditure on research and development (GERD). The study assesses the regulatory complexity in R&D within higher education through parameters such as the researcher's autonomy, feasibility of research collaboration, private sector engagement, etc. The study roots itself in the new growth model which emphasizes innovation and technology adoption as primary factors for long-term economic development. The study uses the capacity-complexity framework to identify India's standing on higher education R&D indicators and to explore the impediments to Indian higher education institutions research output.

1. Introduction:

The world has seen significant technological strides post the first industrial revolution in the late 18th century in England. Technological innovation has been a critical lever driving economic growth and development for countries especially in the long term. Global life expectancy has more than doubled since 1900, rising from about 32 years to 73 years in 2023 (Dattani et al., 2023). Over a similar modern period, world population increased from around 1 billion in 1800 to around 8 billion today, and long-run historical estimates suggest world GDP has grown by US$ 168 trillion since 1900. (in 2021 prices) (Herre, 2025; Roser et al., 2023; Roser & Ritchie, 2023). A significant proportion of research leading to these technological advances, especially after the First World War, has happened in higher education ecosystems (Taylor, 2018); however, the distribution of research across the countries may vary significantly.

A state's capacity to innovate and the regulatory complexity within its innovation ecosystem shape the degree of innovation in a country (Furman et al., 2002; OECD, 2025). Some countries are leaders in driving innovation, and some countries depend on the leaders. State capacity and regulatory complexity can shape whether countries become technological leaders ("technopoles"/core) or remain technologically dependent on others (a form of client/dependent state) within global innovation systems (Harvey & Moore, 2022; Mayer & Lu, 2025). It is thus interesting to explore what sets these countries apart in terms of their capacity and regulatory complexity to drive innovation and whether there is any relation between the nature of capacity and complexity and the degree of innovation in these countries.

This paper conducts an extensive literature study on research and development architecture in higher education policies, followed by a comparative assessment of R&D capacity and regulatory complexity in R&D within higher education in five diverse economies - India, China, the United States, Japan and South Korea.

2. Literature Study

The present study roots itself in the New Growth Model, also known as Endogenous Growth Theory, which suggests that long term growth is determined by investment in human capital, innovation and technology adoption (Lucas, 1988; Romer, 1990). This is in contrast to the Old Growth Model also known as Solow-Swan model, where technology was taken as an exogenous variable and growth simply came from accumulation of factors of production (Solow, 1956; Swan, 1956). The new growth model builds upon Schumpeter's theory of creative destruction (Schumpeter, 1942) and internalizes other growth models. Schumperian economists such as Aghion and Howitt (1992) and Akcigit and Kerr (2018) have continued the work in this field and have emphasized how investment, infusion and innovation are important to increase productivity and long term growth of economies (World Bank, 2024).

2.1. Capacity as a positive determinant for R&D

Among determinants of innovation, R&D expenditure, trade openness, technology transfer, and institutional quality have been identified as important factors that shape and promote innovation and, hence, innovation-led growth (Furman et al., 2002; Malik, 2020). State capacity has long been established as a critical positive determinant of the level of R&D in a country (Cavalcante, 2023; Feng & Jiang, 2021). State capacity is defined as the extent to which the state can realize its objectives in policy (Feng & Jiang, 2021). Funding instruments such as tax incentives and state aid are important to strengthen state capacity in R&D (Hodžić, 2022). For example, in Canada, a stable core funding provided by the government allows innovation think tanks to develop talent, create independent research programmes, and fund public outreach to ensure that results would inform national and international policy dialogues (OECD, 2021b). Furthermore, there are two kinds of funding systems in R&D - top-down project system and bottom-up project system. In a top-down project system, the state determines the funding areas according to its will, selects grantees and controls the processes; however, in a bottom-up project system, the funding processes are decentralized and delegated to local governments or institutions (Aagaard et al., 2021; Lepori, 2023; Porta, 2020).

Availability of research funding is a key feeder for innovation. For example, in the US, technology normally progressed but accelerated in distinct phases in the past (Gordon, 2016). One such phase was after the Second Industrial Revolution between 1870 and 1914. Due to industrial growth, multiple innovation opportunities were being created;

however, such growth could not have been possible without the capital availability that the Second Industrial Revolution created (Gordon, 2016).

Beyond the capital, infrastructure (which is also acquired using capital) plays a role in increasing research outputs in a country. Acemoglu et al. (2016) identified that a surge in the number of post offices in the USA (as a proxy for infrastructure) had a direct positive correlation with patenting activity, thus emphasizing the importance of the infrastructural capacity of the US in driving technological development in the country. The national innovative capacity of a country is dependent on the strength of a country's common innovation infrastructure, the innovation environment, and the strength of linkages between these two areas (Furman et al., 2002). The production function of a country's innovation is characterised by R&D manpower and spending, intellectual property (IP) protection laws, openness to trade, academic research and private sector investment in research and development in academia (Furman et al., 2002).

State funding also has a crowding-in effect on innovation investment. Lanahan et al. (2016) estimated that every 1% increase in federal research funding leads to a 0.47% increase in industry research investment, a 0.41% increase in nonprofit research investment, and a 0.22% increase in state and local research funding, respectively, thus doubling the overall investment cumulatively. State funding also creates centres of regional economic growth. Engelke and Manning (2017) mention that federal funding attracts technology incubators and start-ups, as well as a more significant industry presence for innovation. Further, Hong et al. (2015) find that government grants have boosted private R&D expenditure in China.

2.2. Higher education as a medium to push R&D

Higher education institutions (HEIs) are repositories of knowledge and researchers in these institutions are involved in basic and applied research. A lack of research funding in these institutions adversely affects overall innovation outputs of a country (Basken & Voosen, 2014). Furthermore, public funding is critical for fundamental research in universities and colleges, which the private sector is not usually incentivised to support (Mandt et al., 2020). The success of public sector research funding in higher education institutions relies on its flexibility to use, continuity and a predictability of budget, etc. (OECD, 2014; 2017). Government grants are one of the most effective ways to increase innovation and productivity in these institutions (Bloom et al., 2019). Further, research grants to HEIs also crowd in private sector investment and patent filing (National Academies, 2011). Public funding for innovation within higher education is also important due to market failure (Arrow, 1962). For private firms to invest in research and development, there must be sufficient incentives (Altuzarra & Serrano, 2010). Further, to protect fundamental research as a public good and to disseminate it widely, public investment is needed (Arrow, 1962).

The composition of funding for research also determines the structure of innovation architecture in HEIs. Successful policies that have led to radical innovations in HEIs have been more about market making through public financing (Mazzucato & Semieniuk, 2017). While public R&D spending contributes to the common innovation infrastructure in the higher education ecosystem, private R&D spending directly reflects the innovation environments of a nation's industrial clusters (Furman et al., 2002). Hence, government funding is critical for developing common innovation infrastructure (Furman et al., 2002). This funding includes the investment in basic research and its dissemination. Nevertheless, industry-academia collaborations are critical to strengthening the common innovation infrastructure (Novillo-Villegas et al., 2022).

There is limited comparative literature that establishes the correlation between the state of capacity and complexity in the higher education ecosystem and the overall innovation output of different countries. The present study attempts to fill this lacuna by suggesting a framework that can be used to compare the innovation architecture within the higher education ecosystem of different countries with respect to capacity and complexity and suggesting the strategies to be followed by the emerging economies such as India.

