

# **Base Paper**

## **Framework for Measuring the Contribution of Knowledge and Knowledge Products to the Indian Economy**

**Ministry of Statistics and Programme Implementation**

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Comments and suggestions on the Base Paper are invited as part of the consultation process. Feedback may be shared with this Ministry on the email IDs: [maneesh.jindal@mosp.gov.in](mailto:maneesh.jindal@mosp.gov.in) and [neeraj.kumar007@nic.in](mailto:neeraj.kumar007@nic.in) latest by 15 June 2026.

## Chapter 1

### Knowledge and Knowledge Economy—Conceptual Considerations

#### I. Introduction

1. India's growth and development are demonstrably promising. The economy is growing at a vigorous pace; but the key question is of sustaining high rates of growth long enough to achieve its ambitious development goals. Countries that experienced rapid long-term growth in the previous century have had the advantage of a supportive global economy as explained by Krueger (2004)<sup>1</sup> & Krugman (1980)<sup>2</sup>. That helped them export their rapidly increasing output, secure easy imports and take advantage of favourable capital flows. As Paul Krugman observes, “The raw fact is that every successful example of economic development this past century.....has taken place via globalization” (Krugman, 1999)<sup>3</sup>.
2. The current global scenario and the foreseeable future are not promising on this count. Restrictions on investment and trade flows over the last quinquennium have eroded many of the global catalysts that previously produced growth champions. At the same time, India seeks to achieve a transformation in its output structure, employment dynamics, efficiency and competitiveness. This has multi-frontal ramifications. In an environment of constrained capital flows and limited market access, sustaining competitiveness and high growth increasingly depends on knowledge-driven production and continuous gains in productivity. To quote Romer (1986)<sup>4</sup>, “...knowledge may have an increasing marginal product. In contrast to models in which capital exhibits diminishing marginal productivity, knowledge will grow without bound. Even if all other inputs are held constant, it will not be optimal to stop at some steady state where knowledge is constant and no new research is undertaken.”
3. The purpose of this chapter is to delve into the concepts used in the literature on dimensions of knowledge, its creation and dynamics, knowledge products and the recent discussions surrounding its impact on socio-economic advancements.

#### II. Knowledge and Knowledge product

4. The role of knowledge as a driver of human progress has been widely recognised and extensively theorised throughout history. This has been articulated in diverse strands of development thought well before its formal consolidation in modern policy frameworks. Close to three decades ago, the World Bank devoted one full World Development Report for knowledge, postulating that it is knowledge, and not capital, that would foster sustained economic growth and well-being.

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<sup>1</sup>Krueger, A. (2004). Economic Growth in a Shrinking World. *IMF Publication*, 20.

<sup>2</sup>Krugman, P. (1980). Scale economies, product differentiation, and the pattern of trade. *American economic review*, 70(5), 950-959.

<sup>3</sup>Krugman, P. (1999). Enemies of the WTO, *Slate Magazine*.

<sup>4</sup>Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political economy*, 94(5), 1002-1037.

*“Knowledge is like light. Weightless and intangible, it can easily travel the world, enlightening the lives of people everywhere. Yet billions of people still live in the darkness of poverty - unnecessarily. Knowledge about how to treat such a simple ailment as diarrhoea has existed for centuries - but millions of children continue to die from it because their parents do not know how to save them.”*<sup>5</sup>

It recognized two types of knowledge: technical knowledge (about farming, health, accounting, etc) and knowledge about attributes (product quality, borrower’s creditworthiness or worker’s expertise).

#### **i. Information and knowledge**

5. In usual parlance, information and knowledge are used interchangeably. However, philosophical traditions, research and scholarly works distinguish between the two, albeit differently. One of the widely quoted works by Ackoff (1989)<sup>6</sup> states, “An ounce of information is worth a pound of data. An ounce of knowledge is worth a pound of information. An ounce of understanding is worth a pound of knowledge..... Information is contained in descriptions, answers to questions that begin with such words as who, what, when, where, and how many. Knowledge is conveyed by instructions, answers to how-to questions. Understanding is conveyed by explanations, answers to why questions.”
6. In a similar vein, OECD sought to distinguish between knowledge and information. Knowledge, a matter of cognitive capacity, generates capacity for intellectual or physical action. Information is just structured and formatted data that remains passive till knowledgeable persons process it.<sup>7</sup> Reproducing information is much easier because it involves only the cost of reproduction. However, knowledge transmission can be time-consuming (like in the case of learning by doing/emulating) and incomplete and partial at different stages (because of leakages in recording, preserving and communicating the intangible cognitive capabilities).
7. However, there are two key attributes to knowledge which help its seamless transmission. First, knowledge is inherently non-rivalrous, i.e., the transmission and use of knowledge by one entity do not constrain its availability to others. Second, the transmission of knowledge is non-excludable (to an extent) in the sense that no one can be excluded from accessing the knowledge that is in public domain.

#### **ii. Attributes of information and invention, and market failure—The Arrow Thesis**

8. While analysing the attributes of information and innovation, Arrow (1962)<sup>8</sup> examines why a free-market system fails to provide socially optimal amount of inventive activity. Uncertainty (related to uncertain outputs and inability of insurance to take care of risks) is

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<sup>5</sup>World Bank (1998-99). World Development Report: Knowledge for Development.

<sup>6</sup>Ackoff, R. L. (1989). From data to wisdom. Journal of applied systems analysis, 16(1), 3-9.

<sup>7</sup>OECD. (2004). Innovation in the knowledge economy: Implications for education and learning. OECD.

<sup>8</sup>Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. *V-2*(pp. 219-236). London: Macmillan Education UK.

seen as one reason for non-optimal allocation of resources for information. Arrow views invention as the production of new information. Information as a commodity has distinctive properties, because of which markets underproduce information relative to the social optimum.

- a. First, low or near-zero marginal cost of transmission implies that the socially optimal price of information is zero (or close to zero), allowing universal dissemination.
  - b. However, as producers of new information, inventors must charge a positive price to recover their substantial fixed costs, creating a fundamental tension between private incentives and social efficiency.
  - c. This is confounded by the non-appropriable nature of information: once revealed, it can be reproduced at negligible cost, making exclusion difficult without legal protection.
  - d. Finally, the information paradox further undermines market exchange, because a buyer cannot assess the value of information without first acquiring it, but once acquired, cannot be prevented from using it without paying.
9. Because information is difficult to appropriate and cheap to disseminate, private profit incentives are insufficient. The problem is amplified by the cumulative nature of knowledge: new inventions rely on prior information, yet earlier inventors cannot be fully compensated for their contribution. For these reasons, a free-enterprise economy will systematically underinvest in research and development (R&D). In contrast, creation of legal rights like patents enhances appropriability, but introduces static inefficiencies by granting monopoly power and limiting the free dissemination of information.
10. Large firms are able to mitigate some market failures with internal R&D by coordinating information within the firm. However, they still face risk aversion, leaving the issue of systemic underinvestment unresolved. Publicly funded research can overcome appropriability problems and target socially valuable, but privately unprofitable fields. Arrow thus concludes that invention cannot be efficiently organized by markets alone. An alternative form of economic organization combining patents, private enterprise, large-firm R&D, and public funding is required to maintain socially desirable levels of inventive activity.

### **iii. Knowledge Product**

11. The UNDP defines its knowledge product as “a branded published piece offering new insights and analysis that advances learning or increases understanding about a development issue and leads to improved development policies, programmes, practices, products, skills and competencies. It is produced for the purpose of informing or influencing decision-makers, professionals or the interested public. Knowledge products may be classified under eight types: report, technical paper, guidance material, contributing paper, findings, dataset, brief, and think piece.”<sup>9</sup>

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<sup>9</sup><https://popp.undp.org/taxonomy/term/6391>.

12. Analytical discussions on knowledge products reveal the following attributes.
  - a. Knowledge is essentially embedded in knowledge product. The latter codifies and structures knowledge to support decision-making.
  - b. It should enhance the relevance, quality, and impact of existing analytical work and should enable action.
  - c. It, hence, follows that the product should specify deliverables that are operationally clear and capable, *prima facie*, of practical implementation.
  - d. It should be designed for a defined target audience, not merely a general-purpose document.
  - e. It should satisfy evaluability and specify measurable outcomes.

### III. Stock, Flow and Diffusion of Knowledge

13. Akin to physical and financial capital, knowledge has an accumulated stock, its dynamics, and the corresponding flow. Academic literature strongly agrees on the bidirectional relationship between the stock and flow of knowledge, the transmission and practice of knowledge (flow) prevents the depreciation of knowledge base (stock), while the stock itself largely defines the effectiveness and speed of flows.
14. “The term learning by doing is meant to emphasize that learning is the product of experience. Learning can only take place through the attempt to solve a problem and therefore only takes place during activity... The production of new capital goods is itself a learning process” by Arrow (1962)<sup>10</sup>. Another foundational work by Polanyi (1966)<sup>11</sup> states, “We can know more than we can tell... The transmission of tacit knowledge requires personal contact... it cannot be achieved by prescription.”. The basic idea is that skills and knowledge can be sustained only when it is practised. Extending the argument, subsequent works formally theorised the idea by showing that organizational knowledge is created through a ‘continuous and dynamic interaction between tacit and explicit knowledge’.<sup>12</sup>
15. Based on empirical work, Cohen and Levinthal (1990)<sup>13</sup> argue that the ability of a firm to absorb and apply external knowledge depends on its absorptive capacity. This, in turn, depends on the organisation’s accumulated investment in research and development that adds to its stock of expertise and knowledge. While the authors extended an individual’s knowledge absorptive capacity to an organisational context, further extensions to country contexts emerged thereafter. Similar results have been observed in the Indian context while analysing the relationship between the pre-existing capabilities (absorptive capacity) of Indian firms and their gains from patent collaborations.<sup>14</sup>

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<sup>10</sup>Arrow, K. J. (1962). The economic implications of learning by doing. *The review of economic studies*, 29(3), 155-173.

<sup>11</sup>Polanyi, M. (2009). The tacit dimension. In *Knowledge in organisations* (pp. 135-146). Routledge.

<sup>12</sup>Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization science*, 5(1), 14-37.

<sup>13</sup>Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative science quarterly*, 35(1), 128-152.

<sup>14</sup>Mathew, N., Napolitano, L., & Rizzo, U. (2023). The role of domestic-firm knowledge in international patent collaborations: Evidence from Indian firms. *The Journal of Technology Transfer*, 49(3), 1089-1112.

16. Creation of new knowledge augments the existing stock, while seamless diffusion distributes the stock widely, facilitating further extensive knowledge creation. Keller (2004)<sup>15</sup> shows that international technology diffusion, which is central to productivity gains, is slow, localized and mediated by trade, FDI, and absorptive capacity. This reflects the tacit (in the Polanyi (1966) sense) and costly nature of technological knowledge and, in turn, implies that openness alone will not fetch technological gains, but building domestic capabilities (skilling, competitiveness and labour mobility) to extract gains from global knowledge flows is important. This must be read alongside the fact that knowledge in high-tech domains faces faster obsolescence, making prompt diffusion critical.

