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US-India Subnational Innovation Competitiveness Index

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For policymakers to bolster the global competitiveness of their nations and regions, they first must know where they stand. This report benchmarks the 87 regions of India and the United States using 13 commonly available indicators of strength in the knowledge economy, globalization, and innovation capacity.

KEY TAKEAWAYS

- The United States claims the top 51 regions, with California, Massachusetts, and Washington ranking in the top three. The top three Indian states are Delhi, Chandigarh, and Tamil Nadu, although they rank below all U.S. states.
- Indian regions excel in globalization indicators, taking top spots in inward FDI and high-tech exports. However, most of the FDI into India and most of the high-tech export activity are concentrated in five states.
- Indian regions are behind U.S. regions in most indicators, most notably those related to R&D investment and R&D personnel. This represents a key challenge for India as it tries to develop more-innovative ecosystems. Most of the R&D investment activity conducted in India is performed by the government, not the private sector.
- Regions with lower GDPs per capita consistently rank lower in indicator performance. The U.S. states with the lowest GDPs per capita (West Virginia, Arkansas, and Mississippi) rank in the bottom five states in the United States.
- Policymakers must continue to strengthen U.S.-India relations, focusing on building and strengthening critical and emerging technology and R&D collaboration initiatives, which connect start-ups, universities, and venture capitalists in both countries.
- Indian policymakers must utilize incentives to attract private R&D investment from venture capital funds and public-private partnerships to drive investment in innovation.

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INTRODUCTION

In this report, member think tanks of the Global Trade and Innovation Policy Alliance (GTIPA) analyze the subnational innovation competitiveness of the states and regions of two nations: India and the United States.[1]

As per the International Monetary Fund's (IMF's) latest "Asia and Pacific Department Regional Economic Outlook for Asia Pacific," India remains the world's fastest-growing economy, and investment and private consumption drive this growth.[2] Though India lags behind the United States and accounts for only 3.3 percent of global gross domestic product (GDP), the country possesses several characteristics that will be influential in the coming decades.[3] India has one of the world's largest populations of highly educated individuals. Close to 2.5 million students are enrolled in undergraduate engineering degrees in India, and 43.3 million in higher education.[4]

India has set an ambitious goal for its growth trajectory over the next 23 years to aggressively push the nation through its policies toward becoming a developed economy by 2047.[5] The country is gearing up to play a vital role in global competition strategy in the coming years, especially as fractures between the United States and China continue to widen. As the largest country in the world by population, not only does India present a significant market for exports for the United States, but India is also positioned to be a strong manufacturing and technical ally to the United States. With a robust information technology (IT) services market and strong cultural and political connections, high-growth corporations such as Google, Meta, and Oracle have moved operations to India to work on product development in artificial intelligence (AI), virtual reality, data mining, and much more.[6] In the 2022–2023 financial year, India ranked as one of the top recipients of foreign direct investment (FDI) in the world, receiving $70.9 billion in investments, and is targeting a goal of $100 billion in the near future.[7] The country has finally been recognized for its potential in advanced manufacturing industries, but it now needs a subnational innovation network to further support its growth.

The "Global Innovation Index (GII) 2024" report reveals notable differences in the innovation landscapes of the United States and India, ranked 3rd and 39th, respectively, among the 133 evaluated economies.[8] The United States consistently demonstrates a strong and well-established innovation ecosystem characterized by an advanced technological infrastructure, significant investments in research and development (R&D), and a highly skilled workforce. Meanwhile, India has made impressive progress in boosting its innovation capabilities. This is reflected in its first-time entry into the top 40 countries. India has been improving in the GII since its ranking of 81 in 2015. This advancement highlights India's increasing focus on innovation-driven growth and the rise of a dynamic start-up ecosystem.

To fully understand the dynamics of innovation in these countries, it is essential to explore the subnational factors that contribute to their unique landscapes. Regional characteristics, policies, and socioeconomic factors influencing innovation can vary significantly within each country, often leading to a lack of clarity in broader national analyses. For example, California and Massachusetts are recognized as innovation hubs in the United States, where a culture of entrepreneurship thrives and collaboration between academia and industry is strong. In contrast, India's innovation landscape is increasingly shaped by a combination of metropolitan areas and emerging tech hubs, such as Bengaluru and Hyderabad, each with its own distinctive strengths and challenges.

This is why developing a national innovation and competitiveness strategy is so important. For a country to grow into a significant player in the global economy, its capacity to nurture an educated workforce, increase productivity, transfer knowledge, and develop and adopt new, innovative technologies is vital. Understanding these subnational factors is crucial for a comprehensive assessment of innovation capabilities. By exploring specific regional influences, stakeholder interactions, and local policies, we can gain deeper insights into how effective public policy can contribute to national innovation performance. This nuanced perspective can enrich our understanding of national rankings and inform targeted strategies for enhancing innovation ecosystems tailored to the unique contexts of various regions.

The Institute for Competitiveness (IFC) has released three editions of the India Innovation Index, which evaluates the innovative capacity of subnational regions in India. This initiative is in collaboration with NITI Aayog, a public-policy think tank of the government of India. Similar to the U.S.-India Subnational Innovation Competitiveness Index (SICI), this report employs a comprehensive approach to assess innovation based on broader dimensions, with five "enabler" pillars assessing input factors and two "performance" pillars evaluating output factors measured across 70 indicators. The Index ranks regions using a robust methodology and seeks to highlight the opportunities and potential for fostering innovation in each Indian state and union territory. Relevant stakeholders within state governments utilize insights from the Index to formulate policies that promote innovation. The report also aims to encourage the spirit of competitive federalism in India.[9] In line with the India Innovation Index, the Information Technology and Innovation Foundation (ITIF) has contributed significantly to the literature on this topic with a series of in-depth subnational innovation competitiveness reports, which provide nuanced insights into the intricate relationships between innovation, economic development, and regional competitiveness, offering valuable perspectives for policymakers, businesses, and researchers alike. This series includes reports such as ITIF's "State New Economy Index," which assesses the innovative structures of U.S. states to determine to what extent these structures drive innovation.[10] Additionally, ITIF, in collaboration with GTIPA, produced the Latin American Subnational Innovation Competitiveness Index in 2023, the latest in a series of reports examining the role subnational regions play in domestic and international innovation networks.

This report does not serve as a ranking of innovation between American and Indian states, but rather offers a critical comparison. Significant gaps exist between the most-innovative U.S. states and Indian states and territories, with even the most-innovative Indian region falling behind the least-innovative U.S. state. By examining the strategies undertaken by innovation leaders such as California and Massachusetts, India can develop innovation-driven policy to replicate the factors that have led to these states becoming the forefront of innovation. This study aims to showcase the existing innovation networks in the United States and India, informing U.S. states on ways in which they could improve and informing Indian regions of potential directions that could be taken to overcome innovation gaps and come closer to reaching the frontier of innovation.

THE INDEX

The U.S.-India SICI captures the innovation performance of 87 regions across two countries: India (36 states and territories) and the United States (50 states and the District of Columbia). To simplify the comparative analysis, this report refers to all subnational entities as "regions."

This report considers 13 indicators (which were found to be commonly available across the 87 regions of these two countries) representing the relevant determinants of a thriving innovation ecosystem, grouped into three dimensions:

- **Knowledge Economy.** Indicators measure the number of doctoral degree recipients; the share of employees in science, technology, engineering, and mathematics (STEM) activities; manufacturing labor productivity; quality of universities; females enrolled in higher education; and the number of R&D personnel.
- **Globalization.** Indicators measure inward FDI flows and high-tech exports.
- **Innovation Capacity**. Indicators measure household access to the Internet; the number of new business applications; the number of active businesses; patent output; and expenditures on R&D.

The most important dimension of the U.S.-India SICI is innovation capacity, which accounts for 44.42 percent of the Index's weight, while the knowledge capacity indicators account for 44.32 percent of the Index's weight, and the globalization indicators account for the remaining 11.25 percent.

In addition to the indicators used in calculating the Index, this report also analyzes the results of two indicators found incompatible with the analysis: the labor force participation rate (LFPR) of bachelor's degree recipients and emissions intensity. Although these indicators were found to be incompatible, they still provide valuable information regarding a region's innovativeness and competitiveness; thus, insights based on them are included in this report's analysis.

Overall Scores and Rankings

Table 1: U.S. states' performance in the U.S.-India SICI

Overall Rank	State	Overall Score	Knowledge		Globalization		Innovation	
			Score	Rank	Score	Rank	Score	Rank
1	California	64.42	86.06	1	6.19	35	63.95	5
2	Massachusetts	63.47	75.04	2	10.16	19	70.90	1
3	Washington	55.43	63.35	3	5.76	37	65.07	3
4	Delaware	49.48	47.62	23	11.43	34	66.22	2
5	Wyoming	48.75	46.96	25	16.36	30	64.78	4
6	Oregon	48.41	47.75	22	3.73	11	60.14	6
7	District of Columbia	46.88	52.44	13	0.99	70	57.46	7
8	New Jersey	46.00	54.44	8	9.90	21	50.44	13
9	Maryland	45.79	56.35	6	1.59	63	51.02	11
10	Texas	44.94	60.23	5	6.21	14	41.97	28
11	New Hampshire	44.89	52.39	14	4.77	28	50.66	12
12	New York	44.83	62.88	4	7.58	51	41.84	30
13	Connecticut	44.27	49.99	16	5.25	31	51.74	9
14	Michigan	44.09	53.70	9	5.44	44	48.38	15
15	Minnesota	43.30	48.90	19	6.96	40	51.07	10
16	Colorado	42.82	50.49	15	10.31	56	49.26	14
17	Illinois	42.23	52.84	12	4.82	17	43.17	22
18	North Carolina	42.18	53.60	10	5.47	39	44.00	20
19	Pennsylvania	42.03	55.10	7	3.11	47	42.44	23
20	Utah	41.82	49.64	17	3.47	53	47.64	16
21	New Mexico	41.64	39.79	39	9.87	22	54.40	8
22	Indiana	40.32	49.01	18	10.98	15	42.18	26
23	Florida	40.25	48.19	21	2.91	48	44.97	19
24	Virginia	39.78	52.98	11	6.55	57	39.95	33
25	Arizona	39.32	45.32	26	10.16	19	43.69	21

Overall Rank	State	Overall Score	Knowledge		Globalization		Innovation	
			Score	Rank	Score	Rank	Score	Rank
26	Ohio	38.77	47.09	24	6.38	32	41.98	27
27	Wisconsin	38.05	44.76	28	7.38	25	41.83	31
28	Georgia	37.64	44.52	29	8.64	33	41.89	29
29	Idaho	37.39	39.40	42	1.52	55	47.34	17
30	Rhode Island	37.32	44.99	27	9.10	64	42.39	24
31	Vermont	36.85	41.30	36	3.13	23	42.22	25
32	Montana	36.69	40.75	37	2.19	68	45.11	18
33	Missouri	36.11	42.83	34	3.73	59	41.44	32
34	North Dakota	36.06	44.02	30	7.39	51	39.67	34
35	Iowa	35.92	43.99	31	3.25	29	38.11	38
36	Louisiana	35.50	48.45	20	1.40	66	34.96	47
37	Kansas	35.20	43.69	32	1.16	54	38.16	37
38	South Carolina	34.28	39.48	40	2.67	45	39.44	35
39	Nebraska	34.07	43.35	33	6.09	58	36.09	43
40	Alabama	33.77	40.57	38	5.06	49	37.41	41
41	Tennessee	33.68	41.30	35	4.53	36	35.97	44
42	Oklahoma	33.30	39.41	41	3.95	50	37.64	40
43	Maine	32.51	37.44	44	1.66	62	38.49	36
44	Kentucky	32.06	36.88	47	13.08	13	34.04	49
45	Nevada	31.89	35.36	48	1.16	43	37.77	39
46	South Dakota	31.62	36.90	46	5.34	68	37.13	42
47	Mississippi	30.88	35.24	49	0.55	41	35.53	45
48	Hawaii	30.41	37.02	45	0.89	75	34.45	48
49	West Virginia	29.37	37.69	43	0.22	73	31.29	52
50	Alaska	29.18	33.17	51	5.41	80	35.41	46
51	Arkansas	28.70	33.41	50	1.25	67	33.71	50

Table 2: Indian regions' performance in the U.S.-India SICI

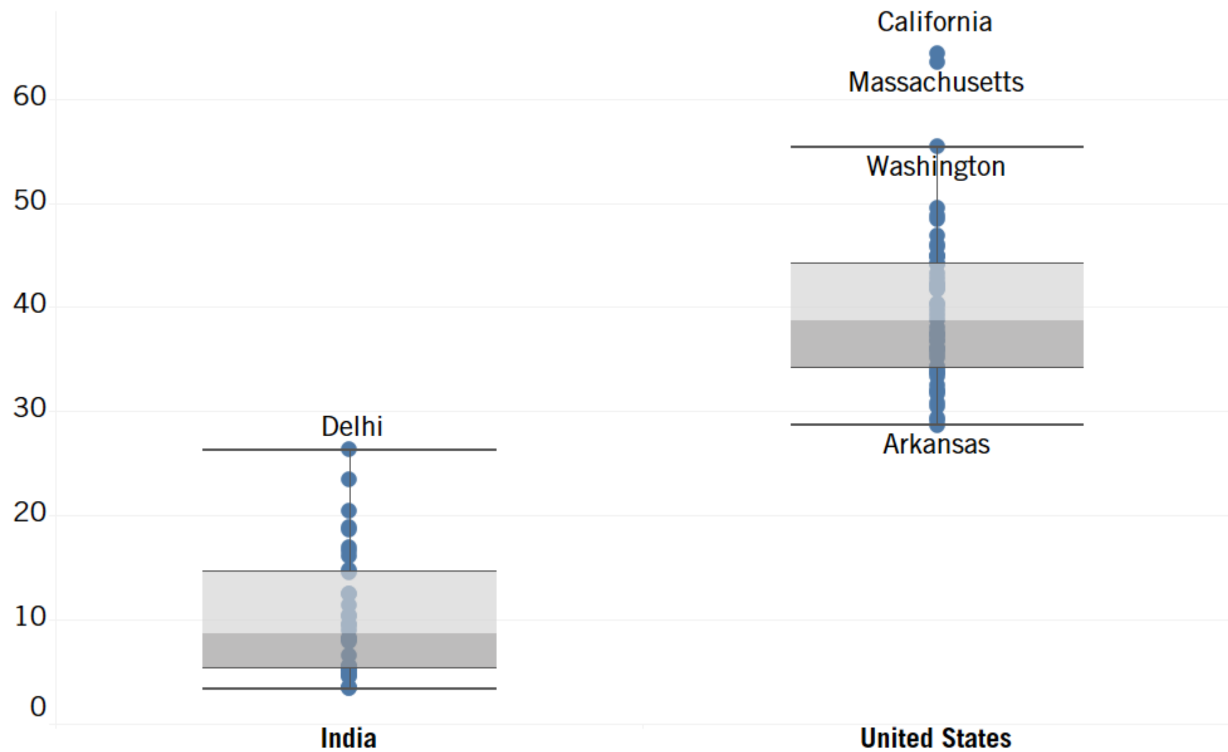
Indian Rank	Region	Overall Score	Knowledge		Globalization		Innovation	
			Score	Rank	Score	Rank	Score	Rank
1	Delhi	26.32	14.27	61	61.57	1	25.62	53
2	Chandigarh	23.47	19.70	53	5.71	38	33.21	51
3	Tamil Nadu	20.42	27.21	52	26.05	7	11.99	59
4	Maharashtra	18.91	17.70	56	46.16	3	10.64	65
5	Karnataka	18.58	16.02	57	45.66	4	11.65	61
6	Puducherry	16.91	19.22	54	19.69	10	13.75	58
7	Haryana	16.55	11.10	64	34.64	5	15.48	55
8	Goa	16.13	9.23	70	52.27	2	10.19	67
9	Punjab	14.72	14.83	59	7.82	27	17.01	54
10	Himachal Pradesh	14.49	14.97	58	21.71	8	11.53	62
11	Gujarat	12.54	9.83	66	5.41	6	10.08	69
12	Uttarakhand	12.43	13.35	62	27.12	41	13.98	57
13	Uttar Pradesh	11.41	14.31	60	10.42	16	8.99	71
14	Rajasthan	10.50	10.67	65	8.79	24	10.92	64
15	Sikkim	10.31	9.61	67	1.52	64	14.01	56
16	Dadra & Nagar Haveli and Daman & Diu	9.65	7.31	76	21.09	18	11.66	60
17	Telangana	9.45	9.43	68	10.30	9	5.45	80
18	Kerala	9.01	17.70	55	2.17	60	3.08	86
19	Jammu & Kashmir	8.25	8.90	72	14.27	71	10.16	68
20	Madhya Pradesh	8.17	9.00	71	0.96	26	7.43	73
21	West Bengal	8.09	11.22	63	8.04	46	6.17	76
22	Andhra Pradesh	7.85	9.31	69	5.03	12	4.23	84
23	Manipur	6.52	4.20	82	0.00	82	10.99	63
24	Jharkhand	5.61	5.02	81	2.07	61	7.39	74

Indian Rank	Region	Overall Score	Knowledge		Globalization		Innovation	
			Score	Rank	Score	Rank	Score	Rank
25	Ladakh	5.54	2.22	86	0.24	78	10.55	66
26	Arunachal Pradesh	5.45	2.72	83	0.00	82	9.93	70
27	Andaman and Nicobar Islands	5.32	8.83	73	0.00	82	3.82	85
28	Assam	5.25	6.37	78	0.65	81	5.94	78
29	Odisha	5.20	7.70	75	0.19	74	4.38	82
30	Chhattisgarh	5.01	6.35	79	0.26	77	5.37	81
31	Meghalaya	4.79	5.25	80	0.00	82	6.00	77
32	Bihar	4.67	6.42	77	0.00	72	4.30	83
33	Nagaland	4.50	2.37	84	0.92	82	8.08	72
34	Tripura	3.60	1.84	87	0.51	76	6.34	75
35	Mizoram	3.46	2.23	85	0.24	82	5.82	79
36	Lakshadweep	3.41	7.98	74	0.00	78	0.16	87

Index Scoring System

American regions lead in this index of subnational innovation competitiveness, with all 50 states and the District of Columbia ranking higher than any region in India. The United States has far more regional variability in scoring than India does, as seen in figure 1. There is a range of over 40 points between the highest and lowest subnational competitiveness scores in the United States, double that of India.

Figure 1: Maximum, minimum, quartiles, and median overall Index scores[11]



Regions were sorted into eight innovation competitiveness categories, as shown in table 3: Innovation Leader +, Innovation Leader -, Strong Innovator +, Strong Innovator -, Moderate Innovator +, Moderate Innovator -, Modest Innovator +, And Modest Innovator -, based on a region's position in the Index within each country. We used a structured, percentile-based approach to categorize regions based on their innovation competitiveness. This method allowed us to classify each region within an eight-tier system, reflecting its relative innovation standing within its country.