2.3. Complexity as a negative determinant for R&D

Complexity in regulations impedes research and development. Despite the desire for innovation, the higher education funding formulae for most state and federal governments remain largely traditional (Swanger, 2016). The bureaucratic roadblocks and lack of exposure to various funding sources limit the innovation architecture. In the US, after 2015, US Medical Product complexity (FDA-issued guidelines) negatively impacted innovation in the medical products area (corresponding FDA registrations). In a study conducted by Sherman et al. (2020), the regulatory environment posed a barrier to innovation in municipal wastewater management in the US.

There are multiple determinants of complexity in innovation. For example, collaborative barriers in research and development increase the complexity of small projects (Rossoni et al., 2023). Further, financing constraints significantly inhibit the input and output of technological innovation in institutions and emerging industries (Li et al., 2021). This paper draws on multiple academic sources to identify different determinants of complexity in the innovation ecosystem of a country and lists them in Table 1.

Table 1: Determinants of complexity in innovation

Determinants	Sub-determinants	Sources
Researcher Autonomy and Decision-Making	Autonomy for researchers to make decisions	Hilliard (2012); Rieu (2021)
	Decentralization	Ecker et al. (2011); Thompson (1965)
	Flow of communication	Thompson (1965)
Regulation, Oversight, and Standardization	Level of standardisation	Xie et al. (2016)
	Degree of oversight	Webster (2019)
	Number of regulations	Blind (2012)
	Number of institutions overseeing R&D	OECD (1997)
Funding and Resource Allocation	Ease of funding	Li et al. (2021)
	Rapid commitment to resources	Thompson (1965)
	Incentives	Thompson (1965)
Research Collaboration and Private Sector Engagement	Feasibility of research collaboration	Rossoni et al. (2023)
	Private sector engagement	Blok et al. (2015)
Political factors	Political influence	Leijten (2019)
	Corruption	Bukari & Anaman (2020)

3. Methodology

The study follows a multi-methods approach, entailing a detailed review of five countries that are quite diverse in terms of size of economy, size of population, size of the country, research needs, level of centralisation and decentralization in research and overall funding in research. Then, the study compares the research capacity and complexity in the context of higher education across these countries to draw key insights into how to transform innovation in a country through higher education. Further, the study uses the comparison to draw out a possible growth trajectory with key steps that an emerging country like India should follow to transform its higher education research and, thereby, its growth story. The study includes the following stages:

- **Stage 1: Review of R&D architecture within the higher education ecosystem of selected countries:** This stage involves an analysis of the R&D policies within the higher education ecosystem of the selected five countries, their funding allocation, and the regulatory set-up with respect to R&D. The USA, China, Japan and South Korea have been selected to be compared with India. The selection of these countries have been done on the following basis. The USA has been selected because it is the gold standard in higher education research and innovation. China matches India's demographic size and aspirations. South Korea is a successful example of a developing country transitioning from technology infusion to innovation with the support of industry and Japan's innovation ecosystem is very mature with a balance between basic, theoretical research and applied research.

- **Stage 2: Complexity-capacity assessment:** The study then compares the research and development expenditure of the selected countries as a variable for state capacity. Further, the regulatory complexity in R&D within their higher education ecosystem is assessed and compared across different countries through a complexity rubric based on determinants shown in Table 1.

- **Stage 3: Discussion of India's R&D in higher education and its effect on research outcomes vis-a-vis other leading countries:** Based on India's assessment of the complexity framework and its relative standing with respect to R&D capacity in higher education, major impediments to research outcomes are discussed in the last stage.

4. Review of innovation and higher education architecture in selected countries:

4.1. India:

India has a long-standing science community that was established much before it gained its independence. Nehruvian science and technology (S&T) policy in India's early independent years had a significant impact on post-colonial India (Krishna, 2021). The early innovation policies were drawn from Nehruvian socialist principles on large-scale industrial development run by the state. The First Five Year Plan (1951-56) was aimed at establishing national laboratories and research centers mainly under the Council for Scientific and Industrial Research (CSIR) (Dhar & Saha, 2014). The Second Five Year Plan (1956-61) placed significant emphasis on broad-based scientific research and as such, research centres were expanded to universities and other research centres (Dhar & Saha, 2014). Since the formulation of the first science policy in 1958, India saw a considerable increase in research centres and science-oriented academic institutes. However, these innovation policies failed to eradicate socio-economic problems in India, such as poverty, hunger, lack of quality education, etc. These policies also ignored critical stakeholders such as social scientists (Sharma, 1976). The 1983 Technology Policy Statement was geared towards self-reliance through the establishment of local technologies ("Technology policy statement - 1983", 1993). The Science and Technology Policy of 2003 promoted research and development and innovation to boost the scientific ecosystem (Ministry of Science and Technology, Government of India, 2003). It also emphasized the need to develop native technology (Ministry of Science and Technology, Government of India, 2003). The Science Technology and Innovation Policy of 2013 focused on the creation of the science and technology-led innovation ecosystem (Krishna, 2013). The 5th Science Technology and Innovation Policy of

2020, is focused on doubling the Gross Expenditure of Research and Development (GERD), in India every five years (Office of the Principal Scientific Adviser (PSA), 2020). The other aspect of this policy is the establishment of a holistic knowledge ecosystem that encompasses issues that are related to rural-urban issues, climatic issues, indigenous issues etc. The policy suggests the idea of "one nation, one subscription" where only one registration would allow free access to a vast number of research papers to Indian researchers (Niazi, 2022). The policy suggests the establishment of an online portal named Indian Science and Technology Innovation Portal (ISTIP) (Ngawang et al., 2022) to record different research outputs, give alerts of the opportunities in various research areas, and inform the massive science and technology community.

The GERD in India is at 0.65% of its GDP which is incredibly low compared to major economies and is significantly lower than the average of the world at 1.8% (NITI Aayog, 2021). In India, the level of private investment in research, especially in universities and colleges is minimal because the private sector is mainly involved in applied research and most of the research institutions are involved in basic research. Although in major economies the corporate sector contributes approximately two-thirds of gross domestic expenditure on R&D (GERD), in India it only contributes 37% (Joseph, 2023). Industry-academia interaction in India continues to be poor (Dhar & Saha, 2014).

The Sarkar Committee, set up in 1945, highlighted the importance of setting up institutions of science and technology particularly aimed at the supply of human resources in large-scale industries (Central Bureau of Education India, 1948). However, these institutions also became pioneers in modern scientific research in the early 1950s and 1960s. But the research funding to these universities stagnated from the 1950s to the 1990s at 6% of the total research expenditure of the government annually (Krishna, 2021). The universities in India were deemed teaching institutions since science agencies such as CSIR, Department of Atomic Energy (DAE), Department of Space (DoS) and others accounted for most of the research funding. However, in the early 2000s, the need for fundamental research increased, and the focus on universities to do fundamental research became more significant after multiple criticisms of the quality of research in Indian universities. The Department of Science and Technology (DST) states that approximately 65 percent of the funds provided by Science and Engineering Research Board (SERB) are allocated to IITs and just 11 percent are allocated to state universities (Department of Science & Technology, Government of India, 2023). This fact is not due to state universities not having meritorious projects; it is due to the systemic difficulties of state universities, such as the subpar infrastructure, complicated internal compliance regulations, inability to execute them due to the shortage of personnel, etc. Moreover, the percentage of GDP spent by higher education on research and development (HERD) was very low at 0.06% in 2021 (Department of Science & Technology, Government of India, 2023).