#### **IV. Depreciation versus rejuvenation of knowledge, and the Indian context**

17. Knowledge products are created on the foundation of knowledge capital. The relationship between knowledge base and knowledge products can well be mutually reinforcing, as an influential knowledge product itself is likely to give added attention to the corresponding knowledge base. Hence, the dynamics, dormancy, policy push, resurgence and growth, in the knowledge base in specific areas holds a close relationship with knowledge products in that area.
18. The knowledge base of a sector may remain dormant for a fairly long time, in the absence of any external or institutional support. This may lead to gradual erosion of the base; thus, the knowledge capital may depreciate over time. However, it may subsequently be revitalised with a change in the growth context or policy environment or support from complementary sectors or renewed scientific discoveries. This may also give rise to a process of ‘reverse obsolescence’ or ‘rejuvenation’, a dynamic which is implicit in the idea of tacit knowledge. This feature distinguishes knowledge capital from physical capital, which typically depreciates monotonously over time. Global growth history has witnessed such documented experiences of knowledge rejuvenation. This idea is implemented quantitatively in the second Chapter.

##### **i. The Indian instance**

19. The Indian knowledge system has demonstrated resilience, enduring and adapting through historical vicissitudes. Yet, it has been remarkably continuous and its evolution, profoundly rooted in its rich and long history. The philosophical traditions such as Samkhya-Yoga, Advaita Vedanta philosophy, Charvaka, Nyaya Vaisheshika and Prabhakara Mimamsaka, refer to knowledge at different places with different interpretations. It was only natural in a society that encouraged plurality and adaptations. The terms like Darsana, Gyan, Bodh, Vigyan, Prama and Pragya are used at different places, sometimes with contextually different interpretations.<sup>16,17</sup> However, the Indian

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<sup>15</sup>Keller, W. (2004). *International technology diffusion. Journal of economic literature*, 42(3), 752-782.

<sup>16</sup>Singh, A. (2023). *Concept of Knowledge in Indian Philosophy*.

<sup>17</sup>Kapoor, K. *Indian Knowledge Systems: Nature, Philosophy and Character*, volume 1.

philosophies broadly converge on the view that knowledge is ‘that which illuminates the subject’. They further distinguish between observational knowledge (gained by the eyes, etc. through observation) and experiential knowledge (gained by the inner self), higher (of ultimate reality) and lower knowledge (of worldly domain). In the realm of knowledge, a single truth is not necessary, allowing for multiplicity of valid viewpoints.<sup>18</sup>

20. One of the most relatable instances of knowledge evolution is the case of Ayurveda, an indigenous ancient medical science of India, which is more than 5000 years old. References to the use of herbs for medicinal purposes are found in the Rigveda. Literally, the word Ayurveda is a combination of two words: Ayu and Veda - Ayu means life and Veda means the science. Though the use of herbs as medicines started as early as the Vedic period, it was not until 3000 years ago that specialized treatises named ‘Samhita’ were written on Ayurveda. This period may be termed the golden period of Ayurveda.<sup>19</sup>
21. Ayurveda suffered a setback during the colonial period (the 18<sup>th</sup> and 19<sup>th</sup> centuries) with the influx of Western medicines. It regained its strength gradually post-Independence, with support to research. The policy support to the sector continued, the reputed practitioners increased and reputable institutions flourished. The establishment of the Department of Ayush and its elevation to a full-fledged Ministry in 2014 were major recent milestones. “Ayurveda is acknowledged as a system of traditional medicine in over 30 countries, and Ayurvedic and herbal commodities or medicines are exported to over 150 nations.”<sup>20</sup>

## **V. Recent Discussions on the Relation between Technology and Global Diffusion of Knowledge**

### **i. Foundational arguments**

22. Robert Solow, while introducing a formal measurement of technical change using a production function approach, stated “It will be seen that I am using the phrase "technical change" as a shorthand expression for any kind of shift in the production function. Thus slowdowns, speedups, improvements in the education of the labor force, and all sorts of things will appear as “technical change”.”<sup>21</sup> This formulation did not explain how technological progress takes place. In a serious departure from the Solow model of exogenous technological progress, Paul Romer declared that Solow treated technological progress as ‘manna from heaven’<sup>22</sup> and indicated, “in contrast to models with exogenous technological change, growth in this model is driven by the accumulation of knowledge by forward-looking, profit-maximizing agents.”<sup>23</sup>

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<sup>18</sup>Kapoor, K. Indian Knowledge Systems: Nature, Philosophy and Character, volume 2.

<sup>19</sup><https://Ayush.delhi.gov.in/Ayush/ayurveda>

<sup>20</sup>Devikrishnan, K. (2024). The History of Introduction and Development of Ayurveda in Various Countries. *Journal of Indian Medical Heritage*, 3(3), 163-169.

<sup>21</sup>Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics*, 39(3), 312-320.

<sup>22</sup>Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic perspectives*, 8(1), 3-22.

<sup>23</sup>Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political economy*, 94(5), 1002-1037.

**ii. The Chip war message: - Increasing Bottlenecks to Knowledge and Technology Diffusion**

23. Miller (2022), in his widely read book, “Chip War”<sup>24</sup> depicts the story of 80-85 years of evolution of global manufacturing sector till the mid-2020s, in eight parts. Each part defines distinct roles for learning, invention and innovation. The story begins with the Cold War period of the 1940s-60s that witnessed inventions like the transistor and integrated circuit, coupled with the Silicon Valley’s emergence. Path-breaking laboratory inventions alongside manufacturing capabilities and scale led to the American success of the 1960s and 1970s. Japan's ascendancy in the 1980s that challenged the American manufacturing hegemony was achieved through process discipline, yield improvement and quality control in memory chips. The U.S. bounced back during the 1980s-90s by restructuring its industry.
24. Korean firms also emerged as major memory producers, supported by government backing, technology transfer, and scale-driven manufacturing, eventually becoming central players in global DRAM and semiconductor production. Over time, this evolution led to deep global specialisation in semiconductor design, manufacturing, and equipment, with different countries and firms dominating distinct segments of the value chain. The industry has become highly concentrated in a small number of firms and geographies, setting the stage for strategic dependencies and rivalries.
25. Miller underscores the exceptional concentration within the semiconductor ecosystem, where a substantial share of global computing capacity, memory chip production, and the supply of critical fabrication equipment is controlled by a handful of firms. This concentration spans multiple stages of the value chain, creating systemic dependence on a limited number of producers for both advanced chip design and manufacturing capabilities. Such structural concentration not only heightens supply vulnerabilities but also amplifies the strategic importance of these firms in shaping the trajectory of technological progress and global economic activity. In the entire description of the chip war, one major message is that it is difficult for the new entrants & late-comers to catch up, because of well-entrenched supply chains and the global domination of the design and production of semi-conductors and chips by a few countries and firms. The fact that the underlying knowledge is embodied in engineers, processes, equipment and products makes global knowledge diffusion increasingly difficult. A few resourceful countries are investing heavily to develop semiconductor technology to overcome monopolistic tendencies.

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<sup>24</sup>Miller, C. (2022). Chip war: The fight for the world's most critical technology. Simon and Schuster.

### iii. **The Voltage Effect Message: - Replicability and Scalability are Critical to Value Generation**

26. List's (2022)<sup>25</sup> "The Voltage Effect: How to Make Good Ideas Great and Great Ideas Scale" (2022) is instructive in describing low commercialisation of intellectual property resources. "Be it a medical breakthrough, a policy initiative, a product innovation, or a social movement, translating an idea into widespread impact depends on one thing only: whether it can be replicated at scale." More broadly, the capacity to scale is a critical determinant of impact across domains, influencing outcomes ranging from business expansion and educational attainment to large-scale public health delivery and the diffusion of new technologies.

### iv. **Extreme Cautions of Varoufakis**

27. Varoufakis (2024)<sup>26</sup> begins with the assertion that capitalism has already been replaced with a phenomenon called techno-feudalism, which is the latest mutation of capitalism. Capital has mutated into cloud capital, and markets and profits have been replaced by digital platforms and platform rents. Digital platforms and cloud space are analogous to land as a factor of production now, while the new "serfs" are data creators and users, workers, and businesses who depend on platforms for market access.
28. The book highlights significant barriers to the global diffusion of knowledge, noting that activities once situated within digital commons are now mediated by large technology and financial platforms. Access increasingly requires not only monetary payment but also the sharing of user data, attention, and consent to monitoring, thereby constraining open and equitable knowledge flows. There are multi-frontal critiques in the book; many of those lack empirical support and ignore the power of competition, innovation and regulation in limiting platform power.

### v. **Ideas Behind the 2025 Nobel in Economics and Their Critiques**

29. **The Mokyr Postulate:** The Nobel Prize in Economics for the year 2025 was awarded to three economists who stressed the role of knowledge in economic growth. Joel Mokyr, who won half the prize money, approached the subject from the prism of economic history. While tracing the history of economic growth, he pointed out that growth was subdued before the Industrial Revolution, partly because economic agents 'did not know enough about the physical world around them' (Mokyr, 2001)<sup>27</sup>. "Technological change, the discovery of new and better ways of doing things, lies at the heart of economic growth."<sup>28</sup>

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<sup>25</sup>List, J. A. (2022). The voltage effect: How to make good ideas great and great ideas scale. Crown Currency.

<sup>26</sup>Varoufakis, Y. (2024). Technofeudalism: What killed capitalism. Melville House.

<sup>27</sup>Mokyr, J. (2001). Economic History and the "New Economy": A historical perspective suggests a reversion back to a way of work and life that pre-dated the industrial revolution. *Business Economics*, 9-14.

<sup>28</sup>Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, 98(5, Part 2), S71-S102.