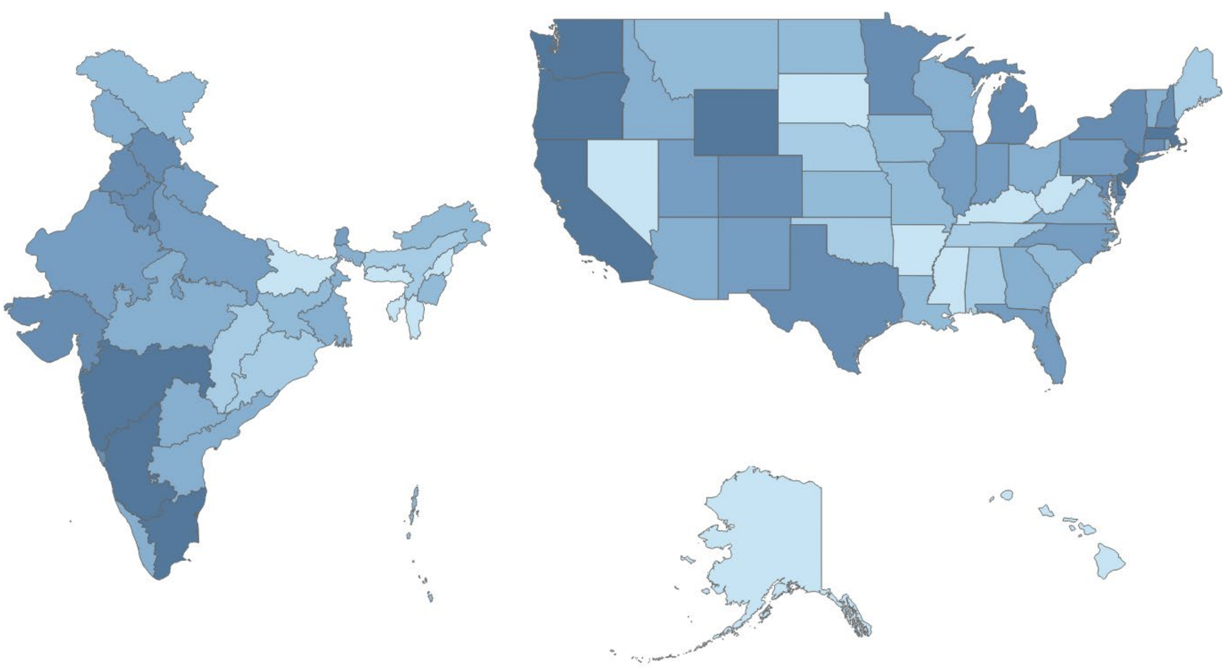
Table 3: Regional groupings in the U.S.-India SICI

Group	Performance
Innovation Leader +	85th to 100th percentile
Innovation Leader -	70th to 84th percentile
Strong Innovator +	55th to 69th percentile
Strong Innovator -	40th to 54th percentile

Group	Performance
Moderate Innovator +	25th to 39th percentile
Moderate Innovator -	20th to 24th percentile
Modest Innovator +	15th to 19th percentile
Modest Innovator -	Below the 15th percentile

This categorization was applied separately to each country, allowing us to capture regional innovation performance within each national context rather than make direct cross-country comparisons. As a result, this approach provided a nuanced view of each region's innovation competitiveness and highlighted areas where innovation leadership or growth potential is most prominent within each country. Therefore, the top innovators in the United States and India will be categorized as Innovation Leaders +, then Innovation Leaders -, and so on. The minus sign in the category's name indicates that its regions fall into a lower category than those in the respective category with a positive sign. As the colors of the charts indicate, the categories' ascending order is Modest Innovator, Moderate Innovator, Strong Innovator, And Innovation Leader, which aligns with the ranking methodology of the "European Innovation Scorecard."[12]

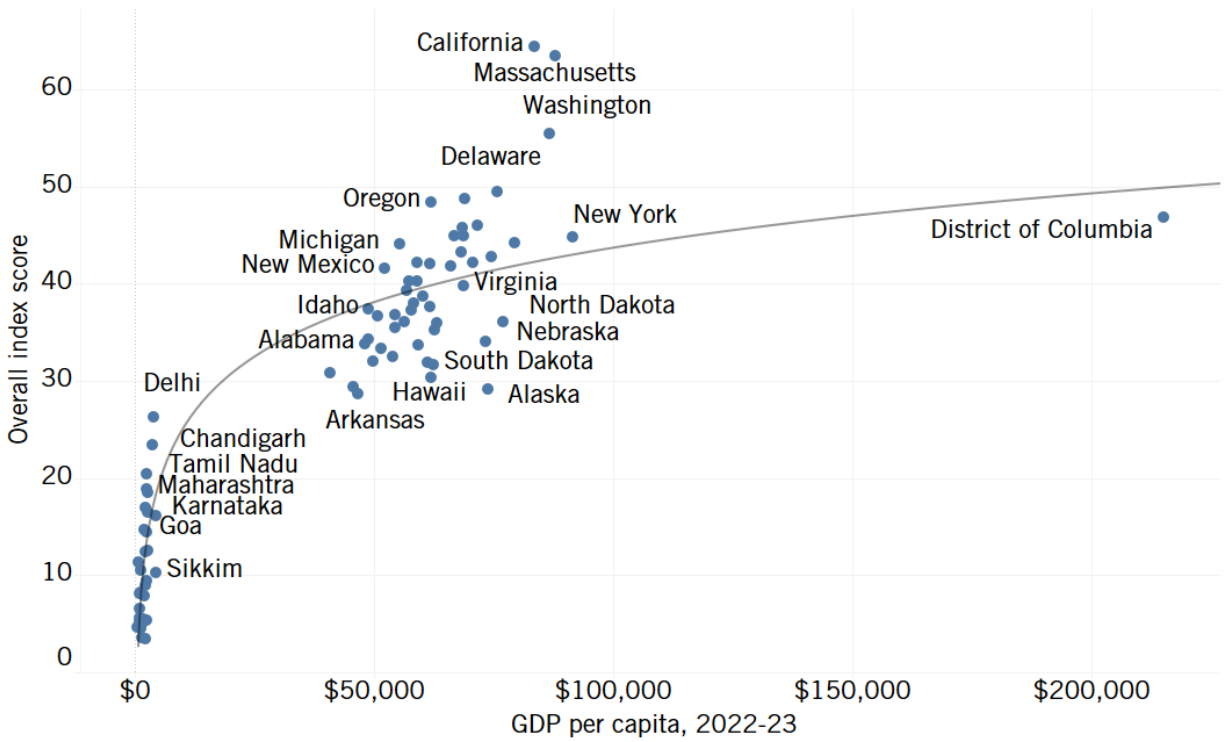
Figure 2: Overall innovation competitiveness scores (highest-performing regions in darker shades)[13]



The importance of economic prosperity cannot be underscored as a precursor to innovation. Figure 3 shows a strong positive correlation between GDPs per capita and overall index scores, suggesting that regions with higher economic prosperity generally perform better in subnational innovation competitiveness index scores.

The differences between U.S. states and Indian regions are stark. Indian states have per capita annual incomes ranging between Bihar ($419) and Sikkim ($4,304), placing them at the lower end of the Index score.[14] In contrast, U.S. states' per capita GDPs fall between Mississippi ($40,667) and Washington, D.C. ($215,067), signifying a vast difference in the countries' per capita incomes.[15] This difference translates to U.S. regions having 10 to 60 times higher GDP per capita than Indian states. There is a strong positive correlation between GDPs per capita and Index score in this model, with a 1 percent increase in GDP per capita leading to an 8.07 increase in score. The United States and India are not playing on an even playing field when it comes to innovation, which underscores the fact that this, again, is not a comparative study between the two nations, but a side-by-side ranking of subnational innovativeness within the two nations. Conclusions drawn about the most innovative states in the United States can guide both Indian and U.S. states on a path toward building stronger innovation ecosystems.

Figure 3: Relationship between GDP per capita and Index scores[16]

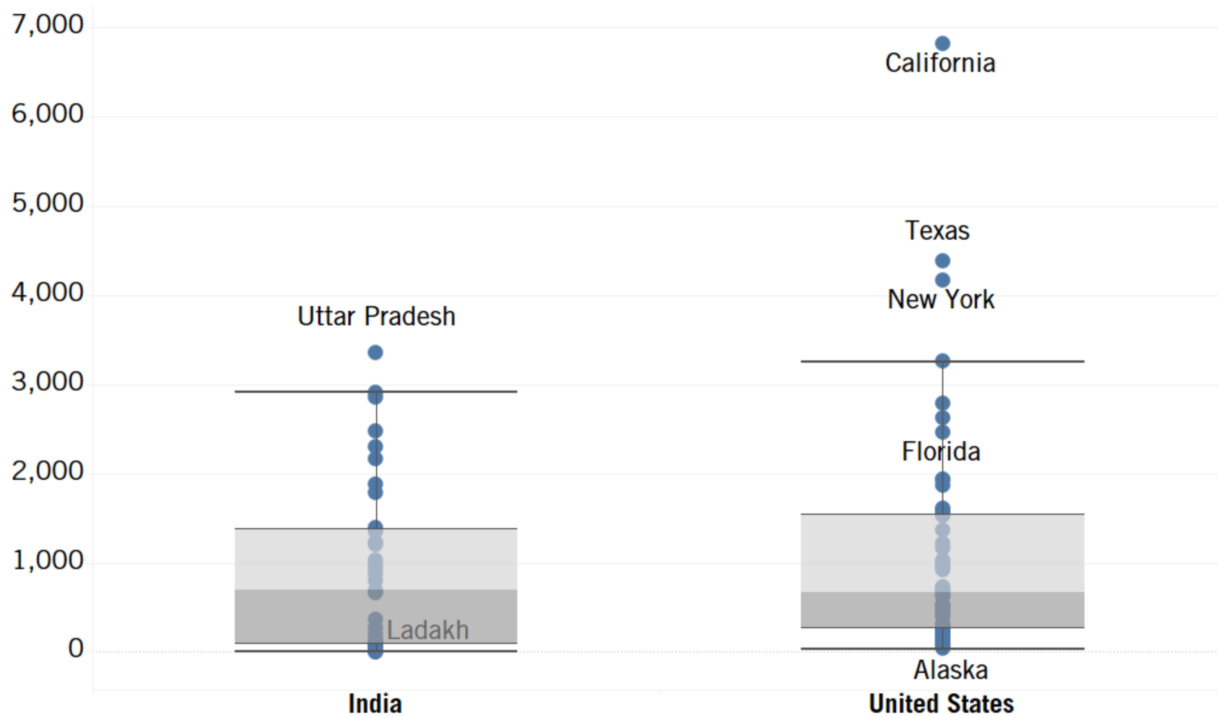


KNOWLEDGE ECONOMY

Doctoral Degree Recipients

Why is this important? This indicator measures the total number of people in the region who have earned a doctoral degree. Doctoral programs are designed to produce highly skilled researchers, an investment in human capital for knowledge creation. Recipients of doctorate degrees go on to teach in universities, inform politics, and become scientists, engineers, researchers, and scholars who lead in creating an innovation ecosystem.[17] The analytical scope of this indicator is constrained, as it measures doctoral degrees in absolute numbers at subnational levels. In contrast, the other indicators presented in this report are normalized relative to population size or economic output. As a result, regions with larger populations are more likely to produce more doctoral recipients. Regions that enable thriving knowledge ecosystems depend largely on universities to conduct advanced R&D and require a sufficient pool of highly educated individuals to drive innovation and sustain higher productivity levels. Therefore, eventually, these doctoral recipients' quality further drives the regional knowledge economy's strengths.

Figure 4: Total doctoral degree recipients, 2022[18]



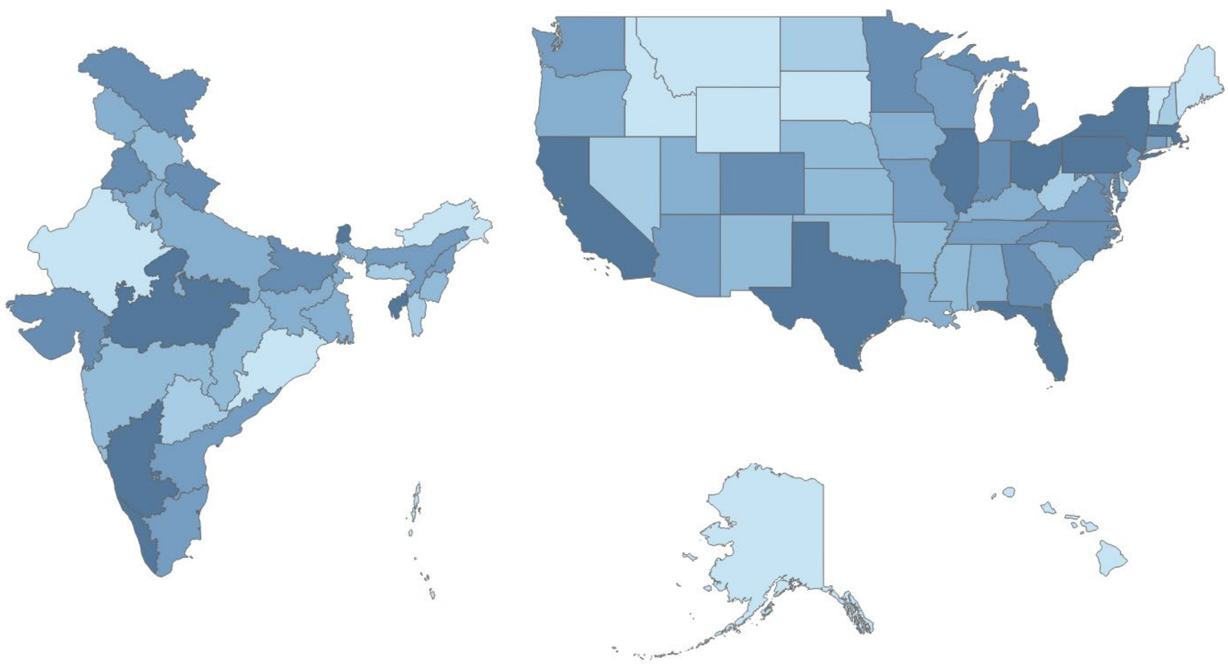
Densely populated Uttar Pradesh (3,353) leads India, followed by Karnataka (2,914) and Tamil Nadu (2,854). Several Indian regions fall to the bottom of the list with no doctoral degree recipients due to a lack of higher education institutions. This includes union territories such as Dadra and Nagar Haveli and Daman and Diu; Ladakh; and Lakshadweep.

Doctoral degree recipients in regions within the United States demonstrate extreme variability, ranging from less than 50 to over 6,700. The states with the most-significant number of universities placed unsurprisingly high in the rankings, while less highly educated and less-populated states perform worse. Innovation leaders such as California (6,817), Texas (4,381), and New York (4,163) lead the regions, while rural states such as Vermont (70) and Alaska (35) lag significantly behind.

Unlike in subnational regions of India, significant regional disparities exist among U.S. states. Most states cluster within a similar range of PhD recipients, as illustrated in figure 4. California, Texas, and New York are positive outliers, with substantially higher numbers. This disparity has important implications for both countries. For the United States, the concentration of PhD recipients in a few states suggests that innovation and research capabilities are heavily localized in these regions. The high number of PhD recipients in these states further enables them to attract more funding, investment, and partnerships with academic and research institutions, reinforcing their status as innovation hubs. Moreover, it should be noted that nearly half of all doctoral degrees in the United States were awarded to immigrants in 2022.[19]

In India, the concentration of PhD recipients is driven in select states due to varying levels of investment in higher education infrastructure, funding opportunities, and research facilities across states. Therefore, states must focus on building robust education ecosystems that provide an environment conducive to accessing advanced research, especially in the regions that are lagging behind. Addressing these disparities is important for regions to enhance their research output.

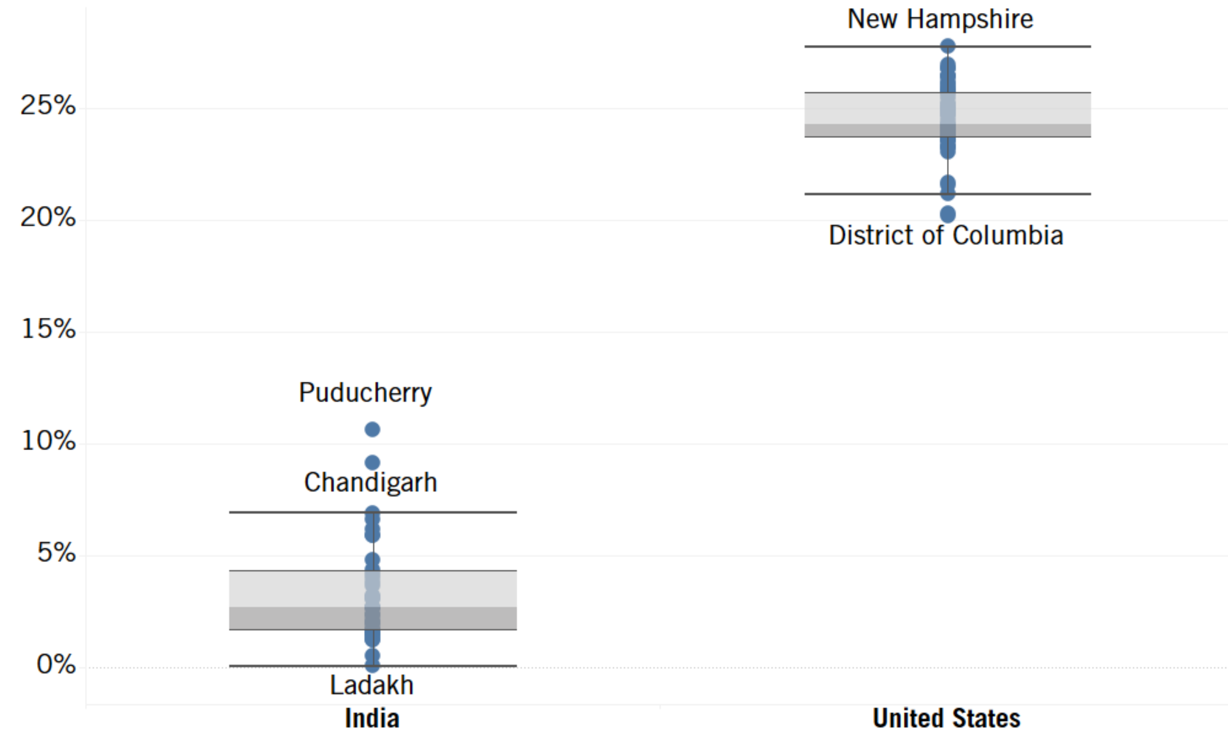
Figure 5: Performance in doctoral degrees (highest-performing regions in darker shades)[20]



Employment in STEM Occupations

Why is this important? This indicator measures the share of employees working in STEM occupations in each region. This includes, for example, engineers, researchers, and computer scientists. STEM jobs represent a vital component of R&D in all fields, and are essential to increasing productivity in all industries. The number of occupations in STEM fields has grown rapidly over the past several decades, and increasing demand for these jobs continues to be driven by globalization and automation. STEM jobs are expected to grow two times faster than all other occupations through 2029 in the United States.[21]

Figure 6: Share of workers employed in STEM occupations, 2021[22]



India has the world's highest number of STEM graduates, which showcases a robust potential workforce with specialized skills. As per All India Survey on Higher Education (AISHE) data, female STEM graduates accounted for 42.6 percent of the total STEM graduates in the 2021–2022 academic year, which is an encouraging sign of progress toward gender parity in Indian education. However, translating this educational success into actual workforce participation remains a challenge.[23]

Despite producing a large number of STEM graduates, India's labor market does not fully utilize this talent. Data from the Periodic Labour Force Survey (PLFS) indicates that regions such as Puducherry and Chandigarh have the highest proportions of the STEM workforce, with 10.6 percent and 9.2 percent, respectively. However, these figures are still lower than the percentage of STEM employment in the United States. Despite being urbanized and economically advanced, Delhi, India's capital, has a surprisingly low STEM workforce engagement rate of just 2.2 percent. This highlights a disconnect between educational achievements and labor market integration.

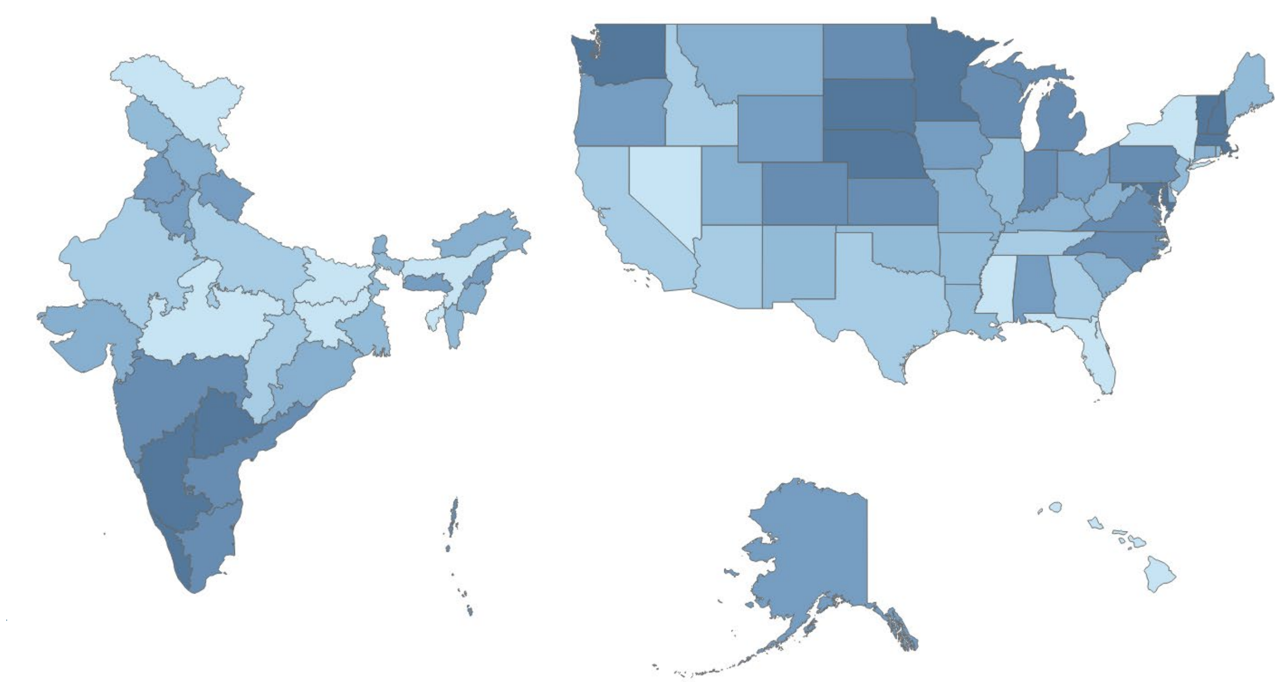
At least 12 out of 36 states in India have a STEM workforce of less than 2 percent, which further underscores the existing gaps in the current workforce. By addressing the barriers that prevent these individuals from entering the workforce, India can harness this potential and make strides toward a more inclusive and innovative future.

U.S. states exhibit little diversity in the share of people employed in STEM occupations. Technology hubs or states with large high-tech manufacturing sectors, such as New Hampshire (27.8 percent) and Washington (27 percent), lead the United States. Hawaii and Nevada, service economies, and Washington, D.C. round out the United States with 21.2 percent, 20.3 percent, and 20.2 percent, respectively. California, a hub for innovation, science, and engineering, falls near the bottom of the list for U.S. states, with 23.3 percent of its workforce employed in STEM occupations.