Too much regulation and permissions in the name of uniformity have curbed innovation in India's premier institutions. The focus on common rules has come at the cost of research autonomy. The research capabilities and quality of the institutions have been on the decline. Although the number of publications have increased, the quality of research deliverables is a matter of concern (Sharma, 2024). Furthermore, approximately 26 percent of the faculty positions in the Central Universities are vacant (Government of India, Ministry of Education, Department of Higher Education, 2025). This also means the pool of faculty who can do research is also limited.

The higher education sector in India consists of more than 1338 universities and 52081 colleges (Press Information Bureau, 2025). There are four categories of universities - central, state, private, and deemed. Besides these institutions, there are standalone colleges, vocational institutions, etc., which can be affiliated with any of the universities. In terms of regulatory authorities, the University Grants Commission (UGC) was constituted in 1956 as a supreme body in order to coordinate, establish, and sustain standards of university education. It gives policies and rules regarding curriculum, faculty, infrastructure, accreditation etc. Conversely, All India Council of technical education (AICTE) controls the institutions of technical education and makes policies to develop them. Teacher education is controlled by the National Council of Teacher Education (NCTE). Medical education is controlled by the Medical Council of India (MCI). In 2009, the Science and Engineering Research Board (SERB) was established in order to facilitate basic research in the field of science and engineering, as well as to offer financial support to research scientists, institutions of higher education, laboratories, etc.

The National Education Policy 2020 promotes 21st century skills, holistic education, digital learning, future skills, encouragement of research, and enrolment of women (Ministry of Education, Government of India, 2020). Under this policy, Anusandhan National Research Foundation (ANRF) has been set up through the Anusandhan National Research Foundation (ANRF) 2023 Act (Department of Science and Technology, n.d.). ANRF is the main body responsible for directing the strategy and course of scientific research in the country. ANRF aims to promote both research and a culture of research across the HEI ecosystem of India. The government recently has approved a budget of ₹ 50000 crore from 2023 to 2028 through ANRF Fund, Innovation Fund, Science and Engineering Research Fund, and Special Purpose Funds (Press Information Bureau, 2024).

Bisaliah (2016) argues that the multiplicity of different types of HEIs and regulatory organisations shows the complexity of higher education. This complexity also impacts the research ecosystem. There has been a considerable increase in the number of universities. There are some mono-disciplinary institutions, and there are some multi-disciplinary institutions. There are some aided colleges and some unaided colleges. There are some autonomous colleges, and there are some affiliated colleges. Quality assurance in such multiplicity is a complex system in India. The quality of various academic disciplines is determined by the National Assessment and Accreditation Council (NAAC) of colleges and universities and the National Board of Accreditation (NBA). Though, NAAC has only accredited about 21 percent of colleges and 38 percent of universities (TNN, 2023). One of the key criteria in most of the accreditations is research outputs, which have been consistently low in many institutions, both in terms of quality and quantity. India has a low gross enrollment ratio (GER) of 28.40% in higher education (Ministry of Education, Government of India, 2024), which is accompanied by low public spending on education and low Human Development Index (HDI). In India, higher education is predominantly made up of the private sector (78% of higher education) (Ministry of Education, Government of India, 2024).

The rapid expansion of higher education has also put the quality of higher education, the need for research funding, and the quality of research under stress. India lags in international rankings of institutions. In the 2026 Times Higher Education World University Rankings, the highest-ranking institution is the Indian Institute of Science, which ranks in the range 201-250 (Education Desk, 2025). Some of the perennial problems are poor human resource management, inefficient research ecosystem, brain drain, rote learning, strict disciplinary divisions, and women involvement in higher education (Bharucha, 2024; Gewin, 2023; Muralidhar & Ananthanarayanan, 2024). India is the third most prolific country in the world in terms of publications; 9th in terms of citations and 38th in Global Innovation Index 2025 (World Intellectual Property Organization, 2025). Such imbalance between publications, citations and innovation implies that not all publications in India are of high quality. India is also 6th in patent applications in 2024 (World Intellectual Property Organization, 2025). 62.5 percent of these applications are granted (World Intellectual Property Organization, 2025). However, these figures consist of a non-resident share of 69.6% (World Intellectual Property Organization, 2025). Therefore, it is also critical to pay attention to the quality of the research and whether that research is indigenous. Most research outputs in India are from the field of engineering and technology (52.6% of total research output) (Chhapia, 2023). Institutions under the administration of the central government resulted in 67.54% of the national research outputs in India between 2001 and 2020 (Kanaujia et al. 2022). However, the quality of these outputs is debatable. Furthermore, innovation architecture in Indian universities still struggle from insufficient research funding, delay in grant disbursement, fragmentation and duplication of efforts in research and the dire need to drive innovation, productivity, and growth (Brookings India, 2019).

4.2. United States

The United States has been a leader in the innovation field of the world. It has a very decentralised innovation system encompassing various stakeholders, including government, business, universities and nonprofit organisations. Immediately after the establishment of the country, the federal government was very active in funding innovation, but during the initial 125 years of the establishment, nations like the UK and Germany were more advanced in terms of innovation than the US (Atkinson, 2014). The Civil War increased the equitable research growth in various and under-represented regions of the United States (National Archives, 2022). Later in the 19th and early 20th centuries, as markets started to rise to prominence, independent firms entered the field of path-breaking innovation. Ford, GE, DuPont, 3M, etc. were all companies that were vigorously innovating in their areas of products (Chandler, 1990). The Sherman Act (1890) and the Clayton Act (1914) might also serve to keep firms motivated to innovate by restricting anticompetitive practices and ensuring competitive rivalry (Kwon & Marco, 2021). During World War II, defence innovation became central, and in the post-war era, science-based innovation became dominant. US R&D was funded and influenced by the federal government over decades (usually through defense priorities), and the 1980s represented a more explicit shift to commercialization, industry-linking policies and a retrogression of some civilian R&D that was also perceived as being commercially oriented (Rowberg, 1998). Since the 1970s, Japan has been a major competitor which has pushed the federal government to the centre stage (Atkinson, 2014). It was also during this time that the US enacted Bayh-Dole and Stevenson Wydler Acts that helped in the protection of intellectual property in case of technology transfer, R&D tax credits, and the Small Business Innovation Research Program (Shapira and Youtie, 2010). The competition to the US innovation started to slow down in the 1990s as Japan experienced internal economic and political issues. The emergence of Silicon Valley led the US to the forefront of innovation that is technology oriented. Nevertheless, the competitive pressure re-emerged in the 2000s, this time from China. Many industrial and technological jobs were lost, and China began to soar in its technological development (Pierce & Schott, 2012).

The US innovation system is characterised by a high degree of alignment between research and development and market requirements. The US federal government provides support for innovation through building infrastructure and regulating intellectual property, markets, and commerce. It sponsors both basic and applied research. About 50% of US R&D funding goes into the defence sector (Congressional Research Service, 2024). The state governments also sponsor research in the United States, but the decision-making on the utilisation of those funds is highly decentralised at the level of the institutional boards to which the funds are allotted and project teams. The National Science Foundation (NSF) is a key player that is focused on sponsoring peer-reviewed basic research and some industry-oriented programmes. Several departments, like the National Institute of Health, the Department of Defense, etc., have separate research budgets. Further, Congress can pass legislation related to research and development in the country.