30. **The Gordon Counter:** The view that knowledge and technology will be important drivers of growth is not without contestation. Gordon points towards the recent slowdown in total factor productivity growth in the US and contends that the productivity gains were through IT-based technological progress, leading to replacement of humans by machines. This creates only one-time effects, not as durable as the productivity gains of the late 19<sup>th</sup> and 20<sup>th</sup> centuries led by electricity, mass production, telecommunication, etc. Coupled with headwinds like increasing inequality, adverse demographics and environmental concerns, subdued productivity growth will make future economic growth in advanced economies, particularly the U.S, lower compared to the previous century (Gordon, 2016)<sup>29</sup>. He also dismissed the concerns about mismeasurement of productivity growth and its failure to capture digital products, indicating the error in measurement is unlikely to be larger now (Gordon, 2018)<sup>30</sup>.
31. **The Mokyr-Feldstein Defence:** Mokyr (2018)<sup>31</sup> pointed out that these arguments cannot be right together. Important changes in the economy are often very slow and gradual and may even go unnoticed. These changes may be captured by productivity at some stage, if measured correctly. However, in practice, productivity measurements miss many important changes and effects, because measures are often computed based on National Accounts Statistics, which misses many non-marketable changes. Thus, the impact of technology on economic welfare (for instance, the invention of aspirin in 1898) may not at all be captured by the national accounts and productivity statistics (Mokyr, 2020)<sup>32</sup>. Feldstein (2017)<sup>33</sup> makes similar arguments about inability of national accounts to reflect fully on economic growth and productivity growth because of its failure to capture new products and changes in quality fully. He says, “converting the nominal GDP to real GDP.....requires creating an appropriate price index with which to divide the rise in nominal quantities into a real component and an inflation component. Although much of the growth in the real value of economic output reflects quality change and the introduction of wholly new products, the official procedures do not adequately reflect these sources of increased value”.
32. **Further Critiques:** Kvangraven (2025)<sup>34</sup> argues that the prize winners’ liberal account of progress rests on Eurocentric assumptions, evident in Mokyr’s account of the Industrial Revolution and Aghion–Howitt growth theory. Technological change is treated as an autonomous driver of accumulation, overlooking its embedding in global capitalist relations. She contends that their prescriptions for the Global South, focused on domestic reforms such as savings, education, liberalisation, and finance, assume largely endogenous growth while neglecting constraints from global competition and uneven development.

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<sup>29</sup>Gordon, R. J. (2016). *The rise and fall of American growth: The US standard of living since the civil war*. Princeton university press.

<sup>30</sup>Gordon, R. J. (2018). Declining American economic growth despite ongoing innovation. *Explorations in Economic History*, 69(2018), 1-12.

<sup>31</sup>Mokyr, J. (2018). The past and the future of innovation: Some lessons from economic history. *Explorations in Economic History*, 69, 13-26.

<sup>32</sup>Mokyr, J. (2001). Economic History and the "New Economy": A historical perspective suggests a reversion back to a way of work and life that pre-dated the industrial revolution. *Business Economics*, 9-14.

<sup>33</sup>Feldstein, M. (2017). Underestimating the real growth of GDP, personal income, and productivity. *Journal of Economic Perspectives*, 31(2), 145-164.

<sup>34</sup>Kvangraven, I. H. (Nov 8, 2025). *The Nobel Fetish Eurocentric Foundations for Innovation-driven Growth*, EPW.

## VI. Artificial Intelligence, Skills and Knowledge Creation

33. The rapid advances in AI models and their widespread deployment makes it important to understand the link between AI and knowledge creation. It is true that AI systems are trained using large amounts of knowledge that humans created. However, AI is increasingly showing the ability to help generate ideas and insights, which potentially displaces humans and brings a new dimension to knowledge creation.
34. Large Language Models (LLMs) are currently the most useful for research work. LLMs, built on large neural networks, are trained in stages - first on vast datasets of human knowledge to learn patterns, then through instruction tuning for task-specific responses, and finally refined using human feedback. AI models have also shown fast improvement in tasks that involve thinking and reasoning, such as working with language, analysing data, and supporting research. Scholarly studies like (Korinek, 2023)<sup>35</sup> show how LLMs can be used in six areas: idea generation, writing, background research, data analysis, coding, and mathematical work. LLMs are effective in tasks like writing, cleaning or restructuring data, and extracting information from text. However, they still need strong human supervision in areas like deep literature review and mathematical reasoning.
35. David Autor looks at this change from the point of view of jobs and skills. He argues that the main value of AI is not that it replaces human intelligence, but that it changes how skills and expertise are used. AI tools can embed complex knowledge into systems, allowing researchers and workers to be more productive in tasks that involve analysis and problem-solving. As a result, some activities that were earlier limited to experts can now be done by a wider group of people. At the same time, human judgment and thinking become all the more important.
36. Thus, current understanding suggests that AI complements, rather than substitutes for, human knowledge creation. As AI becomes more capable, the real value of human work will lie in areas where humans have an advantage, such as creativity, contextual understanding and judgment. The key challenge is not whether AI will be part of knowledge creation, but how policies, skills and institutions can be reshaped to ensure that AI supports inclusive and socially beneficial knowledge creation.
37. Hao et al. (2026)<sup>36</sup>, while examining a large number of scientific papers, showed accelerated adoption of AI tools among scientists. They also showed that AI-using scientists publish much more, get much greater citations, and become project leaders much earlier. However, according to them, AI adoption has shrunk the volume of scientific topics explored and the engagement among scientists, seemingly resulting in a paradoxical situation wherein individual researchers gain and the breadth of scientific reach shrinks. Hence, AI use has fertilized established areas, the fresh scientific explorations suffer.

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<sup>35</sup>Korinek, A. (2023). Generative AI for economic research: Use cases and implications for economists. *Journal of Economic Literature*, 61(4), 1281-1317.

<sup>36</sup>Hao, Q., Xu, F., Li, Y., & Evans, J. (2026). Artificial intelligence tools expand scientists' impact but contract science's focus. *Nature*, 1-7.

Kusumegi et al. (2025)<sup>37</sup> showed that we are experiencing an increase in the quantum of scientific output, and use of LLMs increases manuscript output and discovery of prior literature; yet, the evidence on the impact across domains is not clear yet. Hence, it is too early to make conclusive judgment on role of AI in knowledge creation and productivity enhancement.

38. Estevão (2026)<sup>38</sup> has recently argued that artificial intelligence is increasingly a defining driver of economic growth. The major arguments are the following.
  - a. The US is showing a two-speed expansion in which AI-intensive sectors are advancing rapidly while others lag; noting that, without AI, GDP would have been markedly weaker in Q3-2025. This pattern is echoed globally, where growth remains stable but concentrated in narrow sectors and regions.
  - b. However, national accounts inadequately capture this transformation: they record some components like software and R&D but miss much of the value in data, algorithms, and proprietary models. This leads to GDP overstating short-term contributions through capital outlays and understating broader productivity gains.
  - c. The current AI wave is unusually capital-intensive, requiring large-scale investment in computing power and infrastructure with data centres. AI is also reshaping trade and capital flows, with rising demand for semiconductors, servers, and energy, and with countries possessing digital depth attracting more stable investment.
  - d. Macroeconomic effects depend on diffusion. While firms are experimenting with AI, only a smaller group is deploying it at scale and hence gains remain concentrated. Energy and infrastructure constraints may further limit diffusion. Sustained productivity growth will depend on broad AI adoption across industries and how fast we learn to measure, finance, and govern it.

## VII. Outlining A Framework

39. MOSPI's ongoing research on the knowledge economy aims to develop a framework to evaluate the economic impact of knowledge and knowledge products. This entails defining the scope of work, reviewing existing evidence, assessing the use of available data sources, identifying gaps and possibilities for generating additional information, and arriving at a feasible methodology to quantify the impact. The subsequent three chapters follow this sequence of work.
40. There is now a proliferation of research output, ranging from online and peer-reviewed papers to books, policy briefs, and conference proceedings. This raises the need for a yardstick to determine what constitutes a knowledge product. The knowledge management literature emphasises actionability and measurable, practice-oriented outcomes, though

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<sup>37</sup>Kusumegi, K., Yang, X., Ginsparg, P., de Vaan, M., Stuart, T., & Yin, Y. (2025). Scientific production in the era of large language models. *Science*, 390(6779), 1240-1243.

<sup>38</sup>Estevão, M. (2026). AI Can Lift Global Growth, IMF.

actionability itself is normative and difficult to quantify. A more concrete approach is to assess whether a knowledge product is actually utilised, such as in subsequent research. Chapter 2 explores this possibility indicatively. Second, a limited set of credible estimates and data points exist shedding some light on the impact of knowledge. Chapter 2 also reviews such available methods and quantities, albeit not exhaustively.

41. Indian knowledge systems warrant particular attention in this context. The literature suggests that traditional knowledge undergoes cycles of flourishing, dormancy, renewed support, and regeneration. While some components remain poorly documented and their developmental status uncertain, others are witnessing growing research interest and are thriving, contributing to economic resilience in uncertain times. Against this backdrop, Chapter 3 explores the possibilities for classifying and valuing traditional knowledge.
42. However, a comprehensive estimation of the knowledge economy is a tough exercise. First, there is no global parallel, nor are there broad conceptual frameworks or guidelines, except for components like digital economy, legal rights related to intellectual property rights, etc. Data on knowledge generation and knowledge products are scattered and insufficient. Hence, there will be a need to generate new sources of information. Second, the scope of the current research goes beyond the valuation of knowledge products. An economy-wide approximation of the impact of knowledge must set aside noise, setting a theoretically and empirically justifiable framework for aggregation. This exploration is the subject of chapter 4. Given the Government's emphasis on the importance of knowledge and innovation<sup>39,40</sup>, identifying sectors where the knowledge base lags will provide valuable inputs for policy, further investigation, and corrective action. This motivation also drives and orients the current research.

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<sup>39</sup>PIB (Nov 4, 2025). India's Leap in Research and Innovation.

<sup>40</sup>NITI Aayog (Sep 2025). AI for Viksit Bharat: The Opportunity for Accelerated Economic Growth.

## Chapter 2

### Available Methodologies and Quantities

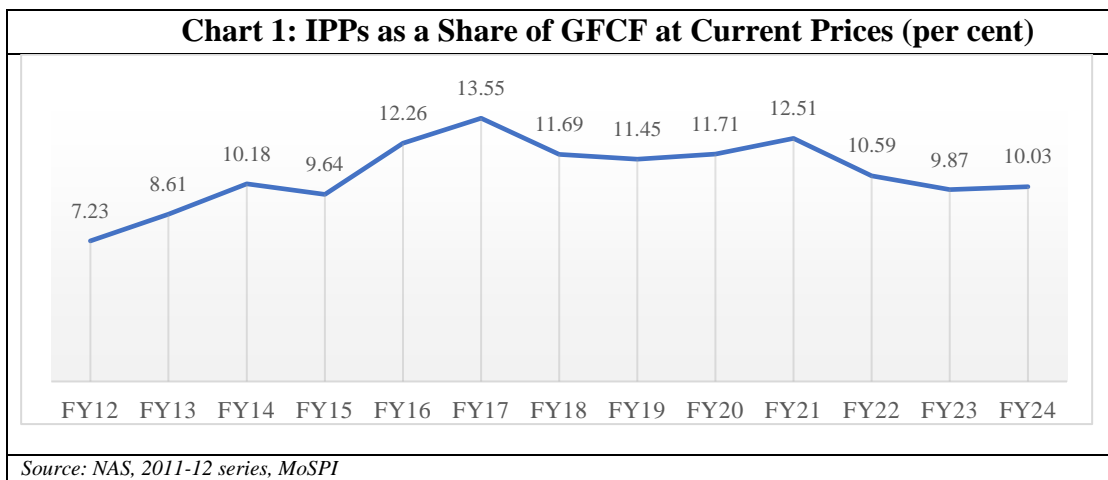
#### I. Organisation of the Chapter

1. The chapter reviews the methodologies used in credible academic research to quantify the components of the knowledge economy. Drawing on publicly available data, it also develops and presents a set of new quantities.
2. The chapter is organized into eight sections. The next section discusses the presentation of intellectual property products in the national accounts, along with the estimates therein. However, national accounts, by definition, capture intellectual property products primarily from an accounting perspective and do not fully illuminate their knowledge content. The third section examines research and development (R&D), a key component of intellectual property products, and analyses both its flows and stock. R&D generates multiple outputs, one of which is legally recognized intellectual property rights; this forms the focus of Section 4. Section 5 addresses the most noticeable outcome of R&D, the full spectrum of academic output. Section 6 dwells on the quantification of the digital economy, which, although not exclusively a knowledge product, is primarily driven by knowledge and plays an important role in advancing knowledge and Section seven talk about Creative Economy. Section 8 concludes the chapter.