India has no shortage of eligible STEM employees; however, the deficit comes in the number of STEM professionals actually in the workforce. India can only increase its STEM employment by attracting innovative and growing multinational firms. By attracting these firms, regions can become hubs for industries dense in STEM positions, and other firms will be attracted to or created in these regions. For Instance, in New Hampshire, incentives have attracted STEM-intensive firms to the state. A key example of one such incentive is the Build Back Better Regional Challenge. As a winner of this challenge, New Hampshire earned $1 billion to grow its bio-fabrication cluster, a small biotechnology subsector, which is poised to experience an increase in jobs and funding due to this award. In addition to this grant, New Hampshire has attracted other large biotechnology firms, such as Pfizer and Merck, with its low taxes and strong technology workforce.[24]

Local, regional, and national governments in India should create financial incentives for cities and regions looking to develop regional clusters with the intent to attract more STEM jobs. By leveraging strong corporate incentives and their highly educated workforces, leading Indian states can begin to bring the share of workers employed in STEM occupations closer to that of U.S. states.

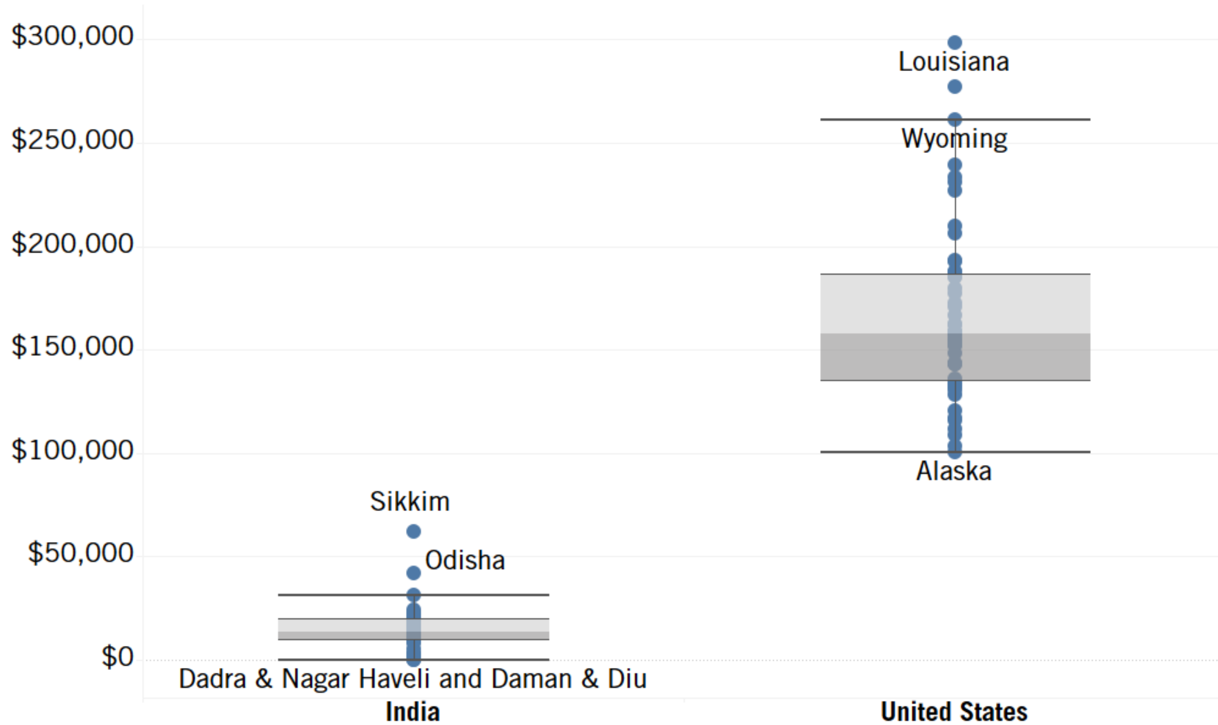
Figure 7: Performance in employment in STEM occupations (highest-performing regions in darker shades)[25]



Manufacturing Labor Productivity

Why is this important? Gross value added (GVA) measures the contribution to GDP made by an individual producer, industry, or sector. This indicator measures the average GVA per manufacturing worker on a purchasing power parity (PPP) basis. Within manufacturing, high-value-added firms are most often capital intensive, producing more technologically complex products and organizing their workers to take better advantage of their skills. They typically pay higher wages because their workers are more productive, generating greater value for each hour worked. All else being equal, firms with higher value-added levels are more likely to be able to meet global competitiveness challenges. Unfortunately, U.S. manufacturing labor productivity has declined for over a decade, shockingly falling 5 percent between 2014 and 2023.[26]

Figure 8: GVA in manufacturing per employee, 2020 (PPP-converted U.S. dollars)[27]

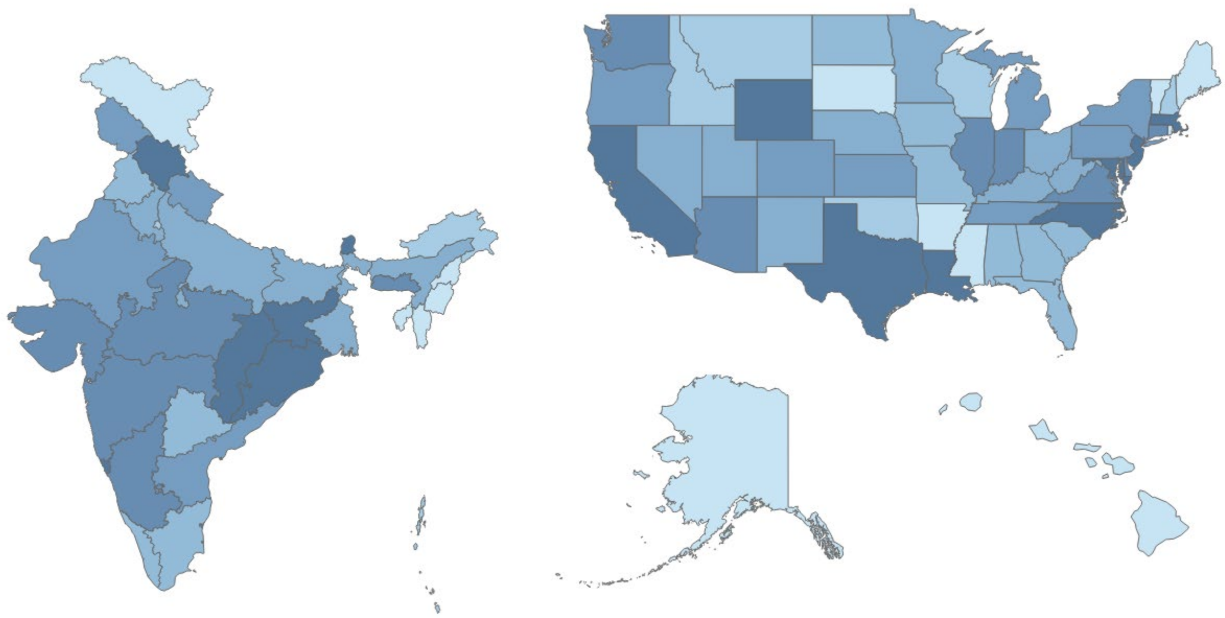


U.S. regions leading in manufacturing GVA show minimal similarity, with states such as Louisiana ($298,374), Wyoming ($261,049), and Texas ($239,329) among higher-tech regions such as California ($277,144) and Massachusetts ($233,439). This data is partially skewed due to the prevalence of costly energy commodities such as oil and gas in Louisiana, Wyoming, and Texas. Manufacturing hubs such as Indiana, Michigan, and Ohio fall in the middle of U.S. state rankings, while tourism-driven Hawaii ($108,418) and less-industrial South Dakota ($103,130) and Alaska ($100,671) fall behind the rest of the U.S. states.

In India, Sikkim and Odisha are the leaders in manufacturing productivity, boasting GVA per employee figures of $62,098 and $41,901, respectively. These states significantly outperform others in the country, where most regions report productivity levels ranging from $9,000 to $20,000 per employee. In stark contrast, Manipur ($2,333) and Tripura ($2,197) rank as the lowest among Indian states with available data, highlighting a substantial productivity gap in these areas. It's important to note that, despite their high productivity, Sikkim and Odisha contribute to only around 5 percent of India's manufacturing GVA. The majority of the country's manufacturing GVA—over 50 percent—is driven by states such as Maharashtra, Gujarat, Tamil Nadu, and Karnataka.

Though India has experienced growth in overall productivity in recent years, manufacturing GVA has struggled to keep pace with the growth of service industries. Manufacturing in India as a share of total GVA has been declining for years, with the industry accounting for 14.7 percent in 2022–2023, the lowest since 1968–1969.[28] For states lagging behind in manufacturing GVA, it is imperative that they increase their GVA; regions must attract high-value industries, such as in vehicle production, pharmaceuticals, chemicals, and electronics. Though the most productive states in the United States are all fossil fuel reliant, behind those states are technology hubs such as Massachusetts and California. Like STEM employment, regions must utilize incentives, tax breaks, and the potential for a robust and highly educated workforce to attract high-value firms, which can increase GVA for Indian regions.

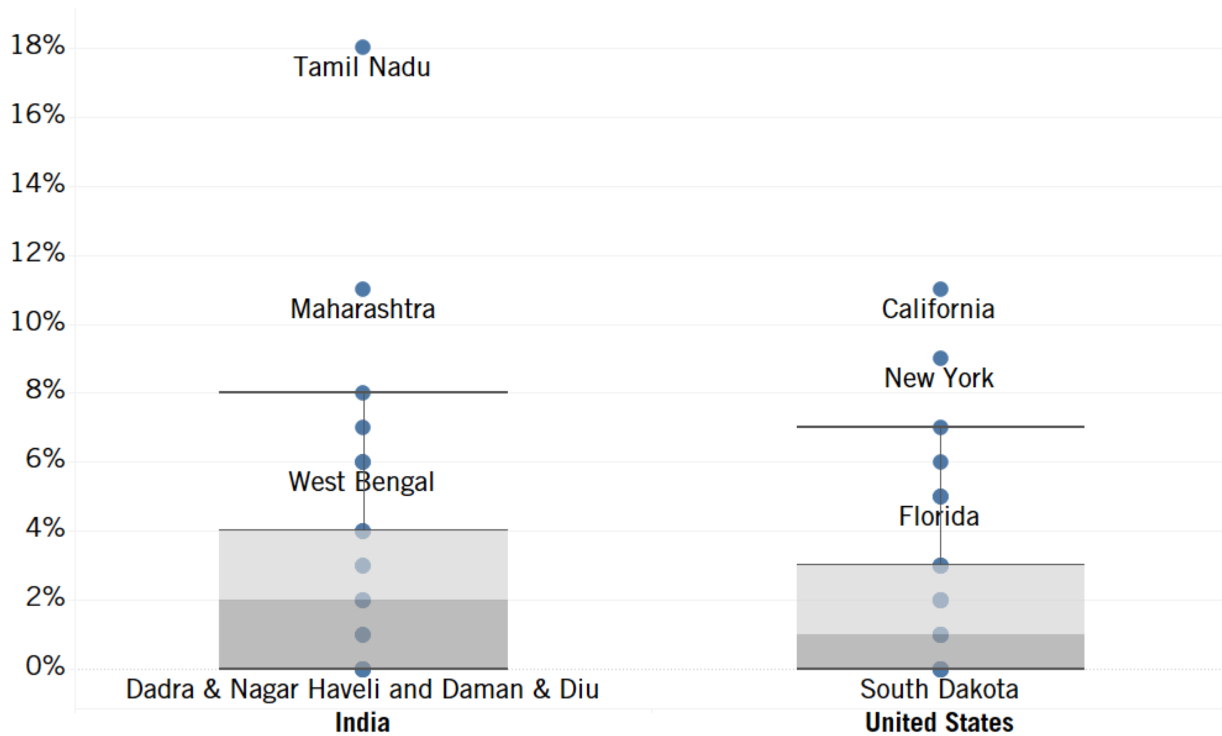
Figure 9: Performance in manufacturing labor productivity (highest-performing regions in darker shades)[29]



Quality of Universities

Why is this important? This indicator measures U.S. states' and Indian regions' respective shares of the top 100 universities in each country. Universities are pivotal in fueling innovation through their investments in research, with universities in the United States producing most of the country's non-product-related basic research. Universities are also strong producers of human capital, with highly educated individuals having a greater chance of excelling and innovating in their careers.

Figure 10: Share of top 100 universities in each country, 2023[30]

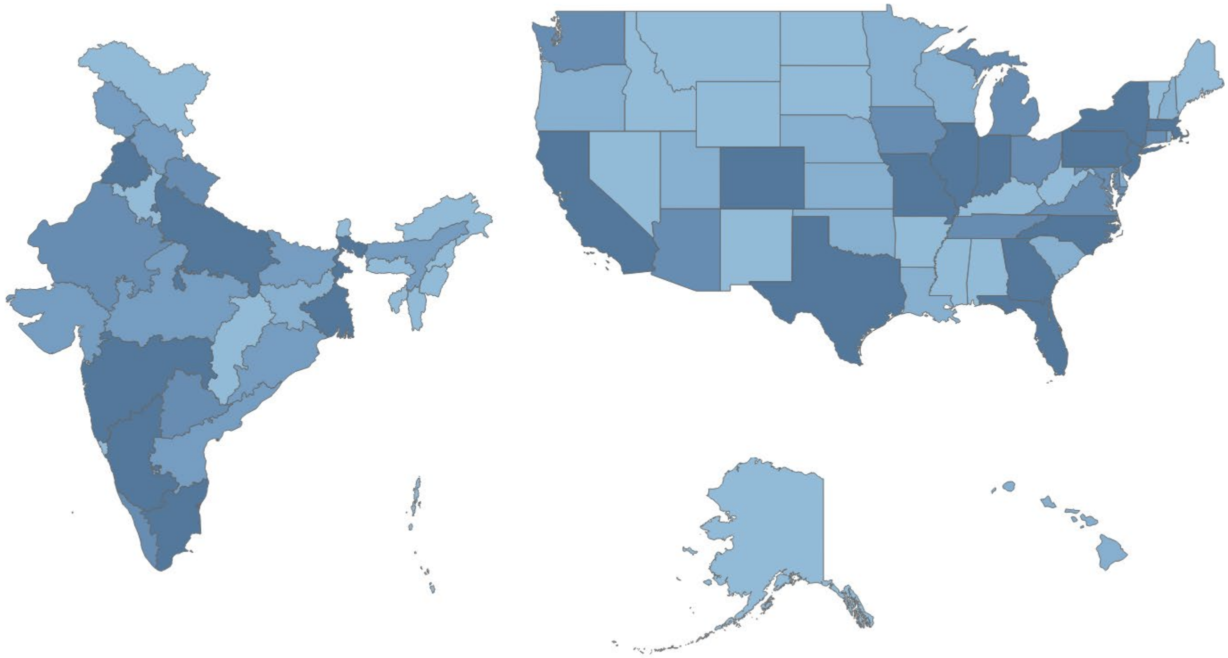


Tamil Nadu, India, has the highest number of top-ranked universities, totaling 18. Other Indian states, such as Maharashtra and Uttar Pradesh, also host many highly ranked universities. However, 14 states did not secure a place in India's National Institute Ranking Framework's (NIRF's) top 100 universities ranking. (NIRF is a yearly ranking system used by the Indian government to evaluate higher education institutions.)

Most U.S. states have at least one top university. California leads the United States, followed by New York and Massachusetts, all with large, highly educated populations. Among U.S. states, 23 have two or more top universities, and 13 have just 1. States with top universities range widely in characteristics, with industrial states such as Pennsylvania (6), rural states such as Iowa (2), and technology hubs such as Washington (2) all containing multiple highly ranked universities.

Data on the U.S. and Indian universities was sourced from two different ranking sites: QS and NIRF. The QS World University Rankings is one of the most well-known ranking systems, analyzing over 1,500 schools from 105 higher education systems. This ranking system was used for the United States due to the absence of a state-sponsored national ranking system. As noted, Indian ranking data was taken from NIRF. Both sources are reputable, but the difference in sources and methodology in the rankings is noteworthy.

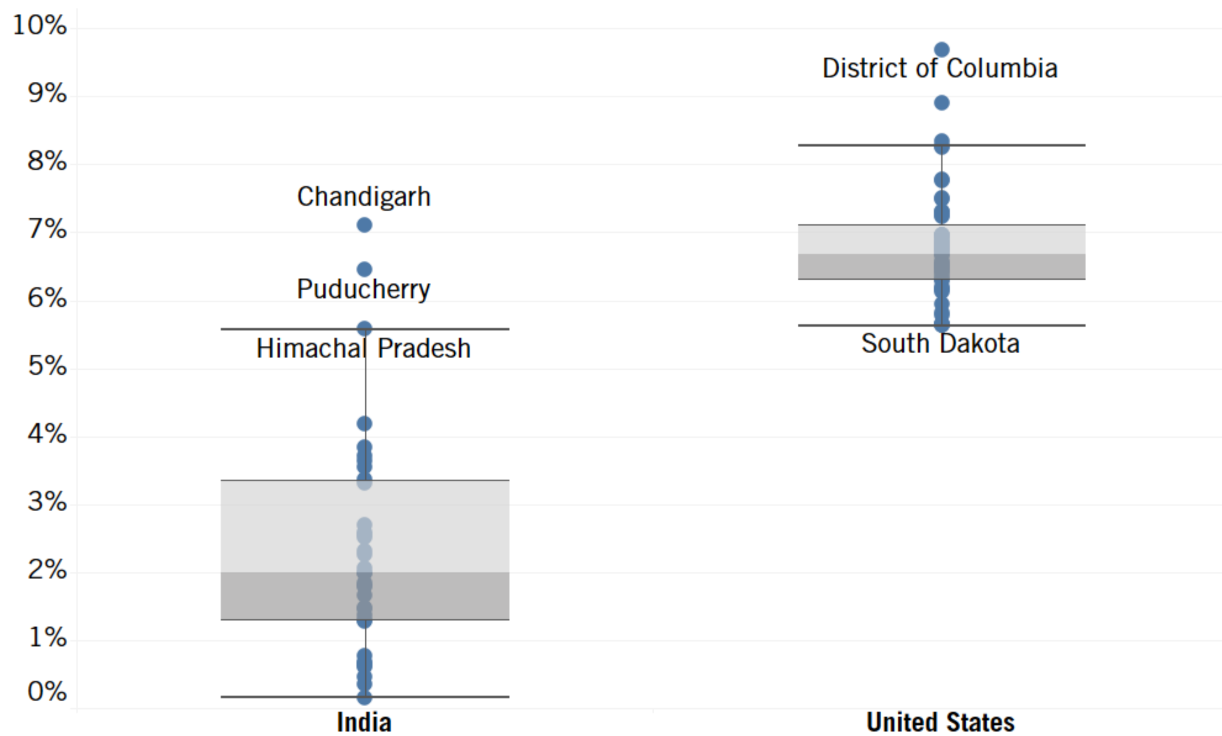
Figure 11: Performance in quality of universities (highest-performing regions in darker shades)[31]



Female Educational Attainment

Why is this important? This indicator measures the percentage of all females enrolled in higher education. As previously stated, higher education is a valuable indicator of human capital, with college graduates 24 percent more likely to be employed than are non-college-educated peers.[32] The full participation of women in the workforce leads to the introduction of new skills and knowledge and an expansion of the available workforce. Educated women drive economic growth and contribute to a more robust and innovative economy.[33]

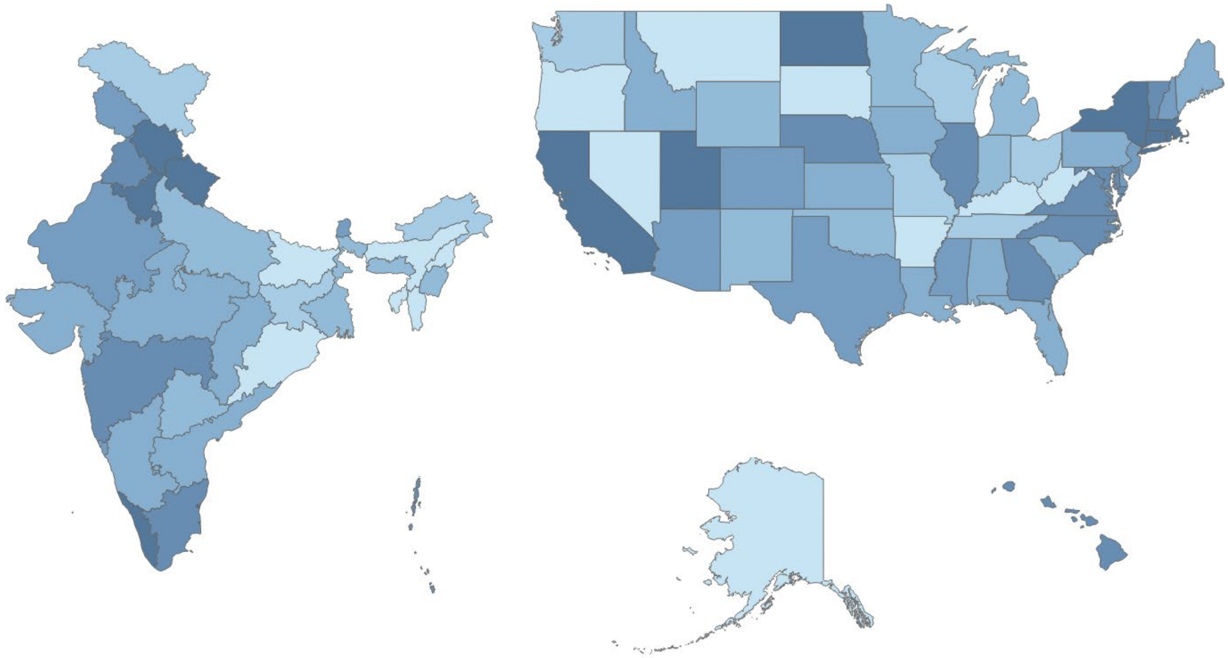
Figure 12: Females enrolled in higher education as a share of all females, 2023[34]



There exists a significant spread in the educational attainment of females in India across regions. Chandigarh has the highest rate of female educational attainment, with 7.1 percent of females enrolling in higher education. Behind Chandigarh, another outlier in India is Puducherry, where 6.5 percent of females are enrolled in higher education. States such as Nagaland (0.4 percent) and Bihar (0.2 percent) have the lowest educational attainment rates for women. Unlike the United States, Nagaland and Bihar both have very high LFPRs with a bachelor's degree—higher than almost all U.S. states—demonstrating that the poor rate of female educational attainment is likely a function of gender disparities.