Within the higher education ecosystem, the National Science Foundation runs the Industry-University Centres. The US government and many independent organisations regulate the higher education system in the country. However, innovation in these universities is not subject to central chartering by the federal government. The federal higher education programmes fall under the purview of the Higher Education Act (HEA), which includes regulations related to the provision of resources and financial aid to students. According to the National Science Foundation, academic institutions perform about 10% to 15% of total U.S. R&D, including about half of all U.S. basic research (National Center for Science and Engineering Statistics (NCSES), 2021). Hence, most of the US patents are owned by companies, with fewer than 2% of utility patents being owned by universities (US Patent and Trademark Office, 2012). Subsequent to the Bayh-Dole Act, the universities set up technology transfer centres within their campuses to foster stronger industry-academic collaboration. In the late 1960s, universities received an average of 200 patents annually (Shapira & Youtie, 2010). By the mid-1980s, this had increased to more than 500, rising rapidly to nearly 1800 patents in 1994 and more than 3000 patents in the 2000s, largely due to the passing of the Bayh Dole Act (Mowery et al., 2001). There are numerous university-based industry consortia that have a strong peer review system for cutting-edge research.

The US spent 3.4% of its GDP on research and development as of 2021 (National Science Board, 2024). Most innovations in the US are performed by private industries, undertaking more than 70% of the R&D in the United States (Shapira & Youtie, 2010). These innovations are funded by venture capitalists and private investors. The Morrill Acts of 1862 and 1890 were among the first major, system-building federal interventions in U.S. higher education, creating and expanding the land-grant college system (South Dakota State University, n.d.). This has been followed by the GI Bill and the Higher Education Act of 1965. The federal funding is mainly for university research and financial aid for the students. The states take care of the operational expenditure of the public institutions. States pay for the general operating expenses of public institutions. 46% of the revenue of the public HEIs comes from the federal and state governments (U.S. Department of Education, National Center for Education Statistics, 2023).

Many universities like Harvard, Yale, Princeton, and Columbia were established in the early 1600s with a focus on disciplines like chemistry, medicine, law and later agriculture and engineering during the 19th century. The research universities, venture capital firms, and economic and workforce development organisations are largely interlinked. University research is supported through a number of agencies to help them achieve mission goals.
The overall US higher education system is largely decentralised and de-regulated. There is a high degree of diversity. US public institutions enjoy significant autonomy with research related decisions, and private institutions are independently chartered.

However, there are some recent challenges that innovative architecture is facing within the higher education ecosystem in the USA. Foote & Atkinson (2019) points out that federal funding for research is seeing a downward trend. The U.S. share of global R&D

spending from 39% in 2000 to 31% in 2010, stabilizing at 30% in 2022 (National Center for Science and Engineering Statistics (NCSES), 2025). Investment in innovation by venture capitalists in university research is falling along with the dip in the pace of innovation breakthroughs. Similarly, recent directives from federal agencies particularly, National Institutes of Health (NIH) has indicated capping facilities and administration (F&A) expenditure at 15% of modified total direct cost (MTDC) (National Institutes of Health, 2025). This is contrary to past practices where institutions were negotiating indirect costs based on actual expenditure and some of the elite institutions were able to get 50%-70% as indirect F&A expenditure to maintain world class infrastructure (Masud-Elias et al., 2025). This along with recent cuts in funding of NIH and National Science Foundation (NSF) in the 2026 R&D budget will stress the research capabilities of higher education institutions in the USA (Congressional Research Service, 2025).

4.3. China:

The innovation system in China has been transformed by the series of reforms that have taken place since the late 1970s, when the country started to transform into a market-oriented economy, as opposed to the centrally planned economy. Initial post-Mao reforms were aimed at the reconstruction of scientific capacity, decentralisation of S&T decision-making and reestablishing the connection between research and production (Simon & Goldman, 1989). Some of the major initiatives involved the restoration of competitive examinations, re-establishment of universities and research institutes, and the 1985 Decision on the Reform of the Science and Technology System, which specifically linked science and technology to economic modernisation and promoted the contracting of research institutes with enterprises (Liu et al., 2011). These changes slowly created a more interactive national innovation system where universities, publicly-owned research institutes and companies were more closely linked, which was supported by the fact that high-tech zones like Zhongguancun were emerging and the amount of Chinese scientific publications in the world were rapidly increasing (Zhou & Leydesdorff, 2006; Gu et al., 2016).

The science, technology and innovation (STI) governance of China is marked by high levels of central coordination through a thick institutional structure. The State Council and important Chinese Communist Party (CCP) groups determine the strategic direction. The Ministry of Science and Technology, the National Development and Reform Commission, the Ministry of Education, and the National Natural Science Foundation of China (NSFC) control various aspects of the policy mix (Liu et al., 2011). Technical advice and assistance in the translation of political objectives into research programmes is offered by expert bodies like the Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering. Meanwhile, the Chinese Communist Party (CCP) committees are also tied to universities, research organisations and most large enterprises, guiding the appointment of leaders and research agenda. It results in a hybrid model that combines the top-down party-state control with an increasing number of research performers, such as big state-owned and privately-owned firms, regional governments and urban innovation zones (Cao et al., 2009).

Another significant shift was the National Medium- and Long-Term Plan of the Development of Science and Technology (MLP) 2006-2020 that made indigenous innovation a central feature of the national development strategy (Cao et al., 2009). The MLP set ambitious targets on the intensity of R&D, patenting and high-tech output, introduced mega-projects on high scale in aerospace, ICT and biotechnology, and signified a transition from pure catch-up to become an innovation-oriented country (Liu et al., 2011; Sun & Cao, 2021). This mission-focused strategy was followed in the next introduction of a new MLP for 2021-2035, where strategic frontier technologies are prioritized, and technology self-reliance and dependence on foreign core technologies are minimized (Sun & Cao, 2021). Recent research indicates that these measures have seen China move past a mere latecomer paradigm, though it also points to ongoing balancing efforts between long-term capability development and short-term output goals (Liu et al., 2017; Gu et al., 2016).

China's innovation strategy is based on a policy mix that includes direct state financing of R&D, tax incentives, state procurement, and industrial upgrading and regional experimentation. The NSFC is now the major body to finance competitive basic research, and mission-oriented programmes and other ministries finance applied research and technology development (Liu et al., 2011; Zhu & Gong, 2008). The quality of implementation and state capacity however differ greatly across programmes and regions. Empirical research on various forms of innovation projects reveals that professional capacity needs to be enhanced in government agencies, the use of quantitative measures (e.g. the number of patents) needs to be strengthened and monitoring of the quality of the project require stronger focus, that can make grantees move away from mere formal compliance to actual innovation. (Feng & Jiang, 2021).

One of the key pillars of the innovation strategy of China has been higher education reform. The state has increased university enrolments by a significant margin since the 1990s, selectively enhancing a cohort of elite universities with Project 211, Project 985 and, most recently, the Double First Class initiative (Gu et al., 2016). Universities are also becoming part of regional innovation systems through science parks, incubators and joint laboratories, and strengthening a triangular dynamic between universities, industry, and government (Zhou & Leydesdorff, 2006). However, the ability to innovate is very concentrated in major regions of Beijing, Shanghai and the Pearl River Delta where the top universities, research institutes and high-tech clusters are located together, and inland provinces are left behind in terms of research infrastructure and absorptive capacity (Gu et al., 2016; Liu et al., 2011).