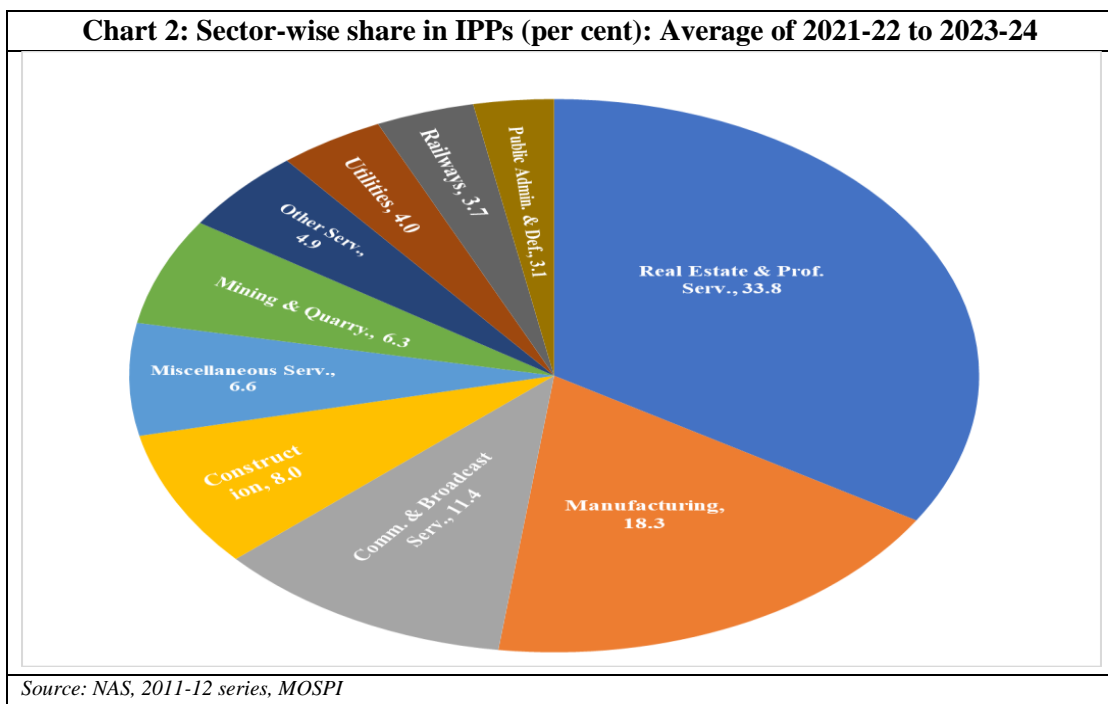
#### II. Treatment of Intellectual Property Products in National Accounts

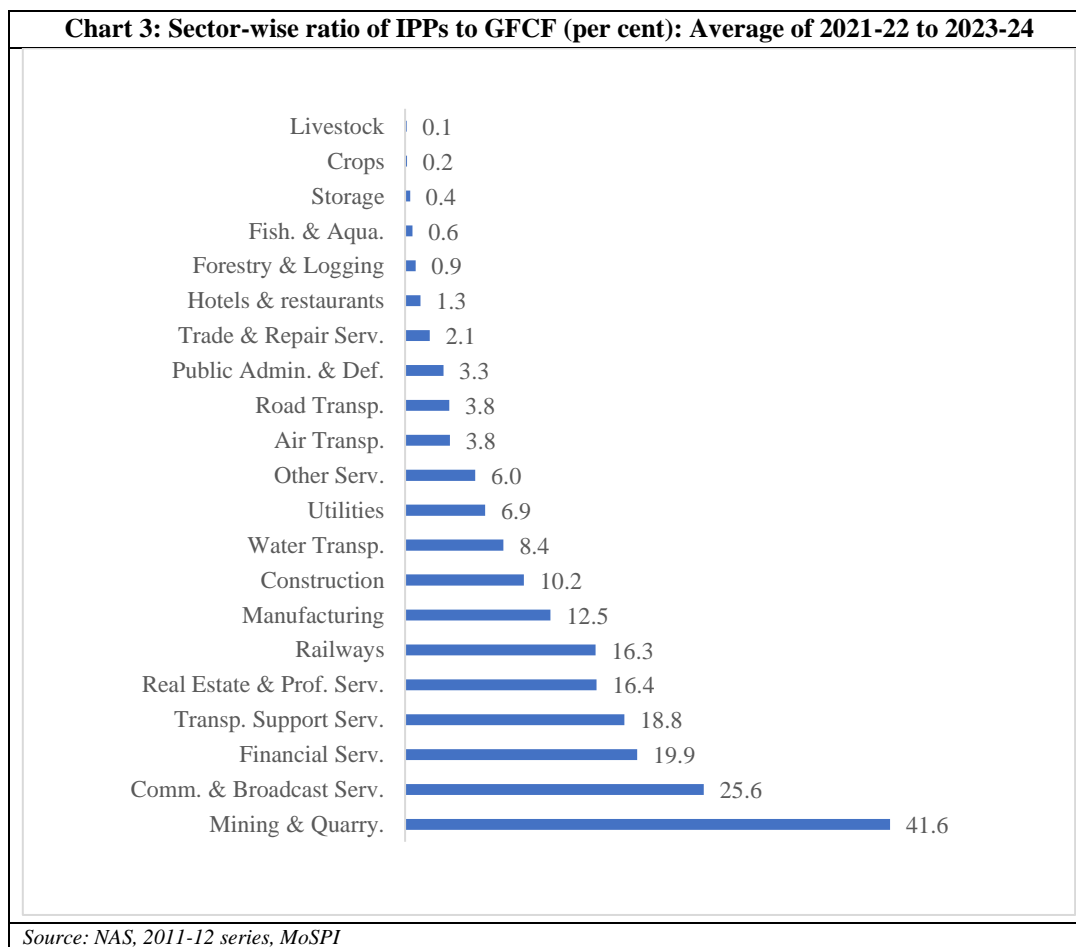
3. On the treatment of fixed assets under the National Accounts Statistics (NAS) the System of National Accounts (SNA) 2008 observes, “Fixed assets are produced assets that are used repeatedly or continuously in production processes for more than one year. Fixed assets include ... intellectual property products such as software or artistic originals used in production.” On the treatment of patents & related rights, the SNA 2008 adds, “With the inclusion of R&D expenditure as capital formation, patented entities no longer feature as assets in the SNA. The patent agreement is to be seen instead as the legal agreement concerning the terms on which access to the R&D is granted. The patent agreement is a form of licence to use which is treated as giving rise to payments for services or the acquisition of an asset.”
4. The four asset categories that account for gross fixed capital formation (GFCF) in India’s National Accounts Statistics (NAS) are machinery and equipment, construction, intellectual property products, and cultivable biological resources. As per the SNA principles, India’s NAS has considered research and development (R&D), mineral exploration, computer software, entertainment, literary or artistic originals and other items as intellectual property products.

- The National Accounts Statistics (NAS), following the System of National Accounts (SNA), compiles Gross Fixed Capital Formation (GFCF) in a manner that avoids double counting of produced assets used in further production. Expenditure on machinery and equipment or construction, even when undertaken for R&D purposes is recorded under their respective asset categories. Accordingly, the estimate of intellectual property products (IPPs) related to R&D in the NAS includes only R&D expenditure net of outlays on associated machinery, equipment, and construction. Conceptually, R&D reflects the creation of knowledge, software represents, to a great extent, its operational implementation.
- Chart 1 shows that there are considerable annual variations in the share of IPPs in GFCF. Of late, there is some deceleration, the reasons of which will be clearer only when the component-wise details can be seen.



- Chart 2 needs to be read in tandem with Chart 3. The share of IPPs in the aggregate of IIPs is the highest for real estate and professional services (possibly because of the presence of computer and software services within them), followed by manufacturing (Chart 2). This pattern does not hold in the share of IPPs in the same sector (Chart 3).





### III. R&D Capital Stock

8. In order to get a full picture of R&D expenditure flows in different sectors, which does not come from the NAS, we examine a survey-based dataset maintained by Department of Science and Technology (DST).

#### i. Data on R&D from DST

9. Data on R&D expenditure are drawn from the Science and Technology Indicator Tables of the DST. The DST has been compiling statistics since 1973, primarily through biennial national surveys on resources devoted to R&D activities. National Science and Technology Management Information System (NSTMIS) is the nodal agency entrusted with the collection, compilation, analysis, and dissemination of R&D data at the national level. NSTMIS shares the survey questionnaires with R&D institutions in both print and online modes. Data are collected from more than 8,000 R&D-performing organisations, covering the public sector, private sector, multinational corporations, higher education institutions, scientific and industrial research organisations and non-governmental organisations. R&D indicators publicly are accessible through the websites of DST and NSTMIS.

10. Economic-activity-wise R&D expenditure data, along with the corresponding National Industrial Classification (NIC) codes, have been compiled for this study for the periods 2005-06 to 2009-10 and 2015-16 to 2020-21. Data for the intervening years 2010-11 to 2014-15 are not directly available. For these years, the required values have been estimated using an alternative methodological approach<sup>41</sup>, aligned with the objectives of the study and the structure of the available data. Linear interpolation has been applied over a six-year interval between 2009-10 and 2015-16, with the total change distributed uniformly across the intervening years. This method assumes a constant annual change over the interpolation period. The results of the ongoing R&D survey of the DST are expected in early 2026-27. This will carry the results for three years from 2021-22 to 2023-24.
11. In addition, changes in the National Industrial Classification system across different years limit direct comparability. To address this constraint, the analysis is restricted to selected economic activities for which reasonable consistency in classification and data availability could be maintained over time.