In the United States, females now make up the majority of students in higher educational institutions.[35] However, female college enrollment levels vary significantly between states, with more progressive regions such as Washington, D.C. (9.7 percent), Rhode Island (8.9 percent), and Massachusetts (8.4 percent) having the highest rates of female higher education participation. There is not a tremendously significant spread between the highest- and lowest-ranking states regarding female educational attainment, with rural Alaska (5.6 percent) and West Virginia (5.6 percent) falling to the bottom of the list. Rural regions in the United States have lower educational attainment rates for both men and women, with Alaska and West Virginia having a lower LFPR with a bachelor's degree, meaning the low female educational attainment is not necessarily a function of gender disparities.

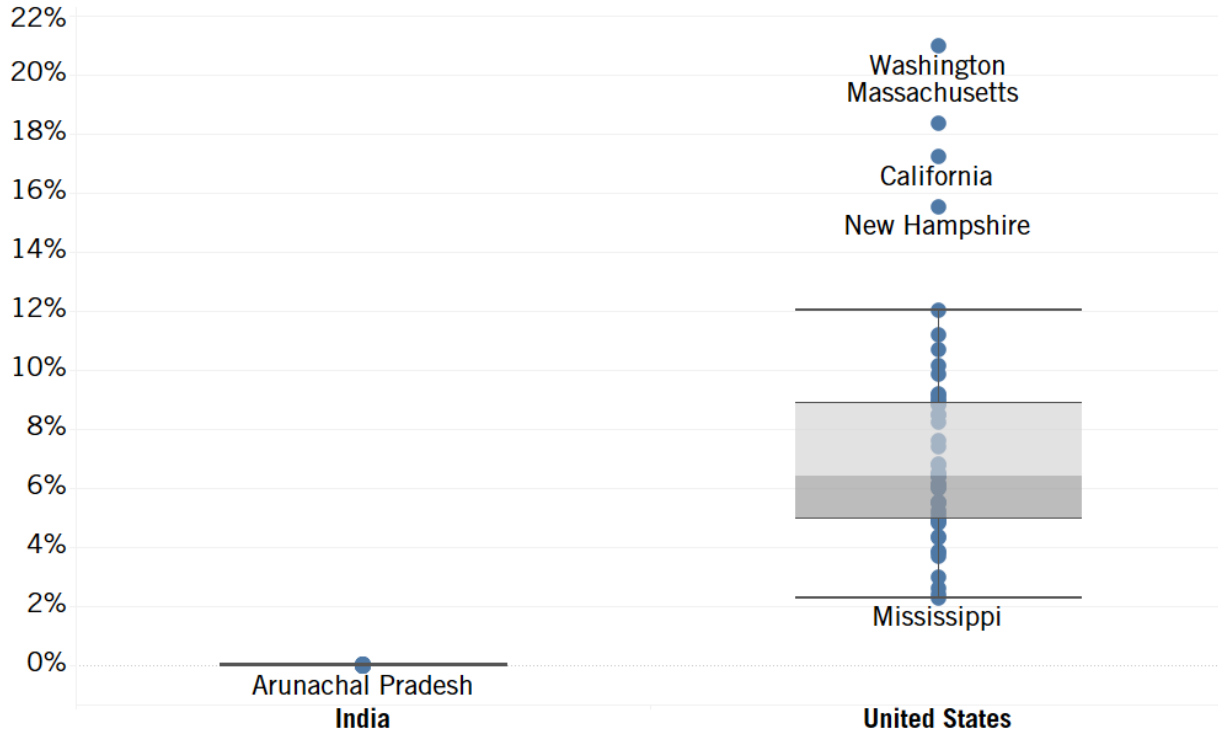
Figure 13: Performance in female educational attainment (highest-performing regions in darker shades)[36]



Employment in R&D Activities

Why is this important? This indicator measures the number of R&D personnel as a share of all employees in a region. R&D personnel are indispensable to conducting R&D activities and turning investments into new productivity-enhancing knowledge and technologies. U.S. data on R&D personnel is from 2021, and India's data is from 2022 to 2023.

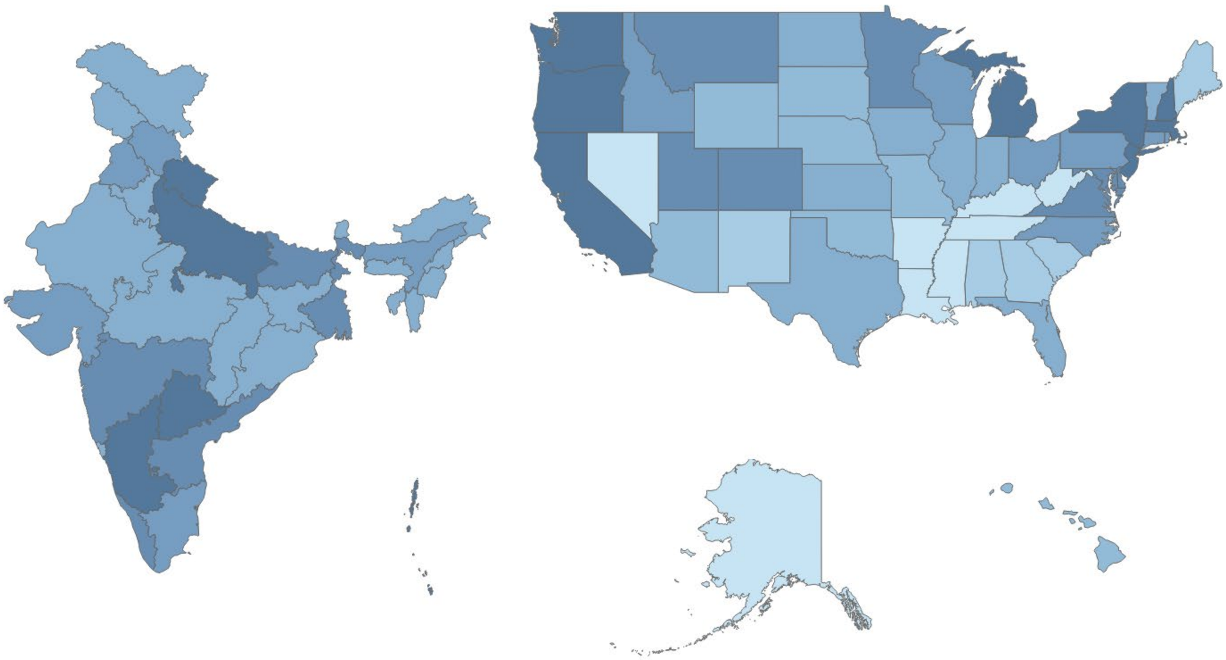
Figure 14: R&D personnel as a share of all employees, 2021–2022[37]



U.S. states with the highest rates of R&D personnel are those with large technology and innovation centers and large highly educated populations. Washington (21 percent), Massachusetts (18.4 percent), and California (17.2 percent) lead the list. There is a significant gap between the states with the largest proportion of R&D personnel and the smallest, with 18 percentage points separating Washington from Mississippi, the state with the smallest R&D workforce (2.3 percent). Kentucky (2.6 percent) and Arkansas (2.4 percent) also fall to the bottom of the list.

On the other hand, the workforce engaged in R&D constitutes a minimal portion of the total workforce in India. This situation both reflects and indicates the limited R&D activity in the country. Across all Indian states, including those with higher rates of STEM employment or greater R&D intensity, less than 1 percent of the workforce is dedicated to R&D personnel. Uttarakhand, one of the fastest-growing states in India, has the highest percentage of its workforce dedicated to R&D, at 0.06 percent. The Andaman and Nicobar Islands and Delhi also have 0.06 percent of their total workforce employed in R&D.

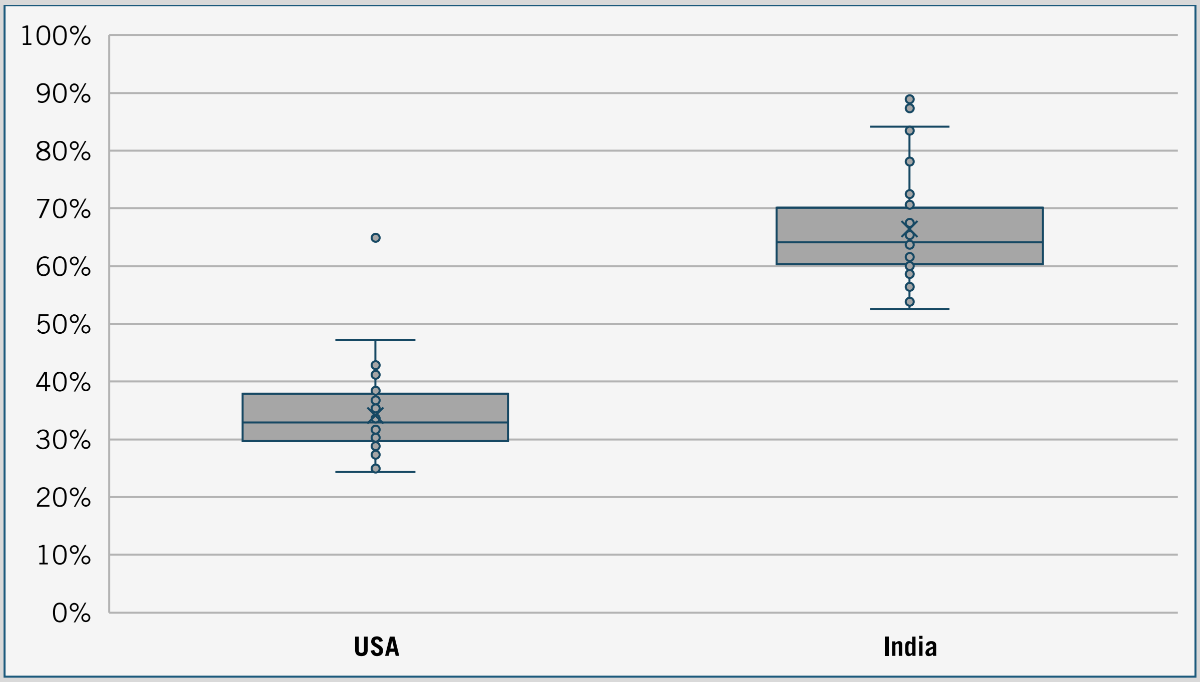
Figure 15: Performance in R&D personnel (highest-performing regions in darker shades)[38]



Highly Educated Population

Why is this important? This indicator measures the LFPR of workers who have earned at least a four-year undergraduate degree or equivalent. Higher education gives citizens the skills and knowledge necessary to compete and innovate in the modern economy. While more time spent in school does not necessarily guarantee sufficient applied skills to compete in the modern global innovation economy—for example, the Council for Aid to Education found that 44 percent of current U.S. university graduates are not proficient in essential career skills—the proportion of highly educated residents remains a strong indicator of human capital.[39] Moreover, evidence suggests that more-educated individuals are more likely and willing to adopt new technological innovations.[40] LFPR with a bachelor's degree was found to be statistically incompatible in this analysis through exploratory factor analysis, so the Index scores do not include this indicator. However, the LFPR of workers with a bachelor's degree still provides valuable insights into a region's human capital.

Figure 16: Labor force participation of workers with a bachelor's degree or higher, 2019[41]



Indian regions rank highly in LFPR with a bachelor's degree, with a participation rate greater than 50 percent in all regions. Remote and union territories regions rank highest, with the Andaman and Nicobar Islands (88.9 percent) and Lakshadweep (87.3 percent) leading the country. In contrast, Uttar Pradesh (54 percent), Haryana (53.8 percent), and Delhi (52.6 percent), regions with large urban centers, have the lowest rates of LFPR.

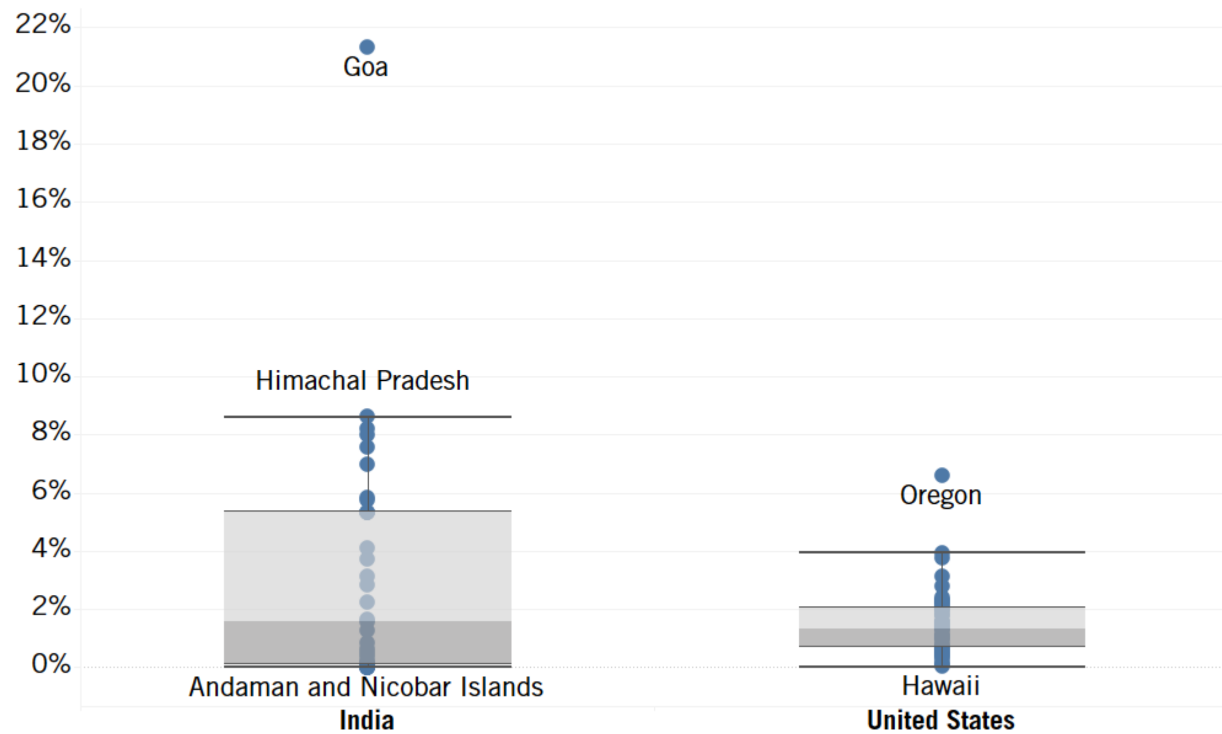
In the United States, the District of Columbia leads the country with an LFPR for people with bachelor's degrees of 65 percent. It is far and away an outlier in the United States, with the next-closest states being Massachusetts (47.3 percent) and New Jersey (44.1 percent). Rural states have the lowest LFPR in the country, with West Virginia (25.4 percent), Nevada (24.9 percent), and Mississippi (24.4 percent) falling to the bottom of the list.

GLOBALIZATION

High-Tech Exports

Why is this important? This indicator measures a region's exports in the machinery manufacturing; computer and electronic products manufacturing; and electrical equipment, appliances, and components manufacturing industries (North American Industry Classification System (NAICS) codes 333–335 or equivalent) as a share of GDP. These represent high-value-added goods that are crucial in the modern global economy. In a drive to derisk supply chain vulnerabilities, the United States and other comparable economies have pushed to reshore the production of these goods domestically and to partner nations, such as India. A region's exports of these goods as a share of GDP show to what extent a region has a comparative advantage in high-tech production and exports. The production of these goods requires a more significant proportion of highly skilled workers and automation, both signs of economic advancement. Moreover, this indicator represents a region's position in global value chains when producing these goods. U.S. high-tech export data comes from 2022, and Indian data is from 2023.

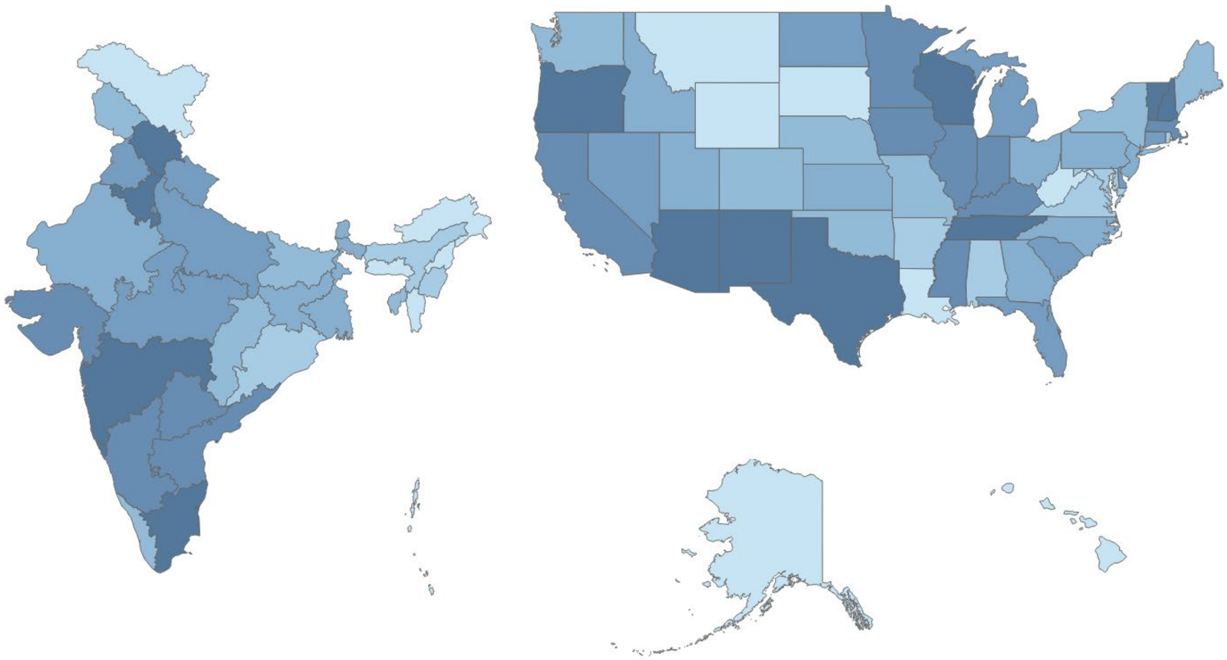
Figure 17: High-tech exports (NAICS 333–335) as a share of GDP, 2022–2023[42]



High-tech exports in Indian regions vary widely, with the state of Goa exporting far more than any other region. Goa's share in high-tech exports relative to its GDP was the highest, at 21.3 percent. Most states have less than a 10 percent share of high-tech exports in their GDP. Himachal Pradesh is the second-largest exporter, at 8.6 percent. Several regions (Arunachal Pradesh, Mizoram, and Andaman and Nicobar Islands) exported no high-tech goods during the year.

The United States has a few states that excel in exporting high-tech goods, with Oregon and its large technology sector leading (6.6 percent). Texas (4 percent), also a state with a sizeable high-tech sector, has the second-largest share of high-tech exports. Most U.S. states export less than 2 percent of their GDP in high-tech goods, with Washington, D.C. (0.1 percent), Alaska (0.1 percent), and Hawaii (0.03 percent) exporting little to no high-tech goods. These states, which rely on services and oil, have a significant gap to close.