At the micro level, within university and public research organisations, the performance-driven evaluation systems have reinforced publication, patent and international visibility incentives, which have led to a fast increase in the Chinese scientific output. Meanwhile, researchers have been concerned with excessive publication pressure, application of limited quantitative measures and probability of academic misconduct or poor-quality work (Cao et al., 2009; Tang, 2019). Journals have advocated that the rapid rise of scientific productivity in China has exceeded institutional response to research integrity and quality assurance, and new reforms have been implemented to address cash-for-publications schemes, to reform promotion criteria and enhance ethics monitoring (Tang, 2019). In general, China is currently a mixture of high and further increasing amounts of governmental and private investment in R&D, a vast and growing research force, and an actively engaged party-state model. The outcome is a dynamic and more competent innovation system, although highly guided by national policy priorities.

4.4. Japan:

Japan's innovation trajectory has pre-war roots, especially from the Meiji Restoration (1868) through 1945, when the state pursued catch-up modernization through promotion-of-industry (shokusan kōgyō) policies, institutional and infrastructure building that accelerated manufacturing expansion, and deliberate importation of Western science and technology, with further bureaucratic consolidation in the interwar period (Ayuso-Díaz & Tena-Junguito, 2020; Hashino & Saito, 2004; Kim, 2007; Nicholas, 2011). It supported technology imports, selected specific industries to promote, and established government research institutions (Nicholas, 2011; Partner, 2000; Saitō, 1975; Yamazawa, 1975). However, the science and technology infrastructure in Japan was severely compromised during the Second World War (Grunden, 2005; Low, 2005). The innovation growth nearly stalled. Then, Japan began facilitating rapid economic growth to narrow the technology and economic gap with the United States (Nicholas, 2011; United Nations ESCAP, 2018). It placed a secondary focus on social needs and facilitated the introduction of foreign technology (United Nations ESCAP, 2018). It increased its funding for research and development and fostered public-private participation in innovation (United Nations ESCAP, 2019). This period also saw an increase in private-sector investment in research and development and strengthening of higher education (United Nations ESCAP, 2018). Between 1945 and 1975, the number of scientists and engineers per 1,000 population increased more than fourfold from 2.8 to 11.3 (United Nations ESCAP, 2018). From the 1980s onwards, Japan started focusing on basic research, investing in future technologies, and strengthening university-industry linkages (United Nations ESCAP, 2018).

The Japanese higher education system has national universities and private universities. The national universities are under the Ministry of Education. Under this system, the universities in the 1980s were suffering from a lack of funds, poor research facilities, obsolete equipment and an outward flight of talent (Nakayama, 1997). Though, by 1990, private sectors were involving the universities in their quest for new technologies through joint research, subcontracting of research, etc., but many structural obstacles to the development of external research funds, especially the inflexibility in the financial and personnel aspects of Japanese universities, continued to hinder effectiveness (Edgington, 2008).

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) legally charters the universities and junior colleges set up by the local governments and private players with advice from the Council for University Chartering and Private Educational Legal Entities (MEXT, 2012). MEXT has an established approval system, quality assurance, and accreditation system to enhance the quality of courses, institutions, and research. It focuses on enhancing global competitiveness.

In 2001, Japan reformed several universities and research institutions to prioritize science and technology development in the information era especially it mandated at least 50% of the time spent by assistant professors on research (MEXT, n.d.). Following the incorporation of universities in 2004 which allowed these HEIs to own intellectual property, the number of university patent applications surged (Motohashi et al., 2025).

At present, Japan is focusing on Society 5.0 (post-information era), a model future society proposed by the Japanese government, in which both economic growth and the resolution of social issues can be achieved by making full use of advanced technologies (Government of Japan, 2022).

Japan is amongst the world's largest investors in science and innovation, spending 3.3% of its GDP on R&D in 2018 (OECD, 2021a). However, the share of government spending on this expenditure is one of the lowest in the world , at 0.59% in 2016 (OECD, 2021a). This leads to the broader issue of decreasing proportion of research funding allocated to universities in Japan (Osumi, 2025).

Private HEIs account for 80% of the total number of HEIs and have their unique education and research activities. However, they are still under strict regulations of the Ministry of Education. All national universities were incorporated as corporations in 2004. Public universities have also incorporated themselves as corporations since 2004. National university corporations are supervised under "a president-centered management system, by establishing the Board of Directors, which is composed of the president and trustees, and by setting up deliberative bodies for management, education, and other necessary actions" (MEXT, 2012).

In the 1990s, the innovation architecture of Japan was marred by administrative rigidities, lack of independence, reluctance to cooperate with competitors, vague and broad national scope, etc. (OECD, 2021a). The enactment of a new Basic Law for Science and Technology in 1995 marked the start of the development of a more cohesive and forceful government S&T policy, which has strong implications for innovative research policies (OECD, 2021a). The number of patents granted grew in

Japan in the early to mid-1990s. However, the quality of innovations aligned with national priorities remained stagnant (Kwon et al., 2017; Yamashita, 2020). The knowledge-based economy required investment in intangible assets like R&D and software, and the employment of experts whose formal qualifications in science and technology were a must. However, the stagnation between 1992-2005 became a lost opportunity for Japan (Yamashita, 2020).

The Council for Science, Technology and Innovation (CSTI) is one of the main bodies determining policies for innovation in Japan (OECD, 2021a). However, there are some major gaps in the functioning of CSTI. The implementation of the CSTI's recommendations is not uniform across universities. The Cross-Ministerial Strategic Innovation Promotion Program led by CSTI suffers from multiple administrative complexities, including high transaction costs, several meetings including the Governing Board, Promotion Committees, and working groups, etc. with many people, insufficient administrative support and financial treatment of Program Directors with regard to their wide array of responsibilities of the Program Directors (OECD, 2021a).

4.5. South Korea:

Since 1960, South Korea has gone through a process of being a low-income state to a high-income state, with the country placing a lot of emphasis on export-led development (Haggard et al., 1991; Yoo, 2017). It placed emphasis on science and technology. It gradually liberalized its economy to the private sector and began developing its digital infrastructure (OECD, 2023). South Korea ranks second in the intensity of R&D among the OECD countries after Israel (OECD, 2023). The majority of the research in South Korea, however, are business-driven. In 2023, gross domestic expenditure on R&D (GERD) in South Korea constituted 4.96 percent of GDP (WIPO, 2025). The growth rate of R&D has been stable at 7% per annum during the 2011-19 period with higher rates in business enterprises (8%) compared to government (4%) and higher education institutions (4%). In South Korea, higher education spending on R&D (HERD) was 0.45% of the GDP in 2021, versus 0.42% in the OECD overall (National Science Board, 2023). In South Korea, there has been a steady growth in R&D outputs between the years 2006 and 2020, with the number of scientific publications per million inhabitants rising from 895 to 1741 (OECD average: 1214), but with low productivity (OECD, 2023).

The governance of South Korean higher education institutions is highly centralized with the Ministry of Education in charge and, as a consequence, the institutions have relatively low institutional autonomy in academic, financial, and managerial decision-making (Kim & Lee, 2006; Byun, 2008). The functions of quality assurance and accreditation are organized on a national level by the involvement of the national bodies like the Korea Council for University Education, which is a key player in the evaluation and monitoring of the system at the system level (Shin, 2018). The higher education system is made up of national universities founded and funded by the central government, public universities run by local governments, and a big sector of private universities that accommodate most students (Lee, 2008; Green, 2015). The current policy focus on the creation of research-intensive universities is a fairly new phenomenon, which has emerged mostly due to the state-driven efforts to increase the competitiveness of global research since the late 1990s and early 2000s (Shin, 2009). Although reforms have facilitated competition and performance funding, fiscal autonomy of the universities is limited, with key funding decisions and allocation criteria made centrally (Kim & Lee, 2006; Byun, 2008). Moreover, the government exerts direct regulatory & on the tuition rates that restrict the capacity of the universities to charge independently (Kim & Park, 2018).

In 2019, a task force was created by the Ministry of Education and the Korean Council on University Education to deal with the regulatory complexity of the operations of universities, and the mentioned objective is to strengthen institutional autonomy (OECD, 2023). Simultaneously, the National Research Foundation implemented procedural changes to streamline the process of funding and lessen micro-level administrative oversight of research projects (OECD, 2023). Although these actions are an indicator of a policy change to a more flexible and trusting approach to the university, it is likely that the shift in the long-established administrative practices and culture of governance will be gradual and will manifest itself only over time.

The industry-led innovation system in South Korea is reflected in its business enterprises that contribute over three-quarters of overall R&D spending in the country. Despite the fact that the total contribution of the government to financing of R&D is relatively high by international standards, the proportion of financing of the higher education sector has been consistently low and only 0.6 percent of total R&D spending in 2021 (Jones, 2024). As a reaction to the historical grievances about the insufficiency of university funding, the National Assembly of South Korea passed the Special Accounting Act on 24 December 2023, which created a specific system of higher education financing. The bill will provide an extra 9.74 trillion won (around US 7.7 billion) in ten years, and the goal is to enhance the teaching capacity and research infrastructure in the higher education sector (Jung, 2023).

Since the Korean War, the education policy of South Korea was clearly defined as a part of a national development strategy, and higher education was placed to serve reconstruction and economic modernization in the long run (Kim, 1989; Yoon, 2014). One of the key stages of tertiary growth was the state reforms of around 1980 that drastically enhanced university enrolment and massification into the 1980s and 1990s (Choi, 1996; Jung, 2024). From the 1990s to the beginning of the 2000s, the policy of higher education began to react to the pressure of globalization, and the idea of internationalization became one of the primary policy frames of universities (Jeon et al., 2023; Green, 2015). University-industry connections and commercialization of knowledge became more popular in the 2000s, with national policies on innovation and an apparent rise in industry-university collaboration and technology-transfer-based activity (Eom & Lee, 2010). Combined together, these changes enhanced the institutional foundation of the growing innovation system of South Korea by intensifying human capital formation, repositioning universities to compete in the global market, and enhancing the speed of knowledge transfer between universities and companies (Eom & Lee, 2010; Jung, 2024).

In 2020, South Korea was ranked 13th among the countries in terms of the number of scientific publications (96990) (SCImago Journal & Country Rank, 2020). In South Korea, there were over 1,35,000 registered patents in 2022 (Statista, 2024). Universities have grown out of a teaching purpose to create research of importance. The fundamental research receives appropriate attention. In 2020, basic research was funded to the level of KRW 2 trillion (USD 1.7 billion), 75 percent of which was funded by the Ministry of Science and ICT (MSIT), and 25 percent by the Ministry of Education (MOE) (OECD, 2023). This is nearly twice as much as in 2017 (OECD, 2023). Nevertheless, most of this finance is directed towards some of the top South Korean universities.

OECD (2023) identifies long-standing structural and governance-related limitations of the South Korean higher education research system, especially, the lack of funding mechanisms, and the complexity of the administrative procedures related to project approval, implementation, and decision-making. Limited institutional autonomy and a short term research horizon are linked with the heavy dependence on project based funding, which limits the ability of universities to follow an exploratory or high-risk research agenda. The administrative demands of the grant applications, reporting, and compliance are cumbersome and they distract academic efforts in conducting research. The inflexible funding regulations and research requirements minimize flexibility and must be changed to allow institution driven and more long-term research paths. Moreover, the research system in South Korea is still insufficiently internationalised, and the degree of international collaboration is relatively low, which restricts the flow of ideas and diversification of sources of funds, which, in turn, influences the quality and impact of research. In response, the government has identified enhancing institutional autonomy, decentralisation, diversification, and functional specialisation of higher education institutions, alongside stronger internationalisation, as core priorities for innovation-oriented reforms in the higher education ecosystem.

Table 2 presents a consolidated comparison of the state capacity in R&D in relation to higher education expenditure across the five reviewed countries.

Table 2: Comparison of state capacity in research and development in relation to higher education expenditure

Countries	Government expenditure in tertiary education as a percentage of GDP – latest available year (Source: UNESCO Institute of Statistics)	Higher Education Expenditure on R&D (HERD) as percentage of GDP as on 2021 (Sources: OECD: Main Science and Technology Indicators & Department of Science and Technology, India, 2023)	Gross expenditure on research and development (GERD) as a percentage of GDP, 2020 (Source: UNESCO Institute of Statistics)
India	1.28	0.06*	0.65
United States	1.70	0.36	3.42
China	0.84	0.19	2.41
Japan	0.73	0.39	3.26
South Korea	0.93	0.42	4.80

*Note: HERD as a percentage of GDP in 2021 for India has been derived using the GERD and higher education proportion data in GERD data from the Department of Science and Technology, Government of India, 2023. The higher education sector's share in GERD of India is 8.8 %, while GERD was 0.65% of GDP in 2021.

Based on the sub-determinants in Table 1, the following rubric (as shown in Table 3) was designed in this study to assess the regulatory complexity in R&D within the higher education ecosystem.

Table 3: Rubric for comparing countries based on their complexity parameters

Parameter	**Highly Simple (5)**	**Simple (4)**	**Neutral - Neither too simple nor too complex (3)**	**Complex (2)**	**Highly Complex (1)**
Autonomy for Researchers	High level of autonomy for researchers	Moderate autonomy with some institutional control	Limited autonomy with significant institutional control.	Researchers have minimal autonomy	Researchers have no autonomy
Decentralization	Research decision-making is distributed across	Some degree of decentralization with shared decision-making across	Centralized decision-making with limited input from diverse	Highly centralized decision-making with no involvement	No involvement of local and regional stakeholders in

	diverse actors including local and regional stakeholders	diverse actors including local and regional stakeholders	actors including local and regional stakeholders	from local and regional stakeholders.	decision-making.
Flow of communication	Open and transparent communication channels.	Somewhat transparent communication channels with occasional barriers.	Limited communication channels with significant obstacles.	Communication is impeded, affecting collaboration.	No effective communication channels.
Standardisation	Clearly defined guidelines for research practices, but flexibility is given to researchers based on the nature of the study.	Guidelines are clear, and they act as guardrails for researchers as long as they stay within those guardrails.	Some rules are strict and must be followed while doing research	Most of the rules are stringent and must be followed while doing research.	All rules are stringent, and no flexibility is allowed while doing research.
Degree of Oversight	Limited oversight ensuring research integrity but not interfering with research	Sufficient oversight with occasional bureaucratic hurdles	Balanced oversight safeguarding against research misconduct but involving moderate bureaucratic hurdles	Excessive oversight, with high bureaucratic hurdles	Over-regulation and bureaucracy affecting research process entirely
Number of Regulations	Limited and reasonable regulations facilitating research.	Moderate number of regulations, occasionally causing barriers.	Multiple regulations imposing significant barriers.	High number of regulations stifling research innovation and progress.	Overwhelming and contradictory regulations impeding research
Number of Institutions	Low number of institutions overseeing research. Simple chain of command.	Reasonable number of institutions with some overlaps. Somewhat simple chain of command	Overabundance of institutions causing coordination challenges. Confusing chain of command.	Highly fragmented institutional landscape hindering research efforts. Complex chain of command.	Complete lack of research oversight and institutions. Highly chain of command.

Ease of Funding	Well-established, adequate and transparent funding sources with highly clear guidelines	Adequate funding sources with clear guidelines.	Limited funding sources with some complexities.	Low funding availability with unclear and complex processes	Severe lack of funding opportunities and high degree of obstacles to acquire funding
Rapid Commitment to Resources	Speedy allocation of resources upon research initiation	Reasonable resource allocation time with rare delays	Slow resource allocation, affecting research progress	Resource allocation process is highly slow and significantly delays research	Resources allocation takes a lot of time, often leading to shutting of research project
Incentives	Robust system of incentives, rewards, and recognition of quality research	Some incentives and rewards available for quality research	Limited incentives and recognition for quality research	Minimal incentives or recognition for quality research	No incentives or recognition for quality research
Feasibility of research Collaboration	Easy to foster strong collaboration between industry and academia	Somewhat easy to foster active collaborations between industry and academia	Some industry-academia collaborations are possible	Difficult to forge industry-academia collaboration	Industry-academia collaboration is close to impossible
Private Sector Engagement	High investment and engagement by private sector	Moderate investment and engagement by private sector	Some investment and engagement by private sector	Low investment and engagement by private sector	Negligible investment and engagement by private sector
Political Influence	No political influence on research decisions and funding	Minimal political influence on research decisions and funding	Moderate political influence on research decisions and funding	Significant political influence affecting research decisions and funding	Research is driven by political agendas
Corruption	Minimal to no instances of corruption in research	Rare instances of corruption in research with limited impact	Some instances of corruption in research	High corruption significantly affecting research integrity	Rampant corruption compromising all aspects of research

			affecting research		

Based on Table 3, the following scores (as shown in Table 4) were given to each country on the sub-determinants based on the literature review. The justification has been provided after Table 4.

Table 4: Scores of each of the five countries on the sub-determinants

Parameter	**India**	**US**	**China**	**Japan**	**South Korea**
Autonomy for Researchers	2	5	4	3	3
Decentralization	2	5	3	3	3
Flow of communication	3	5	4	3	3
Standardisation	3	4	4	3	3
Degree of Oversight	3	4	3	4	4
Number of Regulations	2	4	3	3	3
Number of Institutions	4	5	4	4	4
Ease of Funding	3	5	4	3	3
Rapid Commitment to Resources	3	5	4	3	3
Incentives	3	5	4	3	3
Feasibility of Research Collaboration	3	5	4	3	3
Private Sector Engagement	3	5	4	3	3
Political Influence	2	4	3	3	3
Corruption	2	3	4	3	3
AVERAGE	**2.71**	**4.57**	**3.71**	**3.14**	**3.14**

The following description presents a justification of the scores given in Table 4.

India

- Autonomy for Researchers (2): Limited autonomy with significant institutional control.
- Decentralization (2): Centralized decision-making with limited input from local institutions.
- Flow of communication (3): Somewhat transparent communication channels with some restrictions.
- Standardisation (3): Some rules are strict and must be followed while others are flexible.
- Degree of Oversight (3): Balanced oversight safeguarding against research misconduct.
- Number of Regulations (2): High number of regulations creating a complex environment.

- Number of Institutions (4): High number of institutions providing diverse research opportunities.
- Ease of Funding (3): Moderate ease of obtaining funding with some bureaucratic hurdles.
- Rapid Commitment to Resources (3): Moderate commitment to resources with some delays.
- Incentives (3): Moderate incentives available for researchers.
- Feasibility of Research Collaboration (3): Moderate feasibility for research collaborations.
- Private Sector Engagement (3): Moderate engagement with the private sector.
- Political Influence (2): Significant political influence affecting research decisions.
- Corruption (2): High level of corruption affecting the research environment.

United States

- Autonomy for Researchers (5): High level of autonomy for researchers.
- Decentralization (5): Research decision-making is distributed across institutions.
- Flow of communication (5): Open and transparent communication channels.
- Standardisation (4): Guidelines are clear and act as guardrails.
- Degree of Oversight (4): Balanced oversight safeguarding against research misconduct.
- Number of Regulations (4): Moderate number of regulations with clear guidelines.
- Number of Institutions (5): Very high number of institutions providing vast research opportunities.
- Ease of Funding (5): Very high ease of obtaining funding with minimal hurdles.
- Rapid Commitment to Resources (5): Very rapid commitment to resources with few delays.
- Incentives (5): Strong incentives available for researchers.
- Feasibility of Research Collaboration (5): High feasibility for research collaborations.
- Private Sector Engagement (5): Strong engagement with the private sector.
- Political Influence (4): Moderate political influence affecting research decisions.
- Corruption (3): Some instances of corruption affecting the research environment.

China

- Autonomy for Researchers (4): Moderate autonomy exists for researchers, although major strategic directions remain centrally guided.
- Decentralization (3): Decision-making is partially decentralised but retains strong central control over national research priorities.

- Flow of Communication (4): Communication channels are generally clear and structured with occasional bureaucratic barriers.
- Standardisation (4): Guidelines are clearly defined and provide consistent guardrails for research across institutions.
- Degree of Oversight (3): Oversight is balanced but includes notable bureaucratic processes that can slow research.
- Number of Regulations (3): A moderate number of regulations exist, creating some administrative complexity but not severe barriers.
- Number of Institutions (4): China's large network of universities, national laboratories, and CAS institutes provides extensive research infrastructure.
- Ease of Funding (4): Funding availability is relatively strong, especially for priority sectors, with defined application processes.
- Rapid Commitment to Resources (4): The state rapidly mobilises resources for strategic research, enabling quick project initiation.
- Incentives (4): Strong incentive structures exist through talent programmes, competitive grants, and performance-based rewards.
- Feasibility of Research Collaboration (4): University–industry and inter-institutional collaborations are widely supported and institutionally facilitated.
- Private Sector Engagement (4): Private-sector participation in R&D is substantial, driven by major technology firms and innovation clusters.
- Political Influence (3): Political oversight influences research direction, though technical research proceeds with some autonomy.
- Corruption (4): Rare reported instances of research misconduct and grant misuse. Anti-corruption efforts have significantly reduced major risks.

Japan

- Autonomy for Researchers (3): Limited autonomy with significant institutional control.
- Decentralization (3): Some degree of decentralization with shared decision-making.
- Flow of communication (3): Limited communication channels with significant gatekeeping.
- Standardisation (3): Some rules are strict and must be followed while others are flexible.
- Degree of Oversight (4): Sufficient oversight with occasional bureaucratic hurdles.
- Number of Regulations (3): Moderate number of regulations with clear guidelines.
- Number of Institutions (4): High number of institutions providing diverse research opportunities.
- Ease of Funding (3): Moderate ease of obtaining funding with some bureaucratic hurdles.
- Rapid Commitment to Resources (3): Moderate commitment to resources with some delays.

- Incentives (3): Moderate incentives available for researchers.
- Feasibility of Research Collaboration (3): Moderate feasibility for research collaborations.
- Private Sector Engagement (3): Moderate engagement with the private sector.
- Political Influence (3): Moderate political influence affecting research decisions.
- Corruption (3): Some instances of corruption affecting the research environment.

South Korea

- Autonomy for Researchers (3): Limited autonomy with significant institutional control.
- Decentralization (3): Some degree of decentralization with shared decision-making.
- Flow of communication (3): Limited communication channels with significant gatekeeping.
- Standardisation (3): Some rules are strict and must be followed while others are flexible.
- Degree of Oversight (4): Sufficient oversight with occasional bureaucratic hurdles.
- Number of Regulations (3): Moderate number of regulations with clear guidelines.
- Number of Institutions (4): High number of institutions providing diverse research opportunities.
- Ease of Funding (3): Moderate ease of obtaining funding with some bureaucratic hurdles.
- Rapid Commitment to Resources (3): Moderate commitment to resources with some delays.
- Incentives (3): Moderate incentives available for researchers.
- Feasibility of Research Collaboration (3): Moderate feasibility for research collaborations.
- Private Sector Engagement (3): Moderate engagement with the private sector.
- Political Influence (3): Moderate political influence affecting research decisions.
- Corruption (3): Some instances of corruption affecting the research environment.

Table 5: Nature Index Country Research Ranking: All Journal Groups and Subjects : Time Frame 1st November 2024 to 31st October 2025 (Nature Index, n.d.)

S. No	Ranking	**Country**	**Journal articles published total count**
1	1	China	44599
2	2	USA	33088
3	5	Japan	6108
4	7	South Korea	3724
5	8	India	2998

Interpretation

Table 5 presents the latest ranking (1st November 2024 to 31st October 2025) of these five countries on the basis of natural science and health science journals publication. The ranking is based on the publication by researchers in the higher education institutions of these countries. The Nature index which tracks these publications are based on the list of highly reputed journals in the field of natural and health science. The ranking is topped by China with 44,599 counted publications. The USA has lagged behind with 33,088 publications. India ranks 8th globally in the publication index. These rankings crudely show the outcome of the research ecosystem at the higher education institutions in these countries. This is also corroborated by Nature's top 500 institutions by country. China had 156 institutions in the list of top 500 institutions, in fact 9 out of top ten institutions are Chinese. On the other hand the top ranked Indian institution is Indian Institute of Science at 170 ranking.

Discussion:

This comparative study brings out the key issue of interaction between the capacity of R&D and the regulatory complexity in determining the research outcome in higher education systems. The results of the five countries under review indicate that massive expenditure on research is not enough to produce sustained innovation unless it is accompanied by institutional structures that facilitate autonomy, coordination, and efficient mobilisation of resources in the universities.

The United States is an example of a country that has a high R&D capacity and a comparatively low regulatory complexity in the higher education research ecosystem. The US has a high level of researcher autonomy, decentralised decision-making, open communication and high involvement of the private sector, as shown in Table 2 and Table 4.

This institutional structure enables universities to be flexible to both scientific and market opportunities, and yet have strong oversight mechanisms that ensure the integrity of research. Such a fit between funding, institutional freedom and industry connectivity has facilitated innovation to flourish in institutions of higher learning leading to high research productivity and long-term economic development in terms of the Nature Index rankings and long term growth trend as seen in the previous discussions in the paper.

China offers a different, yet equally efficient structure, with very high levels of R&D investment, and a more centralised and strategically directed system of governance. Modest limitations on researcher autonomy and decentralisation have not prevented China from having an effective state capacity, extensive research facilities, and a speedy marshaling of resources to create a highly productive innovation system within the higher education sector. Efficient communication pathways, strong incentive systems and extensive involvement of big technology companies with universities have ensured that volumes of research are produced. Nevertheless, structural tensions in this model, such as regional variability in research capacity and a very strong dependence on performance-based systems of evaluation, are also visible. These characteristics place the research activity in a highly national priorities and short-term deliverables-focused orientation, which strengthens a highly top-down innovation path. However, the fact that the higher education research ecosystem in China is highly productive, as shown by its top ranking in the Nature Index, indicates that high capacity can partially compensate for higher regulatory complexity in case institutional coordination and resource mobilisation is high.

Japan depicts a moderately balanced and relatively reserved innovation system, with a large research investment being controlled by a moderately complex regulatory framework. The results suggest that although the Japanese universities are governed by comparatively well-organized supervision and management restrictions, these are partially offset by consistent funding, well-developed research institutes, and gradual reforms that are intended to increase the freedom and cooperation between the university and industry. The regulatory framework in Japan as indicated by the complexity scores does not either severely inhibit or severely accelerate innovation. Rather, it generates more stable although less dynamic research results, the constraints of which are especially noticeable in the channels of communication and the intensity of collaboration. The case demonstrates the role of moderate complexity and sufficient capacity in maintaining research activity but constraining responsiveness and breakthrough innovation.

South Korea is also at a similar middle ground, with very high national investment in R&D, and with long-standing regulatory and administrative constraints in the institutions of higher learning. Although the nation has realised an impressive technological progress and economic development, the analysis indicates that the complexity of regulations, which is reflected in the centralised funding choices, institutional lack of autonomy, and excessive bureaucratic processes, still determines the nature of the research conducted by universities. The fact that most business-driven R&D is even more restrictive to the role of universities as independent sources of innovation. The recent policy attempts to trim administrative loads and enhance institutional independence indicate the recognition of such problems, but the results indicate that the changes in regulations are more likely to develop gradually compared with the funding obligations. This example supports the thesis that the transformative power of higher education research can be constrained by high investment without corresponding decreases in regulatory complexity.

The most constrained example in the comparative analysis is India, in which the lack of R&D capacity and excessive regulatory complexity together hinder the performance of research in higher education institutions. India, as indicated in Table 2 and Table 4, is a country that has very low higher education R&D spending coupled with a disjointed and highly regulated institutional environment with a multitude of oversight agencies, minimal autonomy, political interference and poor involvement of the private sector. These limitations limit the efficacy of accessible funds, deter the taking of risks and cooperation, and the capacity of universities to change research action into products of high quality. This structural imbalance is reflected in the relatively high number of publications in India and its low position in terms of citation impact, index of innovation and the rankings of Nature. Unlike the other cases analyzed, the case of India indicates that the regulatory complexity is increasing the impacts of low capacity, and the systemic obstacles to innovation, rather than just slowing down research development.

The combination of the findings confirms the main idea of the paper that research outcomes in higher education are shaped not by capacity or complexity alone, but by their interaction. To some extent, high capacity can offset some types of complexity as observed in China and low complexity can enhance the returns to investment as experienced in the United States. On the other hand, in the case of low capacity and high complexity of regulation, as in India, the results of innovations are limited. This capacity-complexity paradigm can therefore serve as a positive prism of comprehending cross-national disparity in greater education research output and also to recognize structural blocks to innovation in emerging economies.

Conclusion:

This paper brings out the interplay of research spending and regulatory complexity in determining the outcomes of research in higher education systems in different economies. The evidence indicates that the states like the United States are able to combine high rates of R&D investment with the flexible and decentralised regulatory frameworks, which allow the countries to achieve high performance in their research and maintain the growth based on innovation. China is a unique model where resource mobilisation is highly coordinated and the state capacity is very high and where there is centralised strategic control which results in high research output despite the limitation on institutional autonomy. Conversely, the higher education research ecosystem of India is marked by the low level of R&D spending and the high level of regulatory complexity, which limits the research process and restricts the efficiency of the available resources. The fragmented oversight systems, insufficient researcher autonomy, and weak involvement of the private sector diminish the process of transforming research activity into quality outputs. The analysis indicates that in cases where low capacity and high regulatory complexity are combined, the results of innovation are structurally limited, which is manifested in a relatively low performance in the international research visibility and institutional rankings. On the whole, the research highlights that the way to enhance better research results in higher education is not only by investing more but also by creating an environment that is conducive to the autonomy, coordination, and proper distribution of resources.

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