## ii. Converting flows of R&D expenditure into capital stock

12. Based on consistent data availability, the following economic activities are selected for further analysis—agriculture, forestry and fishing, manufacture of food products and beverages, textiles, wearing apparel, coke and refined petroleum products, chemicals, pharmaceuticals, fabricated metal products (except machinery and equipment), electrical equipment, education<sup>42</sup>, health and social work activities, space, exploration and exploitation of the earth and defence.
13. Capital Stock of R&D in each sector has been prepared on the line of NAS as per the formula.

Capital Stock<sub>t</sub> = GFCF<sub>t</sub> + Stock<sub>t-1</sub> – CFC<sub>t</sub>, where: GFCF- gross fixed capital formation; CFC<sub>t</sub> = consumption of fixed capital = Stock<sub>t-1</sub>/life of capital in years

More formally, deploying perpetual inventory method (PIM) and specific to R&D,

$$S_{r\&d\_t} = (1-\delta) S_{r\&d\_t-1} + E_{r\&d\_t}$$

where:  $S_{r\&d\_t}$  = R&D capital stock in time ‘t’;  $\delta$  = rate of depreciation/obsolescence;  $E_{r\&d\_t}$  = R&D expenditure in time ‘t’.

14. The open question is about the assumptions on the rate of depreciation,  $\delta$ , the rate at which capital stock loses value over a period due to wear and tear, ageing, and

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<sup>41</sup> 
$$X_{t_0+k} = X_{t_0} + \frac{k}{6}(X_{t_1} - X_{t_0})$$

Where:

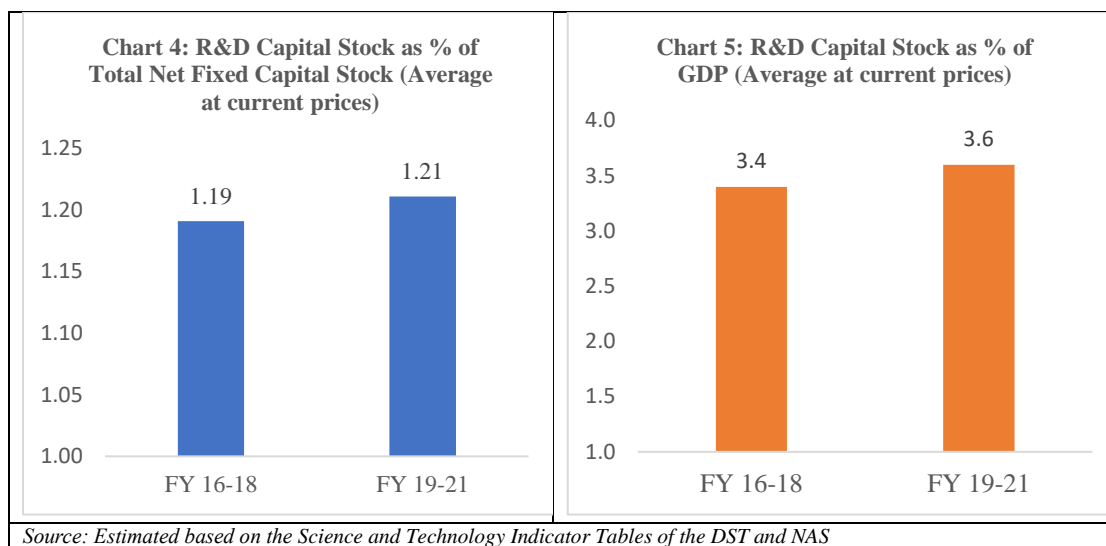
$X_{t_0}$  = observed value in 2009-10;  $X_{t_1}$  = observed value in 2015-16;  $k$  = number of years after 2009-10; Division by 6 reflects the six-year interval between the two observed points

For 2010-11 specifically ( $k = 1$ ):  $X_{2010-11} = X_{2009-10} + \frac{1}{6}(X_{2015-16} - X_{2009-10})$

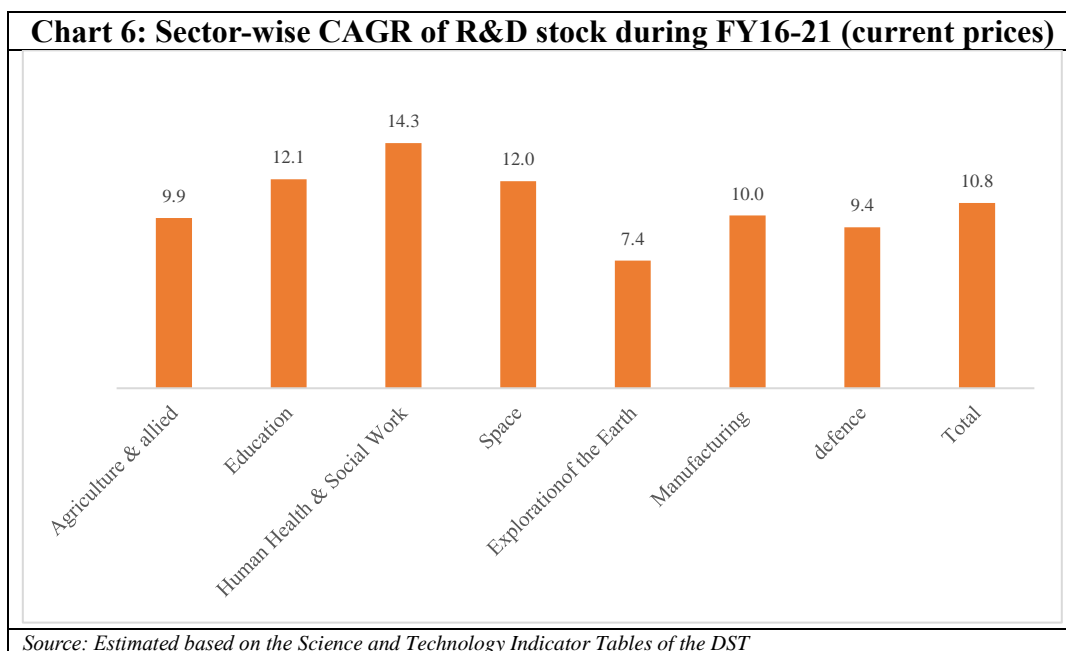
<sup>42</sup>Education covers higher education only, while defence-related R&D expenditure is sourced from the “Expenditure on R&D by Objectives” tables.

technological obsolescence. In PIM, it signifies the fraction of the capital stock that is consumed in one year. The empirically estimated values normally range between 10% to 15%. Following the path of India’s national accounts, we have adopted 10%.

15. Chart 4&5 indicate that the R&D stock as per cent of net capital stock in the country and the GDP for the corresponding period has increased, albeit modestly. The results of the ongoing survey, when available, will only reveal the updated picture.



16. Chart 6 indicates that most of the sectors exhibited a growth rate of close to 10% or higher during 2015-16 to 2020-21.



### iii. Arriving at an Effective R&D Capital Stock

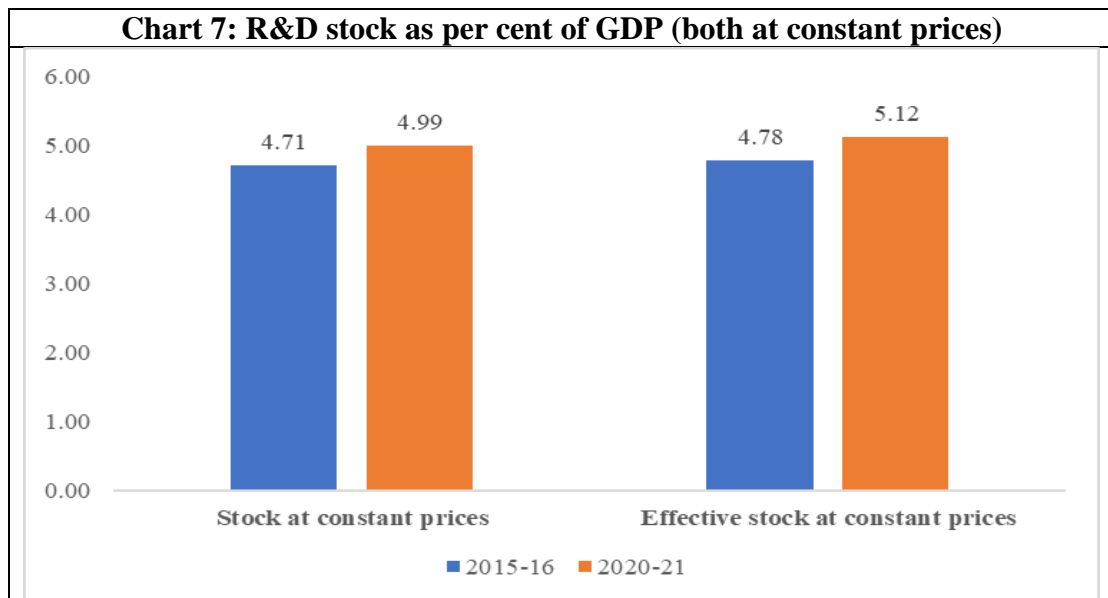
17. Capitalised value of R&D, calculated following the perpetual inventory method, represents the intangible capital stock (in a very limited way). However, treating knowledge capital with a simple constant depreciation rate, as in the standard perpetual inventory method, is conceptually unsatisfactory. Assumptions of constant depreciation and irreversibility are far less defensible for knowledge than for physical capital. This is because, as opposed to physical capital, knowledge capital can rejuvenate with an appropriate push. There is strong conceptual and empirical support to this argument from growth and productivity literature.
18. However, a key issue is how to formalise a rejuvenation rate, or reverse obsolescence rate. Conceptually, this is not as straightforward as a depreciation rate, as it requires identifying the point at which renewal impulses emerge. One possible approach is as follows: if R&D investment in a given sector rises during a period at a rate substantially exceeding its historical average, this may be interpreted as a signal of renewed interest. Such a surge can activate the existing knowledge stock, attract new talent and technologies, and enhance the transmission of tacit knowledge, thereby imparting a “rejuvenating” impulse to the sector’s knowledge capital stock.
19. To do this, one should arrive at the R&D expenditure and capital stock at constant prices, because price changes should not misguide us in locating renewal impulse. Besides, it is the real variables such as hiring of researchers, research output, R&D infrastructure, etc that get a push from renewed attention to research.
20. Once the real expenditure and stock numbers are arrived at, the following equation will get us to the real effective R&D capital stock, with some crucial assumptions.

$$S_{r\&d\_t}^{eff} = S_{r\&d\_t-1}^{eff} * (1 - \delta + \Phi g_t^*) + E_{r\&d\_t}$$

Where,

- $g_t = (E_t - E_{t-1}) / E_{t-1}$  (Expenditure growth in time ‘t’)
  - $g_t^* = (g_t - \theta)$ ,  $g_t^*$  is the difference between actual growth rate in time ‘t’ and the period average growth rate,  $\theta$ .
  - $\Phi$  = rejuvenation rate, the rate at which the existing stock of R&D capital responds to an expenditure push in time ‘t’.
21. If current R&D expenditure grows much faster than its historical average, then it gives a fillip to the entire existing stock. Conversely, a much lower growth rate will lead to accelerated depreciation/ obsolescence implying the retrenchment of existing research teams, inability to make enough provision to manage routine maintenance of the existing equipment, inability to withstand competitor research advancements, etc. Hence,  $S_t^{eff}$  can be greater or smaller than  $S_t$  depending on the behaviour of  $g_t > \theta$ .
  22. There are a few crucial assumptions made while implementing the concept of effective stock. As this is fresh construct in this field, we cannot bank on empirical evidence for guidance.

- i. *Defining the period, of which the average growth rate,  $\theta$ , is taken as the benchmark for assessing the current growth rate,  $g_t$*  – When a fairly long time series is under consideration, defining one benchmark growth rate,  $\theta$ , for full period will have the disadvantage of disregarding the regime shifts in growth dynamics that occurred within the period. We have considered a series of close to four decades, from 1985 to 2001, too long a period to be bunched together while considering any benchmark. Hence, we have considered decadal average growth rates of R&D expenditures as the benchmark for comparing growth rates of the constituting years of that decade. This is a decision that needs to be made after studying the behaviour of the series.
- ii. *Locating the push point/period* – This is essentially a question of defining the time consideration for defining  $g_t^*$ . As seen in the equation above, we have defined the push period as one year with no spill-over/second order effects. However, a more tenable assumption would be to consider a short period of years to locate a long-enough push/rejuvenation to the R&D investment, or perhaps derive the push periods empirically from the series itself. However, we have kept it simple.
- iii. *The value of  $\Phi$ , the rejuvenation rate* –  $\Phi$  can be any non-negative value, it needs to be assigned judgmentally. We have kept the value of  $\Phi$  at 0.5, implying that a 10-percentage-point acceleration of R&D investment beyond threshold recovers roughly 5% of the closing stock of the previous year.<sup>43</sup> The simple assumption is of a one-period push, the effect of which stays, but without any dynamic effects.



23. The R&D effective stock is higher than the simple R&D stock (Chart 7), implying that the rejuvenating effect of positive growth shocks has been more enduring than the

<sup>43</sup>We have assumed the value of  $\Phi$  to be 0.5. However, it is recognised that different assumptions on  $\phi$  would lead to variations in the estimates of effective stock.

negative shocks. In time of rapid movements in R&D expenditure, the analytical value of the effective stock measure will increase considerably.

#### IV. Intellectual Property Rights (IPRs)

##### i. IPRs in India

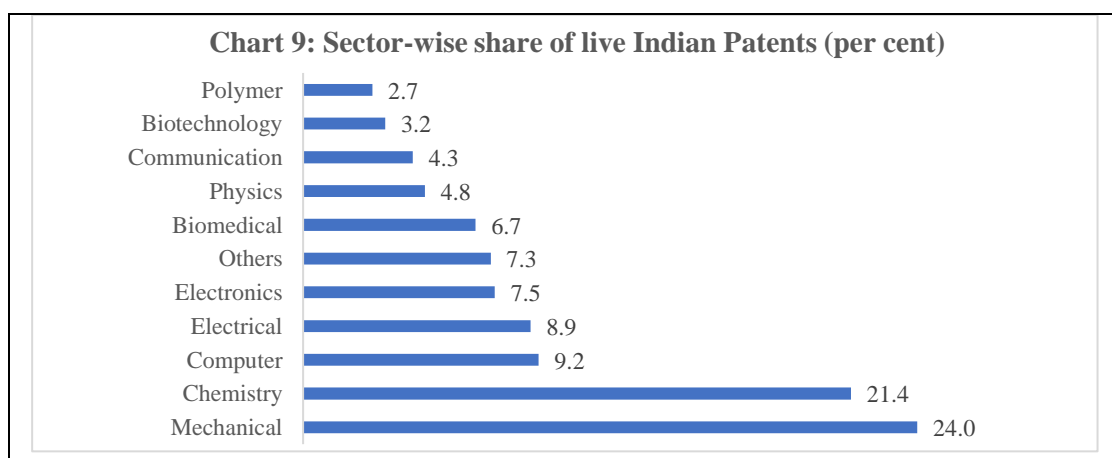
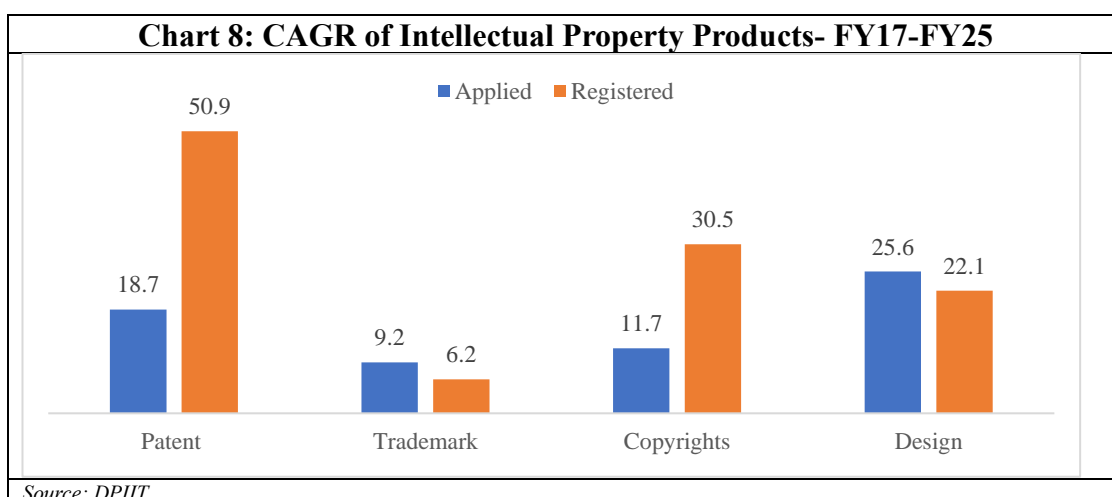
24. IPRs are legal rights granted to creators over the use of their intellectual creations, such as inventions, literary and artistic works, designs, and symbols. The concept of IPR originates from the need to encourage innovation by providing creators with exclusive rights for a limited period, while ultimately benefiting society.
25. Informal recognition of creative effort existed in ancient civilizations, but formal IPR systems emerged in Europe. The Venetian Patent Statute of 1474 is considered the first codified patent law, granting inventors temporary monopolies. Modern copyright law originated with England's Statute of Anne (1710), which recognized authors as rights holders. Trademarks evolved from medieval guild marks used to indicate origin and quality of goods. The Industrial Revolution expanded the scope of IPR, leading to international frameworks such as the Paris Convention (1883) and Berne Convention (1886). In the contemporary era, IPR is governed globally through WIPO and the TRIPS Agreement (1995), reflecting its role in innovation-driven economies.

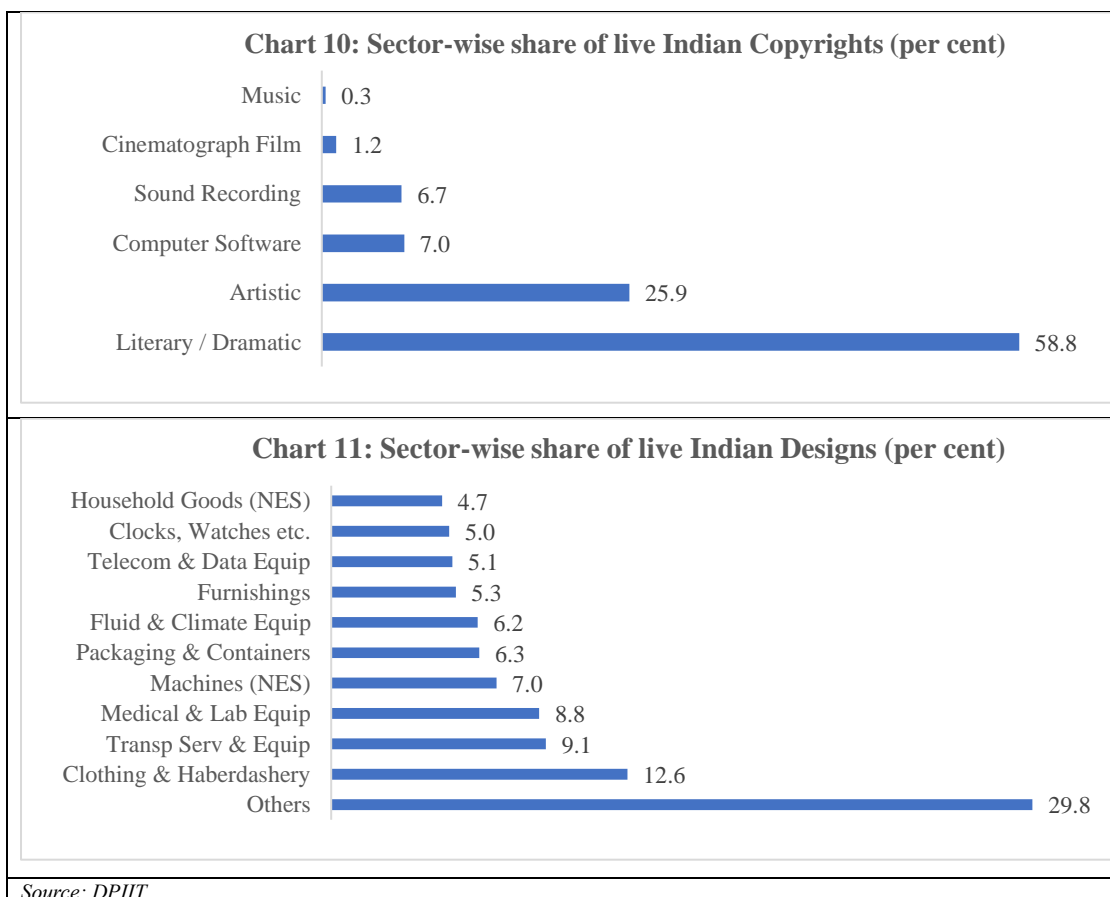
<b>Legal right</b>	<b>Legislation</b>	<b>Duration</b>	<b>Details</b>
Patents	Patents Act, 1970	20 years from the filing date	Exclusive rights over an invention to the patentee; usually the inventor or an assignee (such as an employer or institution); territorial, enforceable only in India; patentee can license the invention or assign it, subject to registration.
Copyright	Copyright Act, 1957	Generally, lifetime of the author plus 60 years.	Protects literary, artistic, musical, dramatic works, films, and software; author is the first owner, unless created under employment/contract; can be licensed or assigned, wholly or partially; registration is optional.
Trademarks	Trade Marks Act, 1999	10 years; can be renewed indefinitely	Protect brand identifiers such as names, logos, and symbols; owner is the registered proprietor; can be licensed through registered users or assignment, ensuring brand control and consumer protection.
Designs	Designs Act, 2000	10 years, extendable by 5 years	Protect the aesthetic features of articles, not their functionality; owner is the registered proprietor; can be licensed or assigned, but rights are limited to visual appearance.
Geographical Indications (GIs)	GI of Goods (Registration and Protection) Act, 1999	10 years, renewable indefinitely.	Identifies goods as originating from a specific region with unique qualities; cannot be assigned or licensed, but authorized users can be registered.

26. The analysis in this section is limited to the IPRs (excluding geographical indications, which is the subject of Chapter 3) applied for and held by Indian entities in India. Table 2 below, giving a snapshot of IPRs in India, makes greater sense when read along with Chart 8. There was a rapid growth in patent registrations in India during the last decade (Chart 8). Trademarks are very large in number, because of the defensive and speculative protection sought by firms. Copyrights and designs also have had a robust growth in the number of applications and registrations during the last decade.

IPR	Applications Filed (FY17–FY26)	Registered (FY17–FY26)	Currently Live	Ratio of Registered to Filed
Designs	179695	140149	140359	78.0
Patents	296111	67635	44273	22.8
Trademarks	3978200	2263521	NA	56.9
Copyrights	254406	171804	171804	67.5

*Source: DPIIT*





27. Charts 9 to 11 summarise the sector-wise distribution of IPRs held by Indian entities in India. There is concentration among a few sectors, but there is also a reasonable coverage of live IPRs across sectors (many sectors have been clubbed together for presentational convenience). Thus, while the registration activity is dynamic in IPRs with broad sectoral presence, the forthcoming review of research studies shows that the market for these legal rights is limited in India for various reasons. Hence, there is a dearth of information that can guide a normative valuation of the stock of IPRs.

## ii. Valuation of Intellectual Properties (IPs): Guidance from literature

28. Gambardella et al. (2005)<sup>44</sup>: The study did a survey of inventors of 9,000 EPO patents across six European countries. The patent values were highly skewed, with a small share of patents generating very high economic returns. It highlights the importance of collaboration, firm-level capabilities, and complementary assets in determining patent value. Licensing, strategic patenting, and start-up formation play a role. Patent value depends not only on technological quality but also on institutional settings, incentives for inventors, and firms' ability to exploit IPs effectively.

<sup>44</sup>Gambardella, A., Giuri, P., & Mariani, M. (2005). The value of European patents: evidence from a survey of European inventors. Sant'Anna School of Advanced Studies mimeo.

29. Kamiyama et al. (2006)<sup>45</sup>: The paper examines how IPs are increasingly viewed as a strategic economic asset rather than merely a legal right. It highlights the growing role of licensing, technology transfer, and IP-backed financing. Challenges that constrain effective use of IPs include information asymmetry, weak markets for IP transactions, and limited financial expertise. Stronger legal frameworks, better valuation practices, and supportive innovation policies are essential for leveraging IPs to promote innovation.
30. Deng (2007)<sup>46</sup>: This paper estimates the private economic value of European patents by analysing joint patent designation and renewal behaviour at the European Patent Office from 1978 to 1996. Patents filed through the EPO were observed to be more valuable than those filed via national routes, largely because higher application costs screen out low-value inventions. Patent values are highly skewed and increase with the economic size of destination countries. It also found that that enforcement quality and legal environments affect patent value even for the same underlying invention.
31. Su (2015)<sup>47</sup>: This study highlights the lack of clear valuation criteria results in subjectivity in trademark valuation practices. Reliance on goodwill-based approaches and loosely defined income methods leads to inconsistent and non-transparent outcomes, particularly in accounting, taxation and financing. The paper proposes more practical valuation criteria by systematically applying the cost approach and income approach. The trademark value is highly sensitive to assumptions regarding economic life, discount rates and contribution factors. There is a need for standardized valuation frameworks.
32. The PricewaterhouseCoopers (2017)<sup>48</sup>: PwC examines the growing economic importance of IPs and other intangible assets in value creation, competitiveness, and corporate strategy. Globalization, technological advancement and digitalization have increased reliance on intangibles. Challenges in valuing and monetizing these assets arise due to limited market transparency, evolving business models, and regulatory complexities. While outlining commonly used valuation approaches, it stresses the need for robust governance, clear documentation, and alignment between legal, financial, and tax perspectives.
33. Țițu et al. (2020)<sup>49</sup>: Drawing on global patent statistics and sectoral evidence, especially from the medical technology field, the study demonstrates that strong intellectual property regimes exhibit higher levels of innovation and economic development. Robust intellectual property management frameworks are essential to effectively utilize knowledge resources and remain competitive in the globalized economic environment.

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<sup>45</sup>Kamiyama, S., Sheehan, J., & Martinez, C. (2006). Valuation and exploitation of intellectual property.

<sup>46</sup>Deng, Y. (2007). Private value of European patents. *European Economic Review*, 51(7), 1785-1812.

<sup>47</sup>Su, K. H. (2015). A Study on the Valuation of Trademarks. *Indian Journal of Science and Technology*, 8, 19.

<sup>48</sup> PricewaterhouseCoopers, (2017). Intellectual property and intangible assets: Key valuation and strategic considerations (PPT).

<sup>49</sup>Țițu, A. M., Pop, A. B., Oprean-Stan, C., & Stan, S. E. (2020). Specific Aspects of Intellectual Property Management in the Knowledge-based Economy. *Management of Sustainable Development*, 12(1), 10-54989.

34. Jajpura et al. (2016)<sup>50</sup>: The authors briefly discuss India's participation in global IP activities and underscores the urgent need for greater dissemination of IPR knowledge to support the nation's technological and economic advancement. In a similar vein, Chauhan (2024)<sup>51</sup> analyzes India's IPR regime in light of constitutional provisions, statutory laws, and international commitments such as the TRIPS Agreement, highlighting how legal protection of inventions and creative works incentivizes research and development. The study discusses the strengths and limitations of India's current IPR framework, including enforcement challenges, awareness gaps, and access-related concerns. India has made significant progress in aligning its IP laws with global standards. It seems to suggest that this alignment alone is insufficient for commensurate value realisation unless supported by effective implementation.
35. Kaushik et al. (2023)<sup>52</sup>: The authors highlight the mixed impacts of IPRs, noting that patents can strengthen firm strategies, while patent pools may constrain innovation among non-members. Through discussions of patents, trademarks, and major Indian IP disputes (Neem patent revocation, Monsanto's GM cotton dispute, Ferid Allani's trademark win, and biopiracy battles over Basmati and Tulsi, etc), it shows how uncertainty in ownership, enforcement, and access can erode IP value. While IPRs can enhance firm growth and valuation, the study implies that their economic worth depends on balanced institutional design that reconciles private returns with public interest.
36. Og et al. (2020)<sup>53</sup>: Patent performance can be understood clearly when both citation indicators and patent renewal data are considered, as each highlights a different aspect of value. Citations, particularly forward citations, show how influential a patent is in terms of technology and knowledge diffusion, and they help capture learning effects over time. However, being highly cited does not always mean that a patent is commercially successful. Patent renewal data, in contrast, reflects real economic decisions by patent owners, as renewal requires paying rising fees and is continued only when the patent is expected to generate sufficient returns. Overall, treating patent renewal as the main performance indicator and using citations as a complementary measure provides a more balanced and realistic assessment of patent value.
37. Hu et al. (2023)<sup>54</sup>: This study shows how high-value patents can be identified early by combining patent indicators with machine learning. Using more than 31,000 integrated circuit patents, the authors develop a multidimensional indicator framework covering legal, technological, competitive, and scientific value, and apply several machine learning models to classify patents. In their results, the Random Forest Model performs best, with accuracy above 95%. Key indicators such as patent family size, forward

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<sup>50</sup>Jajpura, L., Singh, B., & Nayak, R. (2017). An Introduction to Intellectual Property Rights and their Importance in Indian Context. *Journal of Intellectual property rights*, 22(1).

<sup>51</sup>Chauhan, K. (2024). Intellectual property rights and innovation: A study of India's legal framework

<sup>52</sup> Kaushik, M. B., Rajharia, P., Vyas, V. T., & Soni, S. (2023). Navigating intellectual property rights: Fostering innovation, access, and education in the Indian context.

<sup>53</sup>Og, J. Y., Pawelec, K., Kim, B. K., Paprocki, R., & Jeong, E. (2020). Measuring patent value indicators with patent renewal information. *Journal of Open Innovation: Technology, Market, and Complexity*, 6(1), 16.

<sup>54</sup>.Hu, Z., Zhou, X., & Lin, A. (2023). Evaluation and identification of potential high-value patents in the field of integrated circuits using a multidimensional patent indicators pre-screening strategy and machine learning approaches. *Journal of Informetrics*, 17(2), 101406

citations, extended family size, patent and non-patent references, and first-citation speed are especially useful in identifying high-value patents. The study, thus, demonstrates that combining multiple patent indicators with machine learning provides an effective and practical approach to evaluating patent value.

38. Kossecki et al. (2021)<sup>55</sup>: This paper studies how copyrights for audio-visual works are valued across Europe, focusing on the role of Copyright Management Organizations (CMOs), which often operate as monopolies in national markets. It shows that the absence of transparent and standardized valuation methods has led to frequent disputes between CMOs and copyright users, especially with the growth of digital and streaming services. The results reveal clear differences between countries, with richer economies generally collecting higher copyright fees, though large variations remain even among similar countries. The study concludes that copyright fees cannot be treated as true market prices due to the dominant position of CMOs and stresses the need for clearer, harmonized valuation methods tailored to national market conditions.
39. Desai et al. (2025)<sup>56</sup>: Trademarking activity is closely associated with firm growth, higher sales, greater market share, and higher investment. Trademarks create value through both product innovation and product differentiation and are widely used across industries. By linking individual trademark publications to stock market reactions, the authors develop a novel, forward-looking, market-based measure of trademark value for U.S. publicly traded firms.
40. Hsu et al. (2022)<sup>57</sup>: This paper examines how financial markets value newly registered trademarks and whether investors fully incorporate the information contained in trademark activity. Using more than 300,000 U.S. trademark registrations from 1976 to 2014, the authors construct a measure of new trademark intensity (the number of new trademarks scaled by firm assets). Firms with higher new trademark intensity earn significantly higher future stock returns and exhibit better subsequent operating performance. However, investors and financial analysts systematically underreact to this information, leading to temporary undervaluation. The effect is strongest shortly after trademark registration and is more pronounced for complex firms and exploratory trademarks. Thus, market inefficiencies play a key role in their valuation.
41. Institute of Chartered Accountants (2021)<sup>58</sup>: Three internationally accepted valuation approaches are market, income, and cost, are explained in this report. It highlights the importance of professional judgment in choosing suitable methods based on the nature of the asset, availability of data, and purpose of valuation. The decisions to be made for a reasonable valuation include: when to use single or multiple approaches, the need for observable inputs, and the rationale for assigning weights to different approaches. Case

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<sup>55</sup>Kossecki, P., Akin, O., & Wachowicz, J. (2021). Valuation of Intellectual Property Rights-Copyrights to Audiovisual Works: An International Comparison of Copyright Management Organizations. Available at SSRN 3968559.

<sup>56</sup>Desai, P., Gavrilova, E., Silva, R. C., & Soares, M. (2025). The value of trademarks. *SSRN Electronic Journal*.

<sup>57</sup>Hsu, P. H., Li, D., Li, Q., Teoh, S. H., & Tseng, K. (2022). Valuation of new trademarks. *Management Science*, 68(1), 257-279.

<sup>58</sup>Institute of Chartered Accountants of India, (2021). Educational material on ICAI Valuation Standard 103: Valuation approaches and methods.

studies, covering varied valuation contexts and detailing the end-to-end valuation process have been presented.

42. Incwert Advisory Private Limited (2025)<sup>59</sup>: By examining data of 2,016 entities and 10,105 transactions across 16 industries during FY2015 to FY2024, the study shows that royalty rates in India are generally modest, median royalty rates being much lower than those in the US, because of cost sensitivities, market competition, and technology maturity stages. There are significant inter-industry variations, driven by regulatory structures, profitability levels, and the nature of the underlying intangible assets. Regulated sectors such as energy, mining, telecom, and infrastructure show higher rates owing to government-specified fees. The study demonstrated a statistically significant relationship between gross margins and royalty rates, with profitability explaining nearly half of the observed variation across sectors.
43. WIPO-1 (2025)<sup>60</sup>: World Intellectual Property Organization (WIPO) provides a practitioner-oriented guide to valuing IPs in the context of technology transfer, with a particular focus on early-stage innovations emerging from universities and research institutions. While IP valuation is critical for commercialization and decision-making in the knowledge economy, there are specific challenges posed by uncertainty and limited data at early technology readiness levels. The guide compares major IP valuation approaches, cost, market, income (discounted cash flow), real options, and Monte Carlo simulation, emphasizing their appropriate use cases, strengths, and limitations. By combining conceptual explanations with practical examples and case studies, the paper equips technology transfer professionals with a pragmatic, flexible framework for generating defensible IP valuations that support licensing, negotiation, investment, and policy objectives.
44. WIPO-2 (2025)<sup>61</sup>: Bio-technology projects involve long-gestation periods, with ‘pre-clinical, Phase I, II, III, and regulatory approval’ stages and high capital cost, increasing capital cost and uncertainty in returns. The paper is aimed “to facilitate the valuation of early-stage IP in biotechnology and pharmaceutical companies”. The purpose of the IP valuation to be undertaken- investment decisions, licensing agreements, fundraising or strategic planning is important while determining the methodology. The commonly used valuation approaches in the sector include discounted cash flow, risk-adjusted net present value, market comparables and options-based thinking. The early-stage valuation involves heavy “expert assumptions, forward-looking scenarios and flexible methodologies”. The application of the standards of International Valuation Standards Council (IVSC) is suited only where ‘markets and cash flows are well defined’.

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<sup>59</sup>Incwert Advisory Private Limited, (2025). Unravelling the tapestry of royalty rates: A comprehensive study of intellectual property rates in India.

<sup>60</sup>World Intellectual Property Organization (WIPO), (2025). Intellectual property valuation basics for technology transfer professionals.

<sup>61</sup>WIPO, (2025). Intellectual property valuation in biotechnology and pharmaceuticals

<b>Table 3: Methods Employed for IP Valuation (*) - Summary</b>			
Approach	Definition	Source of data	Limitations
Cost Approach	IP value is equated to the sum of the costs invested in its creation till date including all direct and indirect costs	Costs are available from the accounts of the investing entities	Sectors like biotechnology result in many research failures, leading to minimal value creation and substantial costs. Hence, it is suitable only “for certain circumstances such as early-stage IP, tangible assets, and internal decision-making”
Market approach	Valuation is made based on recent, strictly comparable transactions.	Industry surveys, professional networks, company disclosures, regulatory filings, subscription databases, court judgments, and industry associations	Not applicable where markets are not well developed and comparability in deals, maturity, application area, benefits and other features cannot be ensured.
Income method	Estimates risk-adjusted discounted cash flow (rNPV) for IP valuation	Cash flow statements can be used to summarize inflows and outflows	While valuing long-gestation projects at early stages, there is a heavy reliance on assumptions, as income flows will be limited.
Real options method	Methods such as binomial option pricing and risk-neutral valuation; recognizes managerial flexibility in development.	No single data source; based on expert-informed parameters and informed assumptions; based on option pricing theory	Heavy reliance on perception-based, speculative, or scenario-driven inputs; complex and difficult to implement.
Draws heavily from WIPO (2025)			

45. Effective application of these methods requires a vibrant market for guidance. As IPR valuation is constrained by data limitations, professional valuers undertaking mandatory asset valuations, for instance, in mergers and acquisitions, typically adopt a combination of methods and apply their judgments, depending on the assessment context.

## V. Evaluating Academic Output

46. One of the significant contributors to the knowledge economy is the research carried out by various institutions such as universities, laboratories, companies, and government agencies. However, the valuation of research publications poses challenges in terms of data availability and methodological completeness. Many metrics are applied to evaluate academic output; some are easier to compile, while some entail much more detailed attributes. This section reviews the available methodologies and attempts some exploratory measurements.

**i. Specific Purpose Quantitative metrics: - The Instance of Critical Technology Tracker of ASPI**

47. Australian Strategic Policy Institute (ASPI), established by the Government of Australia in 2001, is a think tank that has good reputation in studying and quantifying critical technologies across a wide variety of areas. ASPI has developed a methodology for comparing institutions and countries in terms of research performance in critical technologies. It also assesses the technology monopoly risk among countries. The flagship publication of the ASPI in this area is the Critical Technology Tracker. It tracks research in 44 foundational technologies. The number of technologies tracked has now increased to 74. The focus is on high-impact research, the top 10% cited research papers across the globe.
48. The Tracker analyses research publications on both quantity and quality of research publications in the area of critical technologies which are considered foundational for economies, societies, national security, defence, energy production, health and climate security using the data from Web of Science. The 'quality research' is defined as research from papers that are in the top 10% most cited papers when compared to other papers published in the same technology area in the same year<sup>62</sup>. The insights generated from this data are utilized to rank the countries and institutions which are leading in high impact research in these technologies.
49. ASPI has data on publications related to critical technologies for more than two decades, from 2003 to 2023, based on information downloaded from the Web of Science (WoS) Core Collection Database. It initially downloaded records on 7.8 million publications related to critical technologies. After going through a comprehensive process of data checking and cleaning, they zeroed in on 6.8 million publications. The underlying logic employed the ASPI methodology is simple, the number of citations is a measure of knowledge content in publications, and hence, citational differences can be a parameter based on which knowledge generation across critical technologies, the institutions and countries to which the authors belong to, can be compared.
50. In order to ensure consistency in handling data, ASPI undertook the following precautions.
- a) When they considered publications across subjects, institutions and countries over two decades, one essential requirement was to ensure a threshold level of quality of papers. Keeping this in view, ASPI limited itself to only highly cited papers, stipulating that the coverage of ranks will be limited to papers that have a citation count in the top 10% of all papers published in that year.
  - b) Older papers of similar specifications are likely to have greater number of citations than the newer ones. To take care of this, ASPI compared citations after segregating publications year-wise.

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<sup>62</sup><https://techtracker.aspi.org.au/methodology>.

- c) ASPI indicates possibilities of ‘clubbing’, i.e., the likelihood that scholars in connected professional networks may quote more of authors within the network, which may bias assessment of the underlying knowledge content in publications. Hence, they bank on the WoS database, which follows “strict editorial selection and evaluation processes”.
  - d) The assignment of research credit is complicated when different authors belonging to different institutions and countries are involved. ASPI designed a method of systematically assigning fractional credit to authors, institutions and countries.
  - e) The quantum of research output across subjects will vary vastly in a given year. This variation needs to be interpreted in the light of the stage of development of the subject. It takes the examples of *nanoscale materials and manufacturing* which has 1.2 million publications during 2003 to 2023, while the relatively new *AI algorithms and hardware accelerators* have only 4000<sup>+</sup> publications.
51. ASPI has constructed Technology Monopoly Risk Metric for countries, considering two factors, “how far ahead the leading country is relative to the next closest competitor, and how many of the world’s top 10 research institutions are located in the leading country”. The purpose is to give a ‘leading indicator for potential future dominance in technology capability’. The higher the concentration of top institutions and research leads, the higher is the monopoly risk.

## ii. Making Citation based Assessments for India: - An Illustration

52. Following an approach similar to that adopted in ASPI’s report, an attempt has been made to evaluate academic output for India using data sourced from Scopus and the Web of Science. Scopus and Web of Science are the world’s two most comprehensive and curated citation databases of academic research. Although both Scopus and Web of Science are widely used citation databases, they differ in important respects. Scopus provides broader coverage in terms of the number of indexed journals and tends to index publications more rapidly in recent years. Web of Science, by contrast, follows a more selective journal inclusion policy, with a stronger emphasis on established, high-impact journals.

### a. Data and methodology

53. In this study, Scopus and the Web of Science (WoS) databases are used to examine India’s research output and impact by analysing publication counts and citation metrics for the year 2020. The year 2020 has been selected for analysis as publications from this year can reasonably be considered to have reached a saturation point in terms of accumulated citations. Further, citation counts have been considered only up to 2025, as data for 2026 are still at a nascent stage and remain subject to subsequent revisions. The analysis is illustratively conducted for two distinct subject areas - Economics and Immunology & Microbiology, allowing for a comparative assessment of disciplinary

differences in publication volume and citation dynamics across databases. For the comparison purposes, the same data has also been extracted for USA.

54. Publications and citations were extracted by filtering the WoS database according to publication year and subject categories provided by the WoS. We have considered only three types of documents viz. articles (including early access), book chapters and proceeding papers. These constitute major part of academic knowledge output. While WoS explicitly provides “Economics” as a category, “Business Finance” