

How India can nurture top-ranked S&T clusters

Meaningful policy interventions at the state level can help build successful S&T clusters to propel our economy towards the \$5 trillion mark and beyond in the coming decades.

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Last Updated 08 November 2023, 06:16 IST



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The Global Innovation Index (GII) report, published annually by the World Intellectual Property Organisation (WIPO), offers valuable insights into country-level innovation and ranks the world's top 100 science and technology (S&T) clusters. India has four clusters in the top 100, with Bengaluru ranked 56, Delhi 64, Chennai 83, and Mumbai 84. India's immediate goal should be to elevate at least one of these clusters into the top twenty-five ranks.

S&T clusters represent geographical areas with the highest density of inventors and scientific authors. Their rankings are determined by two factors: (1) patent applications from the cluster under WIPO's Patent Cooperation Treaty published over the most recent five-year period, and (2) S&T publications from the Web of Science's

Science Citation Index Expanded from the cluster published over the most recent five-year period. These factors collectively serve as a proxy for the use-inspired basic research that underpins innovation.

A cluster is more than the sum of all companies and universities in a given geographical area. It includes companies, their suppliers and customers, labour markets, universities and training institutions, financial intermediaries, professional and industry associations, regulatory institutions, and governments, among other elements. S&T clusters like Silicon Valley thrive by focusing their economic activities on a solid foundation of scientific and technological knowledge and its application in products and solutions.

S&T clusters have three important features:

1. Knowledge transfer, innovation, and specialisation among the various cluster constituents. For instance, in Silicon Valley, the University of California system and Stanford University are the knowledge powerhouses.
2. Relationships based on trust between the cluster constituents enhance their reputations.
3. Vertically disintegrated and specialised companies that maintain a web of relationships with other similar supplier and customer companies, often leading to unexpected collaborations, such as Apple's choice of Google as its search engine provider despite their competitive relationship.

S&T clusters are instrumental in creating economic prosperity not only for their regions but also for the entire country. Four Silicon Valley companies, namely, Apple,

Alphabet (Google), Nvidia, and Meta (Facebook), are among the world's ten largest companies by market capitalization.

Given the significance of S&T clusters, it is imperative that India nurture and promote them. To achieve this, several essential aspects need to be considered. The most important thing is to initiate a virtuous cycle of R&D, translating R&D into a product, commercialising the product, creating wealth from this commercialization, and reinvesting some of that wealth back into R&D.

The second aspect is that S&T clusters are not just an agglomeration of organisations but are intertwined and part of each other's supply chain, as are professionals who have world-class knowledge and skills in the cluster's science and technological domain. The foundation of S&T clusters is professionals who are the best in their field and believe that they are advancing the frontiers of a S&T field by sharing their ideas in social settings.

The third aspect is to build a capability in the cluster to re-invent itself across generations of scientific and technological advances, as demonstrated by Silicon Valley, which pioneered Shockley Semiconductor's four-layer diodes in 1956 (Shockley Semiconductor), transistors (Fairchild Semiconductor), and the first commercial microprocessor (Intel). New and younger professional talent coming into Silicon Valley's semiconductor cluster brought with them insights into new materials and manufacturing processes, often from their academic training. Often, these young professionals founded new companies to productize their knowledge and skills.

The fourth aspect is that a S&T cluster becomes strong when there is porosity of boundaries and lots of back-and-forth movement of talent, ideas, and capital. For example, Andrew Grove, a Hungarian immigrant to the US, was an important member of the R&D team at Fairchild and one of the early employees of Intel who rose to become their iconic CEO. Relationships formed in universities and working together in the same organisations build trust among professionals.

How can Indian clusters break into the top 25? The first focus area is to strengthen local and state-level innovation. For example, Karnataka has a pioneering Research, Development, and Innovation Policy that recommends a focus on strengthening the capacity for R&D and innovation to drive the regional ecosystem. The policy should be implemented to nurture the Bengaluru S&T cluster and incubate other S&T clusters in Karnataka. The Government of Karnataka has recently launched a deeptech cluster seed fund of Rs 25 crore to nurture startups specialising in deeptech, including AI. This momentum needs to be sustained. The implementation should track both input factors like human capital and funding and output factors like patents and publications. The second focus area is more tactical. Indian clusters need to create tighter linkages between research publications from S&T higher educational institutions like the IITs and IISc and patents from R&D centres, both multinationals like Samsung and Ericsson, and Indian companies like TVS Motors and Biocon within the clusters. The GII report notes that digital communications and computer technology contribute to 45% of patents in the Bengaluru cluster, while engineering and technology contribute to 22% of research publications. Better alignment between research and development will help build stronger S&T clusters.

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