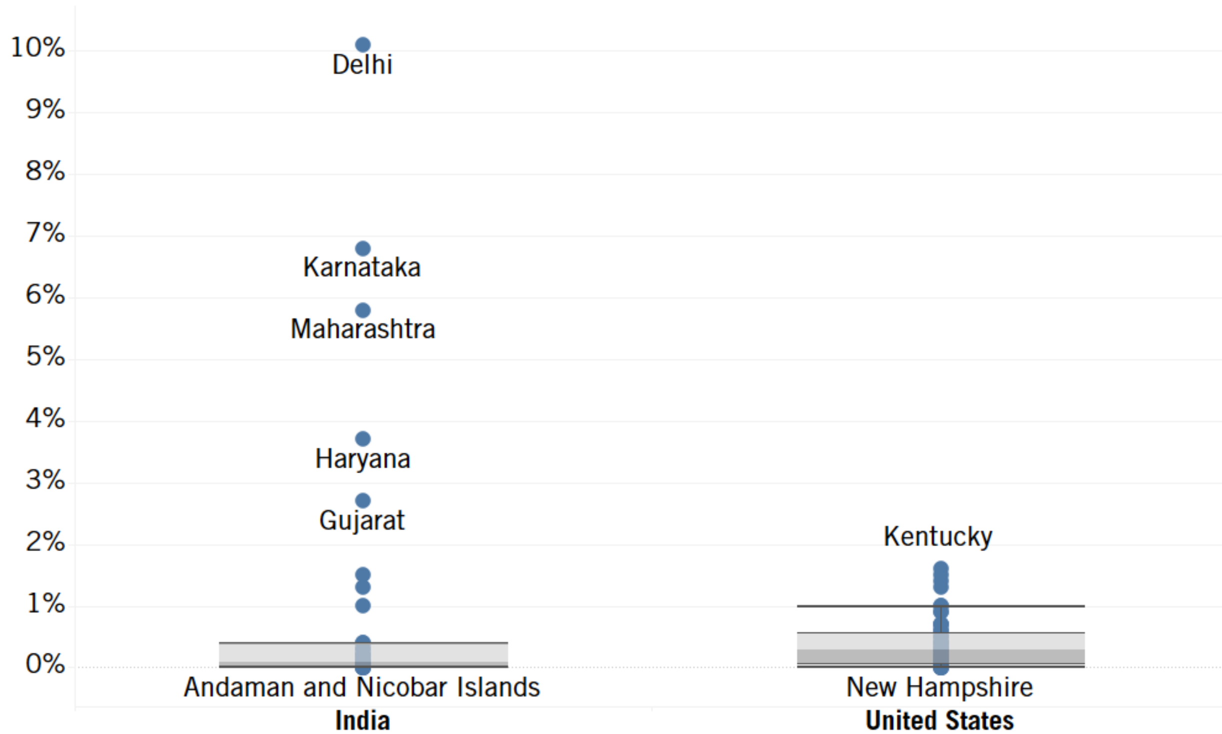
Figure 18: Performance in high-tech exports (highest-performing regions in darker shades)[43]



Inward FDI

Why is this important? This indicator measures the inward FDI a region receives relative to its GDP, measured as the funds an entity in the region attracts from foreign-based entities to acquire, establish, or expand enterprises. Inward FDI spurs domestic economic activity and facilitates technology transfer between foreign-owned enterprises and local establishments. Foreign owners can also introduce domestic firms to new international technologies and new markets to help regions forge positions in global supply chains. Inward FDI has also been associated with greater economic growth, which has significantly impacted technological innovation.[44]

Figure 19: Inward FDI flow as a share of GDP, 2017–2023[45]



Significant variation exists in the amount of FDI received by Indian regions, with the capital Delhi (10.1 percent) earning far more than the next-closest region, Karnataka (6.8 percent), as a share of GDP. Several other states receive over 2 percent of their GDP in FDI, including Maharashtra (5.8 percent), Haryana (3.7 percent), and Gujarat (2.7 percent). Like the United States, many Indian states also receive a very small amount of inward FDI, most of which are rural or remote regions. FDI inflow into India is both highly variable and significantly concentrated. As per the FDI data maintained by India's Department for Promotion of Industry and Internal Trade (DPIIT) since 2020, the top five regions attract 87 percent of the total FDI in the country, leaving just 13 percent for the remaining 31 regions. As a result, even regions that seem to draw considerable investment, such as Rajasthan, receive only 2 percent of the total FDI in India.

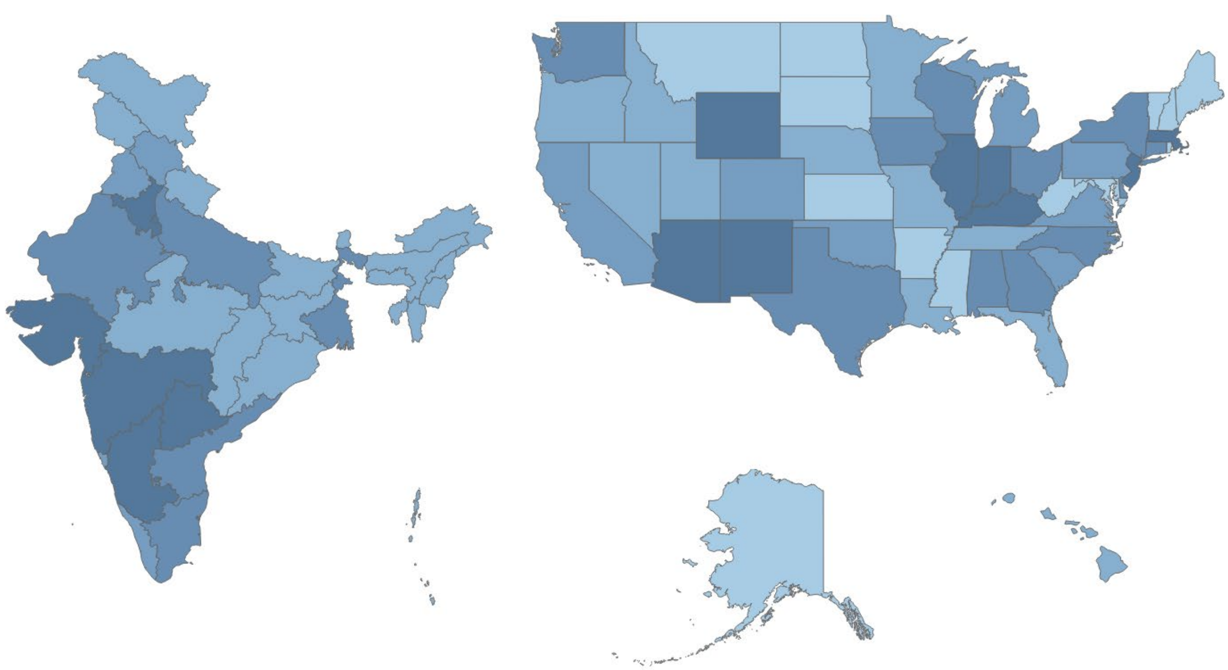
Due to large variability in the data and a lack of disclosed information from the Bureau of Economic Analysis, FDI data from the United States ranges from 2017 to 2023. In the United

States, there is very little variability in the amount of FDI earned by states, with a range of 1.6 percentage points separating the leaders from the bottom. Kentucky (1.6 percent of GDP) and New Jersey (1.5 percent) receive the most inward FDI, with other manufacturing hubs such as Indiana, Illinois, and Arizona also falling near the top of the list (1.3, 1.0, and 0.9 percent, respectively). Thirteen U.S. states receive an infinitesimally small amount of FDI, including Alaska, Arkansas, and New Hampshire.

FDI to India is vital to growing innovative industries. In the United States, states have attracted investment by incentivizing companies, increasing research, and directing regions toward cluster economies.[46] Kentucky, the U.S. state that has attracted the greatest FDI relative to its size, has nearly 740 international companies in the state. Corporations such as Toyota and Advanced Nano Products have built factories and fabrication facilities in Kentucky, largely due to its central location within the United States and the ease of doing business there. Additionally, Kentucky has built up a reputation as a reliable manufacturing state in automobiles and metals, drawing in other international companies to that sector.

India has had little trouble attracting FDI to the country as a whole, with sectors such as telecoms and IT helping to make it the eighth-largest recipient of FDI internationally in the 2022–2023 financial year. However, more than just five regions should benefit from these international investments. For Indian states that are attracting little FDI, developing a welcoming business environment and a cluster economy is key. Just as how Kentucky has found its niche in metal and automobile manufacturing, Indian states that wish to attract more foreign industries must also find their niche in an industry and develop market rules that incentivize international firms to join.[47]

Figure 20: Performance in inward FDI (highest-performing regions in darker shades)[48]

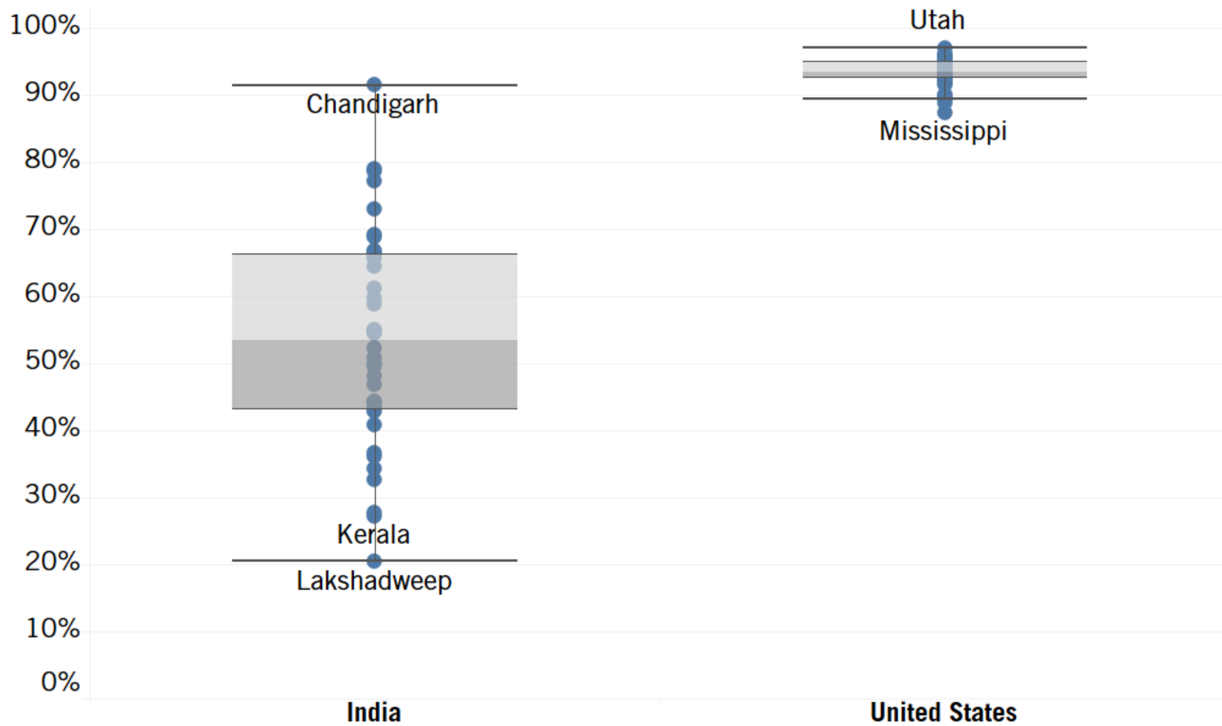


INNOVATION CAPACITY

Internet Access

Why is this important? This indicator measures the share of households in a region with Internet access, including households not subscribed to the Internet but that still have access. The Internet is an essential good for prosperity, productivity, health, and economic mobility and is now vital to full participation in today's increasingly digitalized global economy. The COVID-19 pandemic vividly demonstrated how crucial widespread Internet adoption is to societies, enabling telework, tele-education, telehealth, etc. Access to the Internet increases access to employment and access to information, and thus leads to economic growth.[49] Indian data is from 2021, while the U.S. data is from 2022.

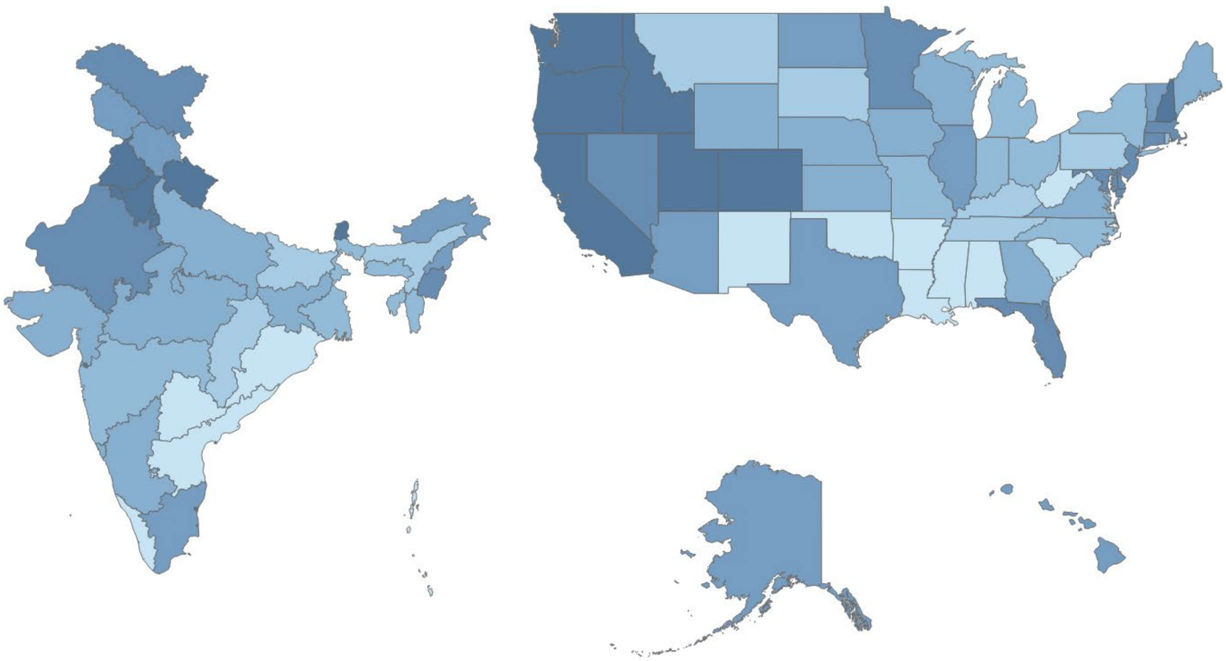
Figure 21: Percentage of households with access to the Internet, 2021–2022[50]



In India, Chandigarh has the highest percentage of the population with access to the Internet, at 91 percent. It is followed by Delhi and Sikkim, where around 79 percent of households have access to Internet facilities. Most regions in India have Internet access rates ranging from 43 to 66 percent. However, areas such as Kerala (27 percent) and Lakshadweep (20 percent) indicate that there is significant room for improvement in digital infrastructure.

Access to Internet in the United States is a given in most states, with at least 87 percent of the population in every state having access to the vital technology. Utah, New Hampshire, and Washington have the greatest Internet distribution, with 97, 96, and 96 percent, respectively, of the population with access. These three states also have significant tech and information sectors. The states with the weakest rollout of Internet, Arkansas (89 percent), Louisiana (89 percent), and Mississippi (87 percent), are all located in the southeastern United States and have small tech sectors, as well as some of the weakest LFPR for individuals with bachelor's degrees.

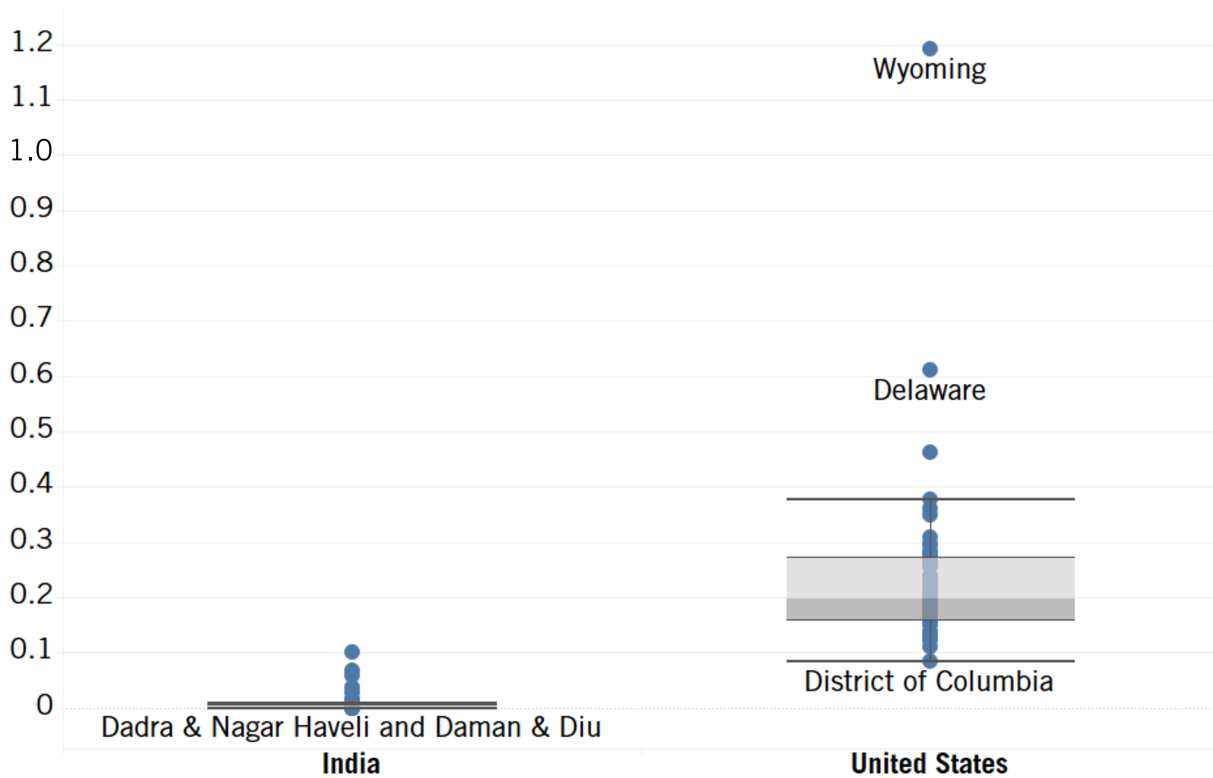
Figure 22: Performance in Internet access (highest-performing regions in darker shades)[51]



Business Creation

Why is this important? This indicator measures the number of new business applications in the past year per $million of regional GDP. A thriving business ecosystem should experience a high volume of business start-ups. The business creation indicator is limited in scope to new business applications without capturing business turnover resulting from the market disruption and creative destruction that forces incumbents to innovate or leave the market. Thus, the full impact of business competition on innovation is not captured. Moreover, this metric does not make a distinction between industries, so there is no differentiation between the creation rates of start-ups in advanced, innovative industries and new businesses in less-advanced industries. Data restrictions at the cross-national regional level leave new business applications the most sufficient indicator to reflect the ease of starting a business and the health of the business ecosystem in regions. While stronger entrepreneurship indicators may exist in the United States, this indicator was chosen to permit comparability with available Indian data.

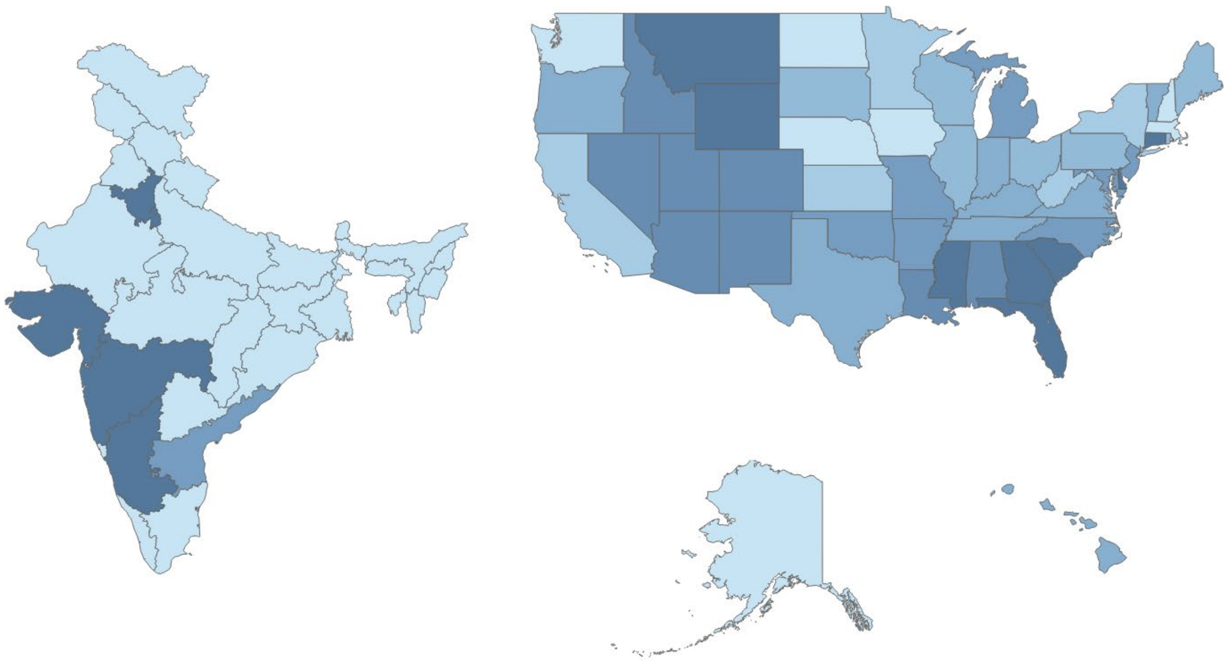
Figure 23: Number of new business applications per $million of regional GDP, 2023[52]



India exhibits limited business creation, even in its most economically advanced regions. Among states, Delhi and Karnataka lead in new business applications as a share of GDP, yet even these regions display only moderate entrepreneurial activity. In contrast, many regions report nearly zero new business applications per million dollars of GDP, highlighting significant untapped potential for growth in business creation across the country.

In the United States, Wyoming (1.19) has the most new business applications as a share of GDP, followed by Delaware (0.61) and Florida (0.46). North Dakota (0.12), Massachusetts (0.11), and D.C. (0.08), on the other hand, show room for improvement in this area.

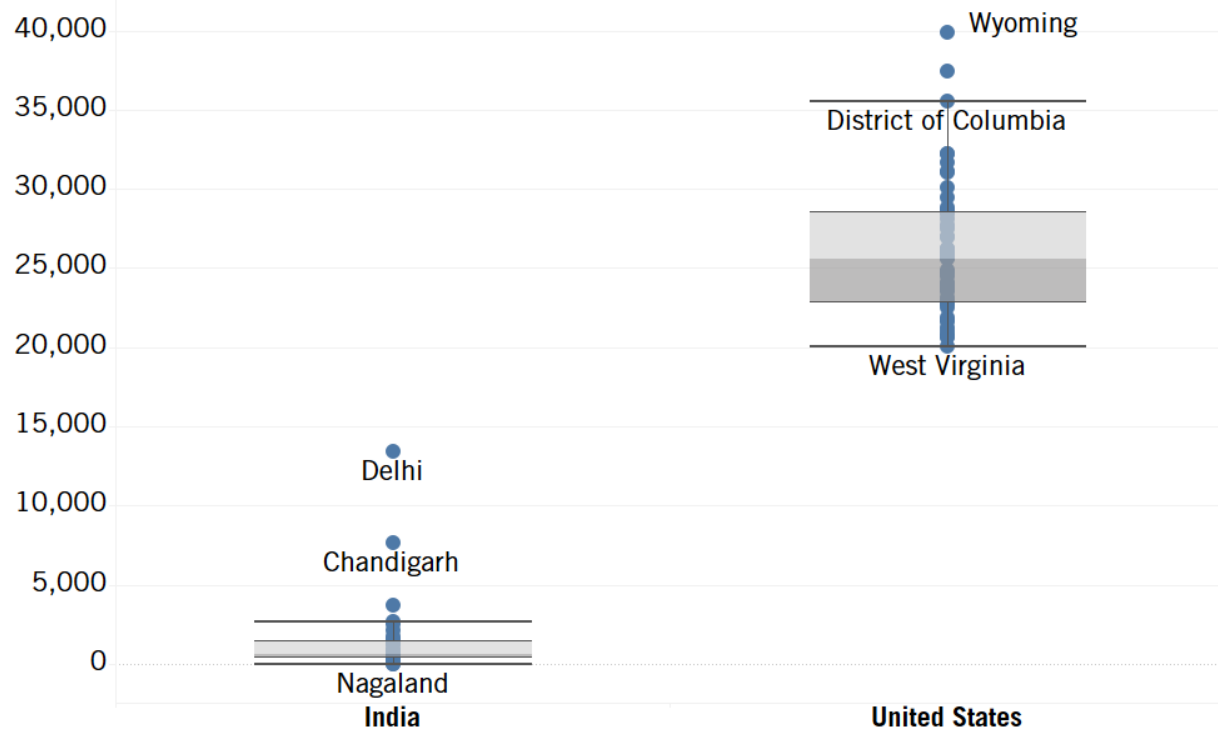
Figure 24: Performance in business creation (highest-performing regions in darker shades)[53]



Active Businesses

Why is this important? This indicator measures the number of active businesses in a region per million inhabitants. Like the number of new businesses, active businesses reflect the ease of starting and maintaining business operations. This indicator also captures the economic well-being and innovativeness of a region, as regions with strong business environments and high consumption cultivate markets that demand R&D to innovate products. Also, like business creation, this indicator does not distinguish between highly advanced industries and less-advanced industries, thus making it limited in scope.

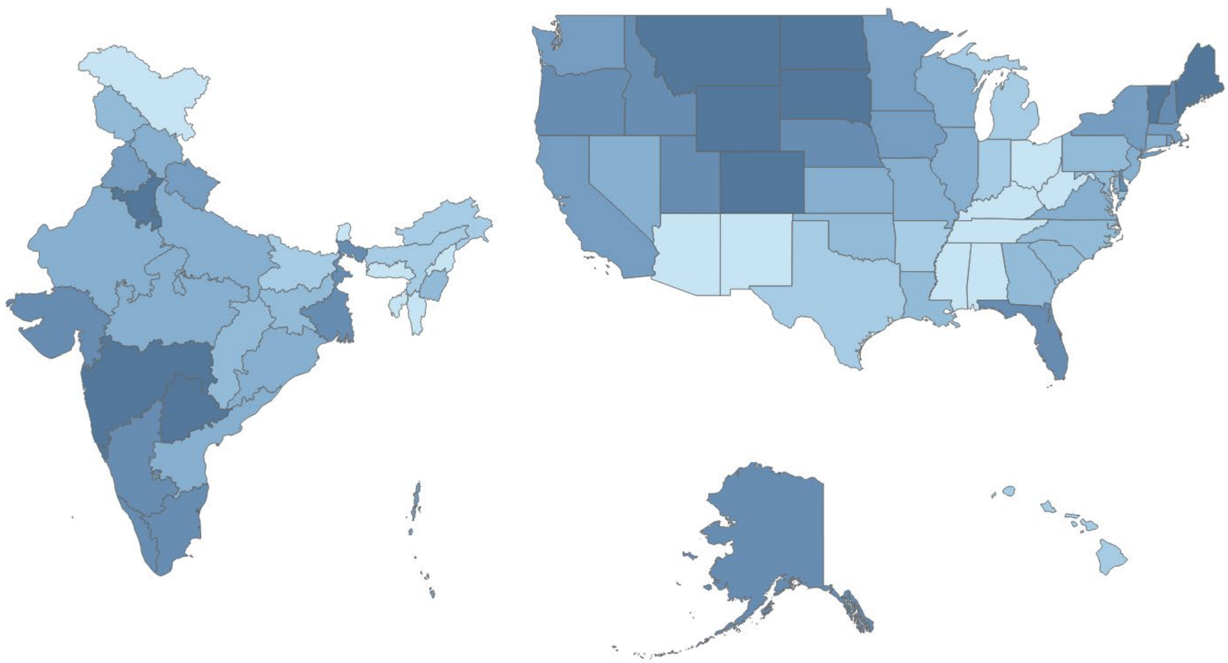
Figure 25: Active businesses per million inhabitants, 2022[54]



In India, Delhi (13,449) and Chandigarh (7,660), two union territories with strong business ecosystems, lead the country with the most active businesses, while northeastern and lesser-populated regions fall behind in this measure. Mizoram (195), Nagaland (21), and Sikkim (2) have significant room to improve. To enhance business activity in Indian states, particularly in the northeastern region and eastern regions such as Bihar, which have fewer than 350 active businesses per million inhabitants, targeted support initiatives such as skill development programs, improved infrastructure, and financial incentives for entrepreneurs are essential. By fostering a more conducive environment for business growth in these regions, states can promote balanced economic development and unlock the potential of their lesser-populated regions.

Wyoming has the most active businesses per million inhabitants (39,881), followed by Montana (37,417) and Washington, D.C. (35,582). Both Wyoming and Montana are sparsely populated states with large tourism sectors, while D.C. is just a single city with a large tourism sector as well. Other lesser-populated states, such as Vermont (32,248) and North and South Dakota (32,222 and 31,716, respectively), fall near the top of the list, while Mississippi (20,575) and West Virginia (20,028) have room to improve in maintaining a successful business environment.

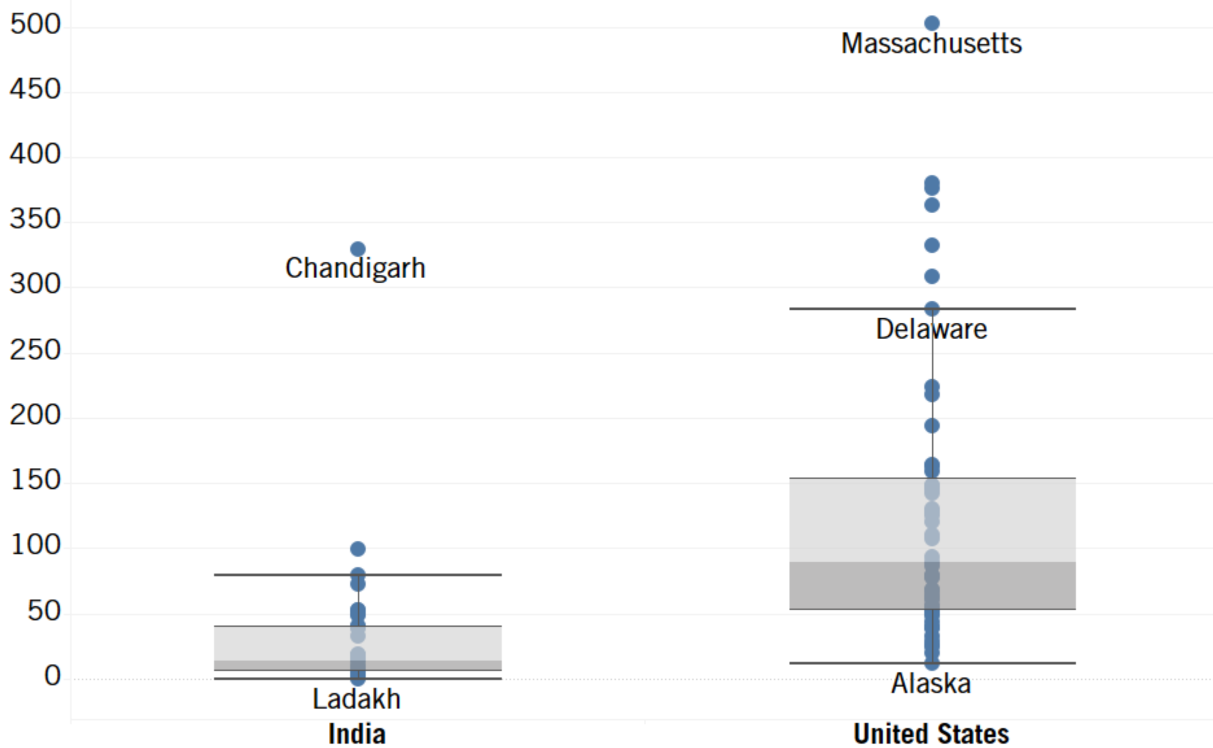
Figure 26: Performance in active businesses (highest-performing regions in darker shades)[55]



Patent Applications

Why is this important? This indicator measures international Patent Cooperation Treaty (PCT) patent applications filed by residents or entities within a region per one million residents. Patent output measures the "inventiveness" of a population. Patents also secure private returns on investment in R&D activities, which are necessary to incentivize these activities and their socially desirable spillover effects. By considering PCT patents, this indicator focuses on internationally filed patents to mitigate differences in patent qualifications between countries' patent offices. Data limitations originating from the United States present challenges in assessing this indicator, particularly given the termination of its state-level PCT patent series in 2015. To encapsulate the recent surge in patent activity within India, the latest available figures reflect patent applications from that country for the year 2021.[56]

Figure 27: PCT patent applications per million inhabitants, 2015 and 2021[57]



Chandigarh was the leader among Indian regions for the most patent applications, with 330 applications per million people. The next-closest region, Delhi (100), had less than one-third of Chandigarh's applications. Nagaland (3), the Andaman and Nicobar Islands (3), and Bihar (1) all have a way to go to catch up to the top regions in India.

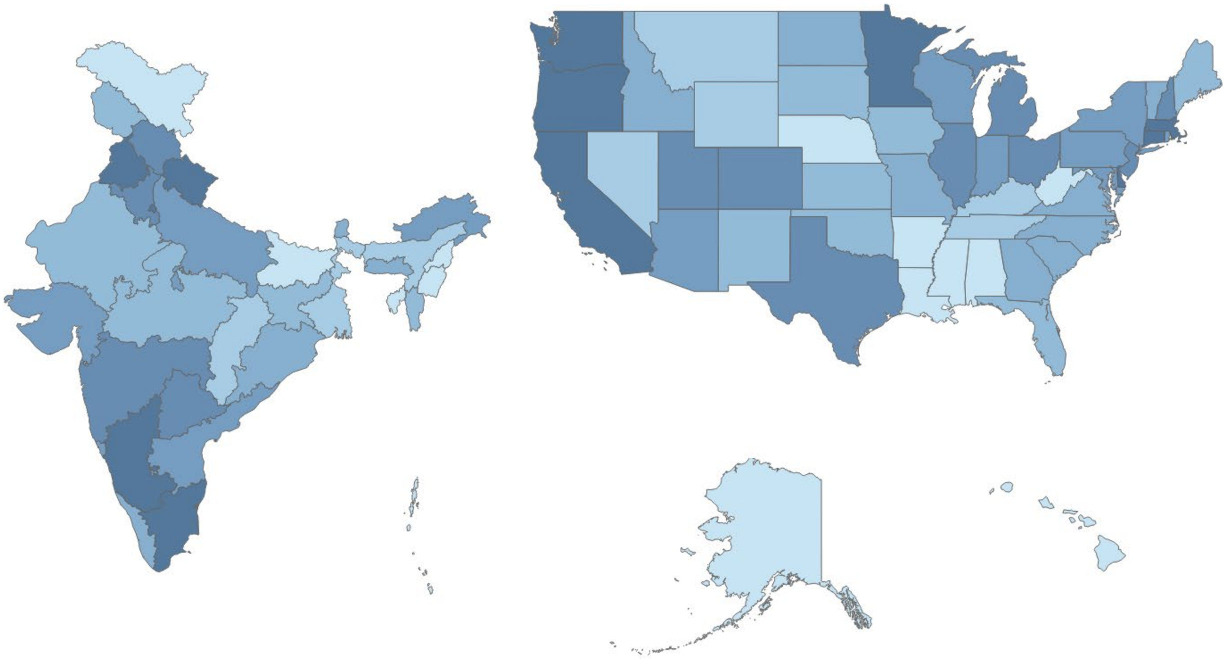
States with strong technology industries in the United States lead the way in having the most patent applications. Massachusetts (502) had the most applications in 2015, followed by California (380) and Oregon (376). States dependent on fossil fuel energy and rural states with small technology sectors fell to the bottom of the list. West Virginia (24), Mississippi (20), and Alaska (12) were the three states with the lowest applications sent to the PCT.

Massachusetts's soaring lead in patent output is driven by Boston and Cambridge, cities that have made concerted efforts to make themselves innovation hubs. Boston and Cambridge have benefitted from the high-quality research institutes in and around the cities, such as the Massachusetts Institute of Technology (MIT), Harvard, and Boston University. These universities have organically become centers of an innovation triple helix, attracting government research funding, which attracts R&D firms, which attract private venture capital investment. These universities have made themselves the center of innovation hubs and have made the areas they are located magnets for innovative firms. However, Boston has also undertaken policies to turn other, newer areas of the city into innovation hubs, areas that do not have research universities at their core but instead rely on public-private partnerships within the city to build innovation.[58]

In 2010, Boston began building the "Innovation District," a development project meant to build and attract innovation clusters through private sector funding, physical proximity, and public sector support. Unlike Cambridge, which has cemented itself as a biotechnology hub, the Innovation District was built to be industry agnostic, allowing self-identifying innovative firms to decide whether to move there. The district was also created with proximity in mind, placing restaurants and apartments near firms and maintaining the area's "Work, Live, Play" motto; the idea being that proximity increases socialization and networking, creating more innovation.[59] With support from Boston mayor Thomas Menino, quality infrastructure, and a powerful regional knowledge base, the now-booming Boston Innovation District has become the state's most prominent hub of venture capital funding, with more than 200 technology, life science, and other companies in the region.[60]

India's highest-performing patent output regions can learn from Boston's Innovation District model. With its already high human capital accumulation and large STEM employee workforce, union territory Chandigarh has produced far more patents than other Indian states and as much as the leading U.S. states. However, to bridge the gap between Chandigarh and Massachusetts, Indian policymakers must consider how to make Chandigarh a more attractive location for private investment in research. Considering the shortage of private R&D conducted in India, Chandigarh's regional government should incentivize private firms to conduct research through investment tax credits or grants. Private sector investment will lead to increased research conducted in the region and an increase in patent output, bringing Chandigarh closer to Massachusetts.

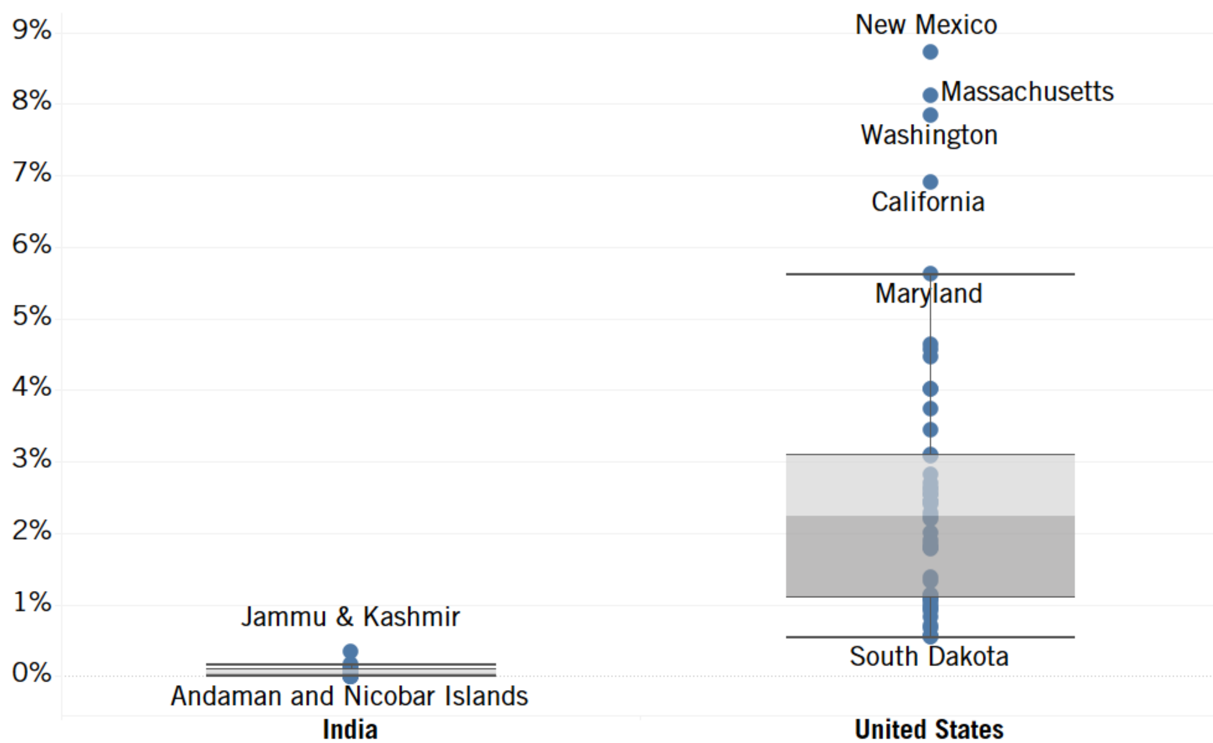
Figure 28: Performance in patent applications (highest-performing regions in darker shades)[61]



R&D Intensity

Why is this important? This indicator measures R&D expenditures in a region relative to its GDP considering R&D expenditures by all sectors: business, government, and higher education. R&D lies at the heart of innovation, as it represents the source of the new knowledge needed to discover, design, and implement innovative technologies and products. R&D results in slightly higher private returns and much larger societal returns than other types of investment, as new knowledge and technology spill over to the rest of the economy.[62]

Figure 29: R&D expenditures as a share of GDP, 2021[63]



In India, there is very little variability for this indicator, with all regions investing less than 0.5 percent of their GDP on R&D. Jammu and Kashmir (0.4 percent) and Punjab (0.2 percent) lead Indian regions with the highest investment in R&D. At the same time, 12 states invest virtually nothing in R&D. These states include relatively innovative regions in India, such as Chandigarh, Goa, and Puducherry.

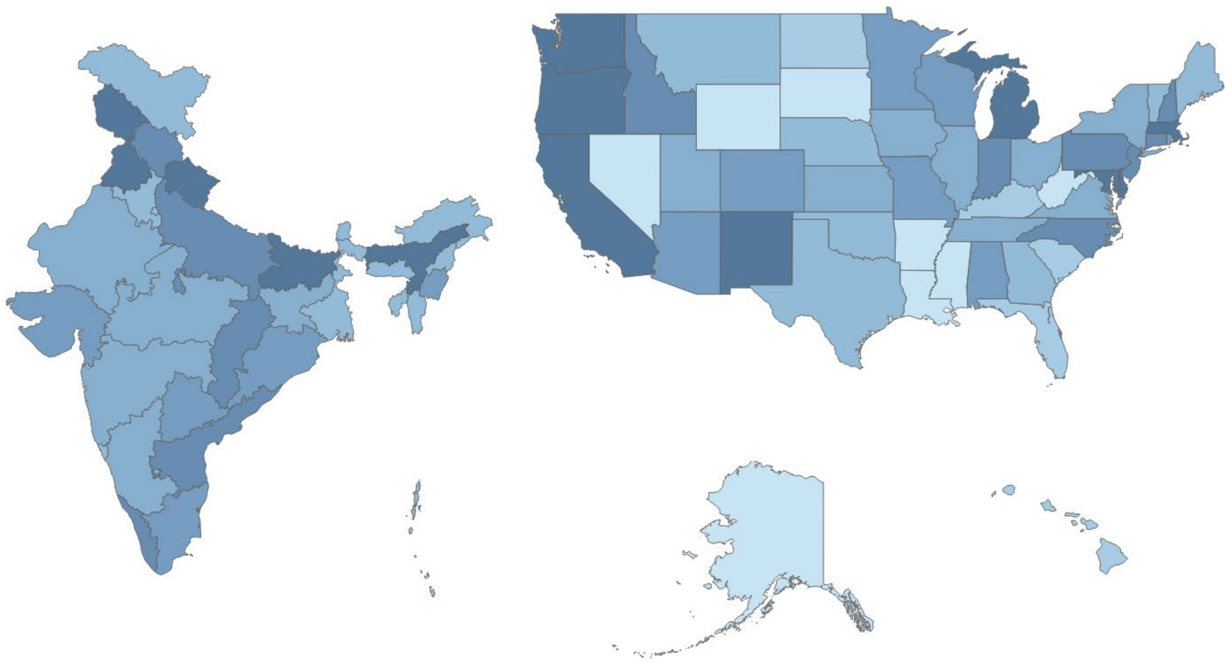
There exists large variability in R&D intensity across regions in the United States, with, unsurprisingly, states with large technology industries investing the most in research. New Mexico (8.7 percent) has the highest R&D intensity out of all states, followed by Massachusetts (8.1 percent) and Washington (7.8 percent). Wyoming (0.6 percent), Louisiana (0.6 percent), and South Dakota (0.6 percent) invest the least in research.

The difference between the region with the greatest R&D intensity in the United States (New Mexico) and in India (Jammu and Kashmir) is startling. With 8.7 percentage points separating them, it can be said that Jammu and Kashmir invest an insignificant amount of money in research. Very little research is conducted in India by the private sector, which is the complete opposite of the United States, where 78 percent of R&D expenditures come from it.[64] In New

Mexico, a history of R&D has been developed in the state, with strong public support and initiation from public universities such as the University of New Mexico and federally funded labs, such as the Los Alamos National Laboratory. Federal funding for research at public institutions has also made New Mexico a location for private firms with a desire to be nearer to cutting-edge research. New Mexico's state government has further incentivized start-up growth through incubator and accelerator programs, which help to mentor and connect firms in order to increase rates of business survival. The venture capital environment in New Mexico also provides a strong support system for start-up firms, attracting research-heavy companies to the state.[65]

For Jammu and Kashmir and all other Indian states to close the gap and begin investing comparable amounts of GDP in research, India must incentivize private firms to get involved in the budding innovation ecosystem in India. Building innovation systems around existing technology hubs will invite private firms and venture capital to the country.

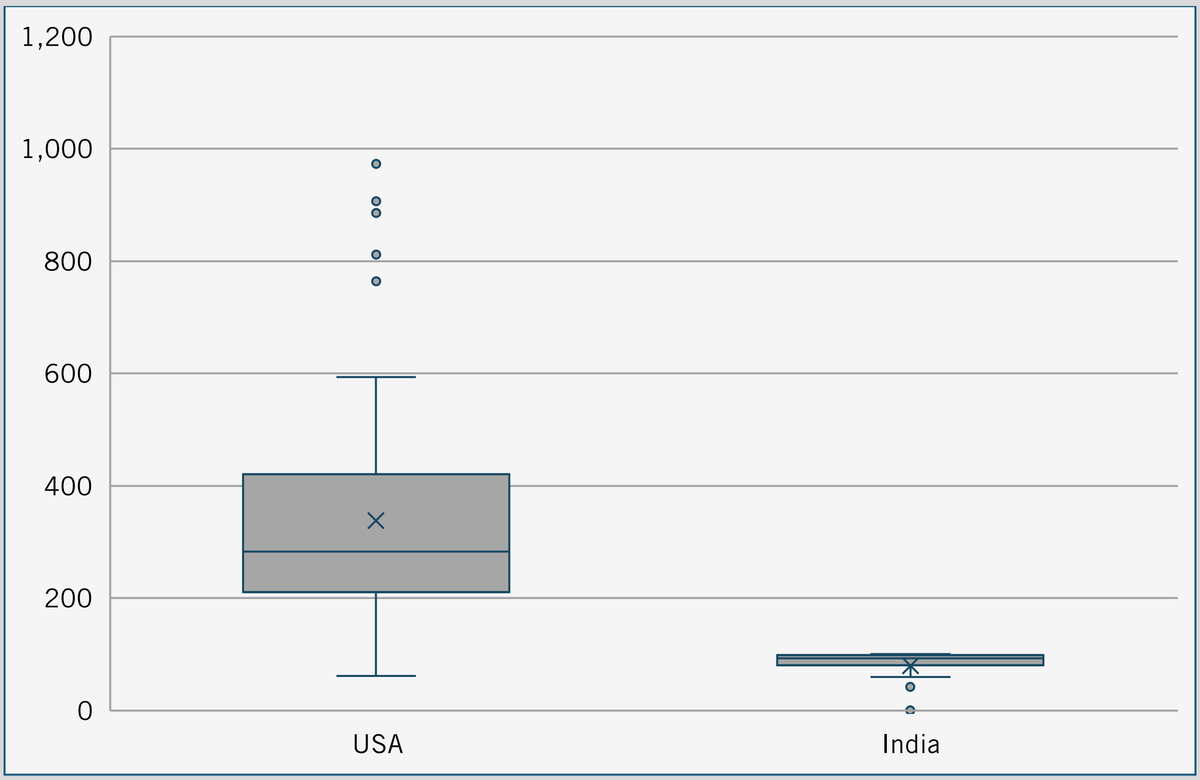
Figure 30: Performance in R&D intensity (highest-performing regions in darker shades)[66]



Emissions Intensity

Why is this important? As the world endeavors to combat climate change, decarbonization is of paramount importance. Regions' ability to innovate sustainably to achieve a reduction in and the efficient use of carbon and other greenhouse gases will determine their long-term competitiveness, as well as their national economic prosperity. This indicator measures metric tons of carbon dioxide (CO_2) emissions per unit of output (as measured by PPP-adjusted million dollars of real GDP). While more-developed regions may have a slight advantage in this indicator due to their more service-oriented economies, it must also be recognized that economic growth has historically been correlated with increased emissions. As policymakers look to improve efficiency and reduce overall emissions, they will take their lead from the regions that are devising new solutions and innovative technologies. Though emissions intensity is not included in the Index calculations, the indicator provides valuable insights into the innovativeness of green technology in a region.

Figure 31: Metric tons of CO_2 emissions per million dollars of real GDP, 2021–2022[67]



Urban hubs are home to the highest emissions intensities in India, with Sikkim (99.9) and Delhi (99.7) leading the nation in the highest emissions per million dollars of GDP. The region of Mizoram, which is known for its slash-and-burn farming economy, ranks third (99.3). Jharkhand (41.7) and Chhattisgarh (0) have the lowest emissions intensities in the country, while the regions of Dadra and Nagar Haveli and Daman and Diu, Ladakh, and Lakshadweep have no data.

DISTANCE TO THE FRONTIER

The distance to the frontier (DTF) analysis offers insights into the drivers of innovative competitiveness by quantifying how far each state is from the leading innovator, California (whose score is 64.42). For instance, Massachusetts ranks second with an overall index of 63.47, so its DTF is 0.95. (See table 4). In contrast, Delhi's overall score on the index is 26.32, ranking it 51st. A lower DTF indicates a closer proximity to the leading innovator.

Table 4: DTF performance

Country	Region	DTF
United States	Massachusetts	0.95
United States	Washington	8.99
United States	Delaware	14.95
United States	Wyoming	15.67
United States	Oregon	16.01
United States	District of Columbia	17.55
United States	New Jersey	18.43
United States	Maryland	18.63
United States	Texas	19.48
United States	New Hampshire	19.53
United States	New York	19.60
United States	Connecticut	20.15
United States	Michigan	20.33
United States	Minnesota	21.12
United States	Colorado	21.60
United States	Illinois	22.19
United States	North Carolina	22.24
United States	Pennsylvania	22.40
United States	Utah	22.60
United States	New Mexico	22.78
United States	Indiana	24.11
United States	Florida	24.17

Country	Region	DTF
United States	Virginia	24.65
United States	Arizona	25.10
United States	Ohio	25.66
United States	Wisconsin	26.37
United States	Georgia	26.79
United States	Idaho	27.03
United States	Rhode Island	27.11
United States	Vermont	27.57
United States	Montana	27.74
United States	Missouri	28.32
United States	North Dakota	28.36
United States	Iowa	28.50
United States	Louisiana	28.92
United States	Kansas	29.23
United States	South Carolina	30.14
United States	Nebraska	30.35
United States	Alabama	30.65
United States	Tennessee	30.74
United States	Oklahoma	31.12
United States	Maine	31.91
United States	Kentucky	32.36
United States	Nevada	32.53
United States	South Dakota	32.80
United States	Mississippi	33.55
United States	Hawaii	34.01
United States	West Virginia	35.06
United States	Alaska	35.24
United States	Arkansas	35.72

Country	Region	DTF
India	Delhi	38.10
India	Chandigarh	40.96
India	Tamil Nadu	44.01
India	Maharashtra	45.51
India	Karnataka	45.84
India	Puducherry	47.51
India	Haryana	47.88
India	Goa	48.30
India	Punjab	49.70
India	Himachal Pradesh	49.94
India	Gujarat	51.88
India	Uttarakhand	52.00
India	Uttar Pradesh	53.01
India	Rajasthan	53.93
India	Sikkim	54.12
India	Dadra & Nagar Haveli and Daman & Diu	54.77
India	Telangana	54.97
India	Kerala	55.42
India	Jammu & Kashmir	56.17
India	Madhya Pradesh	56.25
India	West Bengal	56.33
India	Andhra Pradesh	56.58
India	Manipur	57.90
India	Jharkhand	58.82
India	Ladakh	58.88
India	Arunachal Pradesh	58.98
India	Andaman and Nicobar Islands	59.10

Country	Region	DTF
India	Assam	59.17
India	Odisha	59.23
India	Chhattisgarh	59.42
India	Meghalaya	59.64
India	Bihar	59.75
India	Nagaland	59.93
India	Tripura	60.83
India	Mizoram	60.97
India	Lakshadweep	61.01

U.S. states exhibit robust and consistent performance in innovative competitiveness, clustering closer to the frontier. Massachusetts is only 0.95 points behind California, indicating nearly equivalent competitiveness in their innovative ecosystems. Similarly, Washington (third) and Delaware (fourth) fall behind the frontier by only 8.99 and 14.95 points, respectively, indicating strong innovation ecosystems but with varying degrees of strength. Even the lowest-performing U.S. state, Arkansas, has a DTF of 35.72 points, suggesting that despite inter-state disparities, U.S. states remain generally competitive and closer to the innovation frontier, underscoring their overall strength in innovation.

Indian states have substantially greater gaps from the innovation frontier, with Delhi, the most innovative Indian region, showing a 38.10-point difference from California, exceeding the gap of the least innovative U.S. state. This trend continues with Chandigarh and Tamil Nadu reflecting a significant gap in innovative ecosystems and capacities, highlighting the areas that need improvement. Most of the northeastern and eastern states, such as Arunachal Pradesh, Bihar, and Mizoram, have a 58- to 61-point gap to California, revealing a critical divide in innovation readiness.

The DTF analysis reveals stark contrasts between U.S. and Indian states regarding innovation capacity. Despite internal variations, U.S. states are generally well aligned with global innovation benchmarks. Even the states with lower scores remain within 36 points of the innovation frontier, indicating a solid foundation nationwide. This can be attributed to established innovation ecosystems, robust R&D spending, and favorable business environments that enable subnational competitiveness. This is not to say that there isn't room for growth for U.S. states, as there is still a 36-point gap between the weakest and strongest states. Rather, U.S. states are positioned to close innovation gaps when concerted innovation-centric policy is introduced. In contrast, Indian states face much wider gaps despite high potential with their demographic-dividend and knowledge-based economy, with Delhi already 38 points behind California and the differences widening as one moves down the list. The substantial DTF differences for Indian states indicate that their innovation ecosystems are still factor driven or not at the innovative-driven stage, especially compared with the U.S. states.

Indian regions must focus on developing a robust triple helix innovation ecosystem to move closer to the frontier of innovation. California and Massachusetts have cities with many significant research institutions, attracting substantial federal funding for research. These grants go on to produce basic research, which is, in turn, used to develop products by firms located around the universities. This cycle of interaction between universities, firms, and the government has been proven to produce constant innovation and strong research ecosystems.

In California, universities such as the University of California-Berkeley and Stanford have become the center of these innovation hubs. World-renowned researchers from these universities have created some of the world's most influential technology companies, including Elon Musk, founder of the two wildly innovative firms Tesla and SpaceX. Many of these companies are headquartered in and around the San Francisco/Silicon Valley area, making it the technology and innovation hub it is today. The same can be said about Massachusetts, where universities such as MIT and Harvard have attracted billions of dollars in research funding and become the bedrock of the innovation hub that is Cambridge, Massachusetts.

To help Indian states progress toward the frontier, embracing a triple helix structure that fosters collaboration among government, academia, and industry is essential. Significant advancements can be achieved by increasing private sector investment in R&D and enhancing employment opportunities in STEM fields. State governments can play a pivotal role by incentivizing R&D in both public institutions and private enterprises, as well as in universities and innovative start-ups. While it may take more than a decade to bridge the distance to the frontier, the commitment to investing in research will yield substantial benefits. This approach will enhance innovative capacity and propel Indian regions closer to the frontier and toward a more prosperous future.

California Is an Innovation Model for All Regions

California is the most innovative state in the United States and the most innovative region in the U.S.-India SICI, setting the standard for regional innovation. But how did California get there, and what can other regions learn from its journey?

Much of California's jump into innovation stardom began with the invention of some of today's great and vital technologies in the Silicon Valley region. Silicon Valley, now a global hub of innovation and technology, had humble beginnings as an agricultural region, and its jump to an innovation powerhouse can largely be credited to Frederick Terman. Terman joined Stanford University in the early 20th century, seeking to establish it as a center for radio and communications research. He encouraged his students to launch local companies, helping to lay the groundwork for Silicon Valley's entrepreneurial culture.

After World War II, Terman set about turning Stanford into the "MIT of the West," emphasizing research in microwave electronics, securing military contracts, and making Stanford a top recipient of government research funding. In 1951, Terman founded the Stanford Industrial Park, creating a collaborative ecosystem between academia and industry.

Once California became a magnet for not just novel technology but also investment, the breadth of knowledge in the state began to grow. In 1956, William Shockley established Shockley Semiconductor Lab in Silicon Valley. However, within a year, dissatisfied engineers left to form Fairchild Semiconductor, which became a key player in the semiconductor industry. This entrepreneurial climate reshaped the American semiconductor landscape. Of the more than 30 semiconductor manufacturers founded in the United States during the 1960s, the majority were spin-offs of Fairchild Semiconductor.[68]

Over the years, Silicon Valley has experienced exponential growth in high-tech jobs. From 1992 to 1999, it added over 230,000 new positions. To meet the rising demand for skilled workers, especially engineers, the United States relaxed immigration quotas for individuals with specialized training, leading to a significant influx of workers from India and China.[69]

Over the past few decades, regions worldwide have attempted to replicate Silicon Valley to nurture entrepreneurship and build start-up ecosystems. However, most have struggled due to a limited understanding of how Silicon Valley functions. Silicon Valley should be viewed as an economic model, defined by key components: venture capital, human capital, university-industry collaboration, government support, industrial structure, and a network of professional services. These elements are interdependent, evolving over time to create a self-reinforcing cycle of innovation and growth. Silicon Valley's rise as a global tech hub was not the result of deliberate planning; it evolved organically from its semiconductor manufacturing roots and university research. The ecosystem's growth was driven by its core components. Stanford University, UC Berkeley, and other institutions provided both innovation and talent, while the region's risk-taking culture fostered countless start-ups. Venture capital played a crucial role by providing essential funding to fuel this growth.

Today, the growth and innovation in the Silicon Valley area has spread across the state. The Bay Area has positioned itself as a hub for electronics and tech, largely due to defense projects that attracted talent and investment to the area during World War II and the Cold War. Caltech, located just north of Los Angeles, has become a center for federally funded research in aerospace and jet propulsion.[70] Further south in San Diego, a life-sciences research cluster has emerged, claiming 60 percent of the venture capital funds directed to San Diego in 2023.[71]

Most important to California's success as an innovation hub has been its push to innovate even more. Other regional governments need to do the same. In the United States, regions without high-tech, research-heavy industries need to incentivize them to move or start, and states with these high-tech industries need to encourage further research and expansion while also investing in research universities, which furthers the innovation ecosystem by providing more skilled workers, both domestic and foreign born.

In India, regional governments must enhance their business ecosystems so that skilled workers can stay rather than emigrate to existing innovation hubs. In recent years, India has marketed itself as a beneficial place for multinational companies to move operations, and it needs to continue this push. Bringing large, innovative firms to the country will not only drive economic and technological growth and encourage skilled workers to stay, but also encourage new high-skilled migration.

SCIENCE AND TECHNOLOGY CLUSTERS

The differences between science and technology (S&T) clusters in the United States and India reveal fundamental disparities in innovation capacity, research output, and institutional frameworks that significantly impact their respective national competitiveness. The analysis of World Intellectual Property Organization (WIPO) data for Science and Technology Cluster Ranking 2024 demonstrates striking contrasts in how these clusters function and contribute to their respective national innovation ecosystems. Table 5 illustrates the differences between the S&T clusters in both countries.

The San Jose-San Francisco cluster exemplifies U.S. innovation leadership with 7,885 PCT applications per million inhabitants. In contrast, Bengaluru, India's leading technology hub, generates 313 applications per million inhabitants. This 25-fold difference in patent intensity not only reflects a quantitative gap but also indicates fundamentally different innovation capabilities. Similarly, research output shows significant disparities, with U.S. clusters such as Boston and Washington, D.C., producing over 10,000 publications per million inhabitants, focusing on clinical medicine, biotechnology, and earth sciences. In contrast, Indian clusters generate between 700 and 1,800 publications per million inhabitants, primarily in engineering, chemistry, and technology applications.[72]

The institutional framework driving innovation in these clusters reveals distinct models of development. U.S. clusters operate primarily through a private-sector-driven innovation model, with major technology companies such as Apple, Google, Microsoft, and Qualcomm leading patent generation. American universities such as MIT, Stanford, and the University of California-Berkeley focus predominantly on research publications, creating a clear division of roles between corporate and academic institutions. The Indian model presents a more integrated approach, wherein institutions such as the Indian Institutes of Technology play dual roles in patent generation and research publication, working alongside corporate entities such as Samsung and TVS Motors. This structural difference reflects varying approaches to innovation development and commercialization.

Sectoral specialization patterns further differentiate these clusters. U.S. clusters demonstrate clear regional specialization: San Jose-San Francisco excels in computer technology and digital communications, Boston excels in medical technology and biotechnology, Seattle excels in software development, and San Diego excels in telecommunications technology. Indian clusters show broader focus areas, with Bengaluru concentrating on computer technology and digital communications, Chennai on transport and engineering, and Delhi/Mumbai on pharmaceuticals and transport. Global rankings reflect this specialization pattern, with multiple U.S. cities ranking in the top 10 S&T clusters, while no Indian cluster ranks in the top 50, with Bengaluru standing at 56th globally.[73]

The U.S. model for subnational innovation ecosystems features a high concentration of corporate R&D, strong intellectual property (IP) frameworks, and established venture capital ecosystems, leading to pronounced regional specialization. The Indian model, characterized by significant public institution involvement and developing IP protection systems, demonstrates a broader sectoral focus but less regional specialization. These structural differences reflect the countries' respective stages of development and suggest distinct development trajectories and policy implications for both countries.

Table 5: S&T clusters in the United States and India (number of PCT applications and scientific articles, respectively, in the last five years, per million inhabitants)[74]

City	Country	State	Global Rank	National Rank	PCT Applications	Scientific Articles
Chennai	India	Tamil Nadu	82	3	110	1,871
Delhi	India	Delhi	63	2	39	1,102
Bengaluru	India	Karnataka	56	1	313	1,077
Mumbai	India	Maharashtra	84	4	80	756
San Jose-San Francisco	USA	California	6	1	7,885	9,211
Boston-Cambridge	USA	Massachusetts	8	2	4,462	17,934
San Diego	USA	California	10	3	6,279	5,189
New York City	USA	New York	11	4	864	4,693
Los Angeles	USA	California	16	5	966	3,545
Washington, D.C.-Baltimore	USA	District of Columbia/Maryland	19	6	838	10,327
Seattle	USA	Washington	24	7	4,434	7,821
Philadelphia	USA	Pennsylvania	35	9	1,110	6,448
Chicago	USA	Illinois	37	10	822	4,524
Minneapolis	USA	Minnesota	41	11	2,420	5,425
Raleigh	USA	North Carolina	51	12	1,735	16,473
Denver	USA	Colorado	60	13	1,062	7,029
Atlanta	USA	Georgia	69	14	663	7,930
Portland	USA	Oregon	76	16	1,628	2,934
Pittsburgh	USA	Pennsylvania	79	17	1,367	11,840

POLICY RECOMMENDATIONS

United States

Knowledge Economy

If the United States wants to improve its innovation ecosystem, federal, state, and local governments must take a systemic approach to policymaking. First and foremost, the U.S. government must invest more money in research conducted in universities, government agencies, and private firms. Direct government support for critical technology R&D, such as nuclear power or AI, would incentivize highly focused research at top institutions. Additionally, making a concerted effort to provide specialized research grants to states and universities that have fewer PhD candidates and have a smaller R&D workforce can attract innovative thinkers to locations that, so far, lack an innovative environment. The U.S. government must also do more to expand STEM education for people of all ages and genders. STEM-specialized schools have been shown to increase the number of graduates pursuing STEM degrees by 50 percent.[75] Investing more in public middle and high school STEM programs could help close the gap in the STEM workforce in America.

The United States should also establish career training and retraining programs in strategically important industries, including manufacturing. To maintain its vibrant tech sector, the United States must increase manufacturing productivity by developing and adopting productivity-enhancing technology and automation, including AI and robots. New technology can close the skills gap that has emerged, and workforce training and retraining programs, such as that developed by the ARM Institute (one of America's 17 Manufacturing USA Institutes), could prepare workers to work alongside new technology. This could help prevent or remediate future job loss as technology reshapes industries.[76]

Globalization

With tensions between the United States and China escalating, the United States must expand its capabilities for developing and exporting high-tech goods and services. The threat of a skills gap in these strategic sectors is growing. According to a report from the Manufacturing Institute and Deloitte, the skills gap in manufacturing will lead to 2.1 million unfilled jobs by 2030.[77] Steps have already been taken to bridge this gap, such as passing the CHIPS and Science Act, which invests $53 billion toward the fabrication, research, and development of advanced semiconductors.[78] The Biden administration has also allocated $772 million to expand the U.S. bioeconomy's research, development, and infrastructure capabilities.[79] These programs will expand the availability of jobs in the bioeconomy, but the federal government must also incentivize individuals to fill these jobs by offering competitive wages. The United States must also attract FDI, particularly greenfield FDI, for strategic industries. The U.S. government should expand tax incentives for companies opening new, high-tech-producing firms to incentivize inward FDI. Creating targeted incentives for domestic and international companies that establish and expand high-tech export activities in the United States can make the country more competitive globally and more independent as trade tensions with China grow. Additionally, local governments should prioritize developing cluster economies, focusing on specific industrial sectors, as Silicon Valley has with technology and Cambridge, Massachusetts, has with biotechnology. These clusters will make regions more attractive to investors.

Innovation Capacity

The innovation capacity of the United States must be fostered by a concerted effort to invest in and expand policies for R&D. The United States must increase, or even double, the federal R&D tax credit from its current rate of 20 percent.[80] The United States' R&D incentives are low on an international scale, ranking 24th out of the 34 member countries in the Organization for Economic Cooperation and Development (OECD) plus Brazil, Russia, India, and China.[81] Additionally, the U.S. government should expand the number of firms that qualify for the R&D credit for pre-profit start-ups. Only firms with gross receipts under $5 million qualify for the credit. This limit should be raised to $10 million to incorporate more pre-profit firms and conduct valuable research. Start-ups, including those that are pre-profit, conduct research that leads to the development of innovative technologies, so it should be easier for firms to enter the market and conduct their expensive research even while they're temporarily unprofitable.[82]

State-level R&D credits can also incentivize research and tailor incentives to the needs of a state. Virginia offers an R&D tax credit of 20 percent to businesses conducting research in conjunction with a Virginia college or university.[83] These credits facilitate greater levels of industry-university collaboration, and thereby are building research networks. Louisiana also offers an R&D credit to firms conducting research in the state, with a maximum credit of 30 percent of qualified expenditures.[84]

The CHIPS and Science Act has made a vital contribution to U.S. innovation cap, including $52 billion in appropriated funds for the U.S. semiconductor industry ($39 billion in grants and incentives and $13 billion for R&D) in addition to $200 billion in authorized funding for U.S. science and basic research. Concomitant with passing the CHIPS Act, Congress established a 25 percent investment credit for firms investing in semiconductor machinery and equipment.[85] The next Trump administration should go further by working with Congress to create a program that would, for five years, allow companies in a set of advanced industries to take a 25 percent tax credit on all machinery, buildings, and equipment.[86]

While expanding funding for research conducted by private firms, the U.S. government must also increase funding for R&D across universities. Academic R&D spending is concentrated in a relatively small share of higher education institutions, with 131, or 3.5 percent, of all universities accounting for 75 percent of all research spending.[87] Funding provided by the federal government should be diversified to include more universities, especially in states without a leading private research university, to expand opportunities for STEM researchers in non-innovation hubs.

The U.S. business environment must be bolstered across all industries, but especially for strategically important technology industries such as advanced manufacturing. The federal government should create a manufacturing reinvestment account for small- and medium-sized enterprises (SMEs), establishing a 401(k)-like deferred investment program for them. Firms could set aside up to $1 million in profits on a non-tax basis and invest the money; however, the funds could only be withdrawn tax free if used for investments toward R&D, workforce training, or capital equipment.[88] Such a mechanism could allow small manufacturers to self-fund their growth, as they often find it difficult to find capital needed for investments.

Elsewhere, several U.S. states now offer innovation vouchers to assist them in purchasing services from universities and research institutions. Connecticut, Indiana, New Mexico, New

York, Rhode Island, and Tennessee, as well as the Department of Energy's Office of Energy Efficiency and Renewable Energy, have adopted these vouchers to help SMEs purchase R&D assistance from qualified firms, with each voucher affording grants between $25,000 and $50,000 depending on the size and type of project.[89] Considering that they are successful in promoting the execution of R&D in the short and medium term, more states and federal agencies should develop innovation voucher programs.[90]

Connecticut is an excellent model of what states could do to bolster their innovative capacity. Connecticut-based small manufacturers receive a manufacturing reinvestment account to invest up to $100,000 of profits annually for five years. These accounts are 100 percent tax exempt. These investments can only be used for R&D-related spending.[91] Additionally, Connecticut has developed a Manufacturing Innovation Fund (MIF), investing $100 million in programs geared toward enhancing manufacturing growth and development. The MIF includes an incumbent worker training program (a 100 percent matching fund for workforce training programs), Technology Awareness and Adoption Programs (the programs provide education and demonstration for advanced manufacturing technologies at no cost to manufacturers), and a Manufacturing Voucher Program (grants of up to $49,000 are awarded to applicants for the purchase of specialized equipment and expertise).[92] The programs included in the MIF represent an excellent model of how manufacturing innovation should be undertaken to produce competitive firms in key industries.

India

Knowledge Economy

Improving India's knowledge economy at the subnational level requires a holistic approach that considers the various factors driving innovation and productivity. Knowledge workers play a crucial role in this process and represent contributions from public and private sectors, ranging from state-funded R&D institutions to industry-led skill development initiatives. Analysis reveals that there is a need to increase the share of employment in R&D, participation in STEM jobs, and female enrollment in higher education. However, when policymakers address regional disparities, they need to understand that these parameters represent interconnected drivers of the knowledge economy, and focusing on one will not lead to significant improvements if factors are considered in isolation. Enhancing these indicators is essential for Indian states to bridge the gap and become more competitive with the leading states in the United States.

Globalization

Since 2014, India has become increasingly integrated with the global economy, largely driven by its high share of exports and substantial FDI inflows, which have reached an impressive cumulative total of $667.4 billion (2014–2024). This reflects a remarkable increase of 119 percent compared with the previous decade (2004–2014). The investment covers 31 states and spans 57 sectors, acting as a strong catalyst for growth across various industries. Most sectors are open to 100 percent FDI under the automatic route, creating a welcoming environment for international investors. Additionally, FDI equity inflows into the manufacturing sector have significantly increased over the past decade (2014–2024), reaching $165.1 billion. This represents a 69 percent rise over the previous decade (2004–2014), which recorded inflows of $97.7 billion. These developments have positioned Indian states as a vibrant landscape for investment and innovation, paving the way for a prosperous future.[93]

Our analysis emphasizes the promising potential for greater integration into the global economy among various states. However, it is important to note that Maharashtra, Karnataka, Delhi, Gujarat, and Haryana collectively accounted for 87 percent of the FDI inflows. This concentration highlights the disparities in regional development and indicates significant implications for the country's overall innovative competitiveness. Enhancing the capacity of less-developed states to engage in globalization can lead to significant benefits. By implementing strategic initiatives focused on fostering innovation, improving infrastructure, and facilitating access to funding and technology transfer, all states can contribute to India's overall competitiveness.

Innovative Capacity

To boost innovation, Indian states should increase the private sector's R&D intensity. R&D intensity is a critical driver of innovative capacity at subnational levels, directly influencing a region's ability to generate new ideas, technologies, and competitive industries. For instance, when one looks at India's R&D expenditure, it is currently at just 0.7 percent of GDP and falls significantly short of that of the leading global economies. Moreover, the government, including the higher education sector, drives 59 percent of R&D expenditure, while the private sector's contribution remains low. In contrast, developed economies such as the United States see over 70 percent of their R&D funded by business enterprises.[94] These trends are reflected at the subnational level in India.

In contrast, innovation hubs such as California and Massachusetts stand out for their high and consistent R&D investments, mainly driven by private-sector involvement and partnerships with universities. In the United States, private-sector firms contribute significantly to R&D, especially in regions such as Boston (biotechnology) and Silicon Valley (technology). These regions demonstrate how private investment accelerates innovation. Indian states can adopt incentive structures, such as tax benefits or grants, to stimulate private R&D investment, learning from the United States' model of public-private collaboration. Therefore, Indian states must prioritize increasing R&D investment by using diverse funding sources, such as venture capital funds, public-private partnerships, and international collaboration with the United States.

Additionally, they should strengthen the Triple Helix Model to promote knowledge-based innovation, particularly in tier 2 and tier 3 regions where science and technology clusters are still underdeveloped. The Triple Helix Model encourages collaboration between universities, industries, and government to drive R&D. Key to this strategy is promoting technology transfer and joint research projects and enhancing the role of universities as local innovation drivers. Indian states can learn from successful models in Massachusetts and California, such as MIT's collaborations with start-ups and the Stanford-Silicon Valley ecosystem. However, the Triple Helix Model is not a one-size-fits-all solution. It requires understanding that regions typically achieve breakthroughs in one dimension—university, government, or industry—before promoting the others. In India, innovation is often perceived as government led, and the government can establish regional centers through a statist model. The effectiveness of the Triple Helix Model in the Indian context must consider the model's origins in the United States, where entrepreneurs shape innovation systems. Indian states must, therefore, design and implement collaboration and coordination mechanisms that fit their unique conditions and economic environments, especially in tier 2 and 3 regions.

U.S.-India Cooperation on Enhancing Innovation Capabilities

The U.S.-India partnership has not just emerged; over the recent years, it has strategically positioned itself as a pivotal driver of innovation-led development, especially in critical and emerging technologies. This collaboration spans multiple sectors, with both nations leveraging their comparative advantages to address global challenges, strengthen supply chains, and foster technological breakthroughs.

Over the last few years, the foundation of this partnership has lain in strategic agreements and initiatives that span semiconductors to clean energy, framed by mutual recognition of the importance of a resilient, secure, and sustainable global ecosystem. A key area of focus is the semiconductor industry, where both nations aim to build a robust supply chain and enhance manufacturing capacities. India's recent policy initiatives, including customs duty exemptions and mining auctions for critical minerals, align with U.S. efforts to diversify and secure global semiconductor supply chains. The India Semiconductor Mission exemplifies this synergy in partnership with the U.S. Department of State's International Technology Security and Innovation (ITSI) Fund under the CHIPS Act.[95] Together, they aim to enhance India's role in the semiconductor value chain through comprehensive ecosystem assessments that identify regulatory gaps, infrastructure needs, and workforce development opportunities.

The scope of this partnership extends beyond semiconductors. The U.S.-India Initiative on Critical and Emerging Technology (ICET), unveiled in 2023 by Prime Minister Modi and President Biden, serves as a roadmap for collaboration across several high-tech areas, including AI, quantum computing, and next-generation telecommunications. Both countries recognize the importance of fostering innovation ecosystems, as highlighted by signing a Memorandum of Understanding for the "Innovation Handshake" in November 2023. The India-U.S. Innovation Handshake will connect the two countries by encouraging collaboration between start-ups, venture capitalists, and private sector firms, particularly in critical and emerging technologies.[96]

The U.S.-India partnership has seen substantial progress in R&D collaboration between the two nations. The U.S.-India Global Challenges Institute was launched in September 2024, with over $90 million in funding to support high-impact research collaborations between American and Indian universities and institutions. Key focus areas include semiconductors, next-generation telecommunications, sustainability, green technologies, and intelligent transportation systems.[97]

Furthermore, the collaboration between the National Science Foundation (NSF) and India's Department of Science and Technology has resulted in joint research funding for projects in next-generation telecommunications, machine learning, and green technologies. Together, they have allocated $5 million for joint projects, while another $10 million has been earmarked for research in semiconductors, AI, and other critical technologies. NSF has also partnered with India's Department of Biotechnology to launch a collaborative research initiative tackling challenges in synthetic biology, computational biology, and biomanufacturing.[98]

The Renewable Energy Technology Action Platform (RETAP) was launched in August 2023 and exemplified a joint effort to innovate in renewable energy technologies such as hydrogen, offshore wind, and long-duration energy storage. This initiative reflects a commitment and a shared dedication to building sustainable and resilient energy supply chains. The U.S.-India Roadmap to Build Safe and Secure Global Clean Energy Supply Chains, launched in 2024, is further accelerating clean energy manufacturing in both nations. Clean energy remains a focal point, with the two countries launching a National Center for Hydrogen Safety and deepening their collaboration on hydrogen and energy storage technologies. Through these efforts, both nations aim to enhance their clean energy manufacturing capabilities and secure global supply chains for renewable energy components.[99]

CONCLUSION

Developing a strong innovation ecosystem is the key to success for any country seeking sustained and prosperous development in this century. This report analyzed 13 indicators that help to assess subnational competitiveness in the innovation economy. By understanding this index, policymakers can learn what specific policies should be undertaken to encourage innovation in all regions of the country. Prioritizing advancements in STEM, education, and research are key ways innovation can thrive and technology can advance.

America's innovative landscape experienced rapid growth in the late 20th century, fueled by significant scientific discoveries, supportive legislation such as the Bayh-Dole Act, and extensive public funding. The U.S. Triple Helix Model was characterized by robust collaboration among academia, industry, and government and promoted innovation. The geographic concentration of biotech companies, particularly in Boston, San Diego, and Research Triangle Park, accelerated further growth. Critical lessons for India include establishing policies that promote technology transfer, the promotion of entrepreneurship, the increase in government investment in advanced research, and strengthening relationships between academia, industry, and government. To establish a flourishing ecosystem and stimulate economic development and innovation, India must make concerted efforts to implement innovation-forward policies.

For India, the priority lies in strengthening the innovative ecosystem at the subnational level by increasing R&D expenditures by the private sector, enhancing R&D intensity and patent intensity, investing in STEM education and workforce, and expanding beyond existing specialized regional innovation hubs such as Delhi, Karnataka, and Tamil Nadu. India must overcome regional disparities in innovative ecosystems to fully harness its demographic dividend and grassroots innovators, propelling the country toward a developed economy by 2047. On the other hand, the United States faces various challenges, including maintaining its leadership in specialized innovative ecosystems such as semiconductors, biomanufacturing technology, and the sustainability paradigm while fostering corporate-academic research partnerships and sustaining its knowledge-based economy. The stark differences in subnational innovation intensity, research output, institutional frameworks, and global competitiveness underscore the varying stages of innovation ecosystem development between the two countries.

Indian states can learn from U.S. states by adopting strategies that encourage regional specialization and collaboration between government, private industry, and academia (i.e., the Triple Helix Model for development). Innovative, leading states such as California, Massachusetts, and Washington have excelled by creating ecosystems that foster innovation through targeted support for key industries, strong research institutions, and an emphasis on an entrepreneurship-based model. Indian states can similarly leverage their unique strengths—whether in IT, manufacturing, or agriculture—while investing in skill development and fostering partnerships between universities and the private sector in collaboration with U.S. educational institutions and companies. This could enable a more decentralized yet cohesive approach to driving innovation and economic growth across the country.

U.S. states can leverage their new, collaborative relationship with India to regain leadership in critical and emerging technologies. Cooperative research initiatives between the United States and India launched through the Innovation Handshake and funded with the CHIPS and Science Act will close the research gap between the United States and China while fostering information sharing between high-impact start-up firms in the United States and India. Joint efforts by both countries in semiconductors, clean energy, telecommunications, and more guarantee that supply chains are secure and diversified, a key step toward advancing both the United States' and India's roles in these industries on a global scale.

APPENDICES

Appendix A: Composite and Category Scores Methodology

Since each indicator is measured using a different unit with large variations in scale, indicator values were converted to a standardized score with a mean of zero and a standard deviation of one. Indicator data was normalized using either GDP or population to enable relative state comparison.

We modified all the indicators in the final set such that a greater value corresponds to a higher score for the state or province. Therefore, we applied transformations to ensure a positive impact. We did not invert any indicators during the index assessment.

To determine the compatibility of each indicator, an exploratory factor analysis was undertaken to test the underlying factors among the set of selected indicators in each category. Cronbach's alpha was then calculated to measure internal consistency. The alpha value is expressed as a number between 0 and 1, where an alpha value above 0.7 for any logical grouping of variables indicates consistency and guarantees validity.[100] Cronbach's alpha, α, can be defined as:

$$\alpha = \frac{k \; x \; \bar{c}}{\bar{v} + (k-1)\bar{c}}$$

Wherein k denotes the number of scale indicators, $\bar{c}$ denotes the average of all covariances between indicators, and $\bar{v}$ denotes the average variance of each indicator.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy evaluates the goodness of fit after calculating each pillar. The KMO index ranges from 0 to 1, where a KMO score over 0.5 indicates validity.[101] Table 6 displays the results of this analysis. The alpha and KMO score for all pillars is above the set standards.

Table 6: Cronbach's alpha and KMO scores of three categories

Pillar	Alpha	KMO
Knowledge Economy	0.86	0.74
Innovative Capacity	0.88	0.76
Globalization	0.81	0.71

The Principal Component Analysis (PCA) calculates the weights of indicators within a pillar and the overall index score. PCA is a statistical technique that reduces the number of variables in an analysis by describing a series of uncorrelated linear combinations of the variables that contain the most variance. Indicator weights can be found in table 8.

The last step in determining the pillar score involves transforming the values to a 0-to-100 scale. In addition to using regional indicator data, scores are calculated using the best and worst scenario data, which are the best- and worst-case values from the dataset or adopted from the subnational data.

$$Normalized\ Pillar\ Score\ = \Sigma\,(wi\ \times\ indicator)$$

Here, *wi* denotes the weightage of each indicator.

This method enhances comparability and comprehensiveness across the dataset. We use the following formula for the calculation:

$$(Xj - Worst\ Case)\ /\ (Best\ Case - Worst\ Case)$$

Xj represents the raw pillar values.

The overall index score is calculated as a weighted sum of the category scores. Each dimension's contribution to the overall index will be based on both the PCA-derived dimension weights and an additional set of external weightings reflecting its relative importance.

Each dimension score is calculated as a weighted sum of its normalized pillar scores:

$$Dimension\ Score\ = \sum (Normalized\ Pillar\ Score\ \times\ Pillar\ Weight\ from\ PCA)$$

The overall index is then calculated as a weighted sum of the dimension scores using the external weightings shown in table 7.

Table 7: Dimension weights in the overall index

Dimension	Weight
Knowledge Economy	0.495
Globalization	0.126
Innovation Capacity	0.496

$$Index\ Score\ = (Knowledge\ Economy\ Score\ \times\ 0.4432) + (Globalization\ Score\ \times\ 0.1125) + (Innovation\ Capacity\ Score\ \times\ 0.4442)$$

Appendix B: Indicator Methodologies and Weights

Table 8: U.S.-India SICI Indicator Information

Indicator	Weight	Year	Description	Category
Doctoral Degree Recipients	0.152	2022	Total number of research doctorate recipients	Knowledge Economy
Employment in R&D Activities	0.244	2021–22	Share of workers employed in R&D activities	Knowledge Economy
Employment in STEM Occupation	0.240	2021	Share of workers employed in STEM activities	Knowledge Economy
Female Educational Attainment	0.240	2023	Share of females enrolled in higher educational degree programs	Knowledge Economy
Manufacturing Labor Productivity	0.251	2020–21	Labor productivity in manufacturing measured as GVA per employee (U.S. dollars per worker, PPP converted)	Knowledge Economy
Quality of Universities	0.084	2023	Share of Top 100 national universities	Knowledge Economy
High-tech Exports	0.050	2021–22	High-tech exports (NAICS 333-335, and equivalent) as a share of GDP	Globalization
Inward FDI	0.050	2017–23	Inward FDI flows as a share of GDP	Globalization
Active Businesses	0.267	2022	Number of active companies per million inhabitants	Innovation Capacity
Business Creation	0.217	2023	New business applications as a share of GDP	Innovation Capacity
Internet Access	0.253	2021–22	Percentage of households with access to Internet	Innovation Capacity

Indicator	Weight	Year	Description	Category
Patent Applications	0.226	2015, 2021	PCT patent applications per million inhabitants	Innovation Capacity
R&D Intensity	0.243	2021	R&D expenditures as a share of GDP	Innovation Capacity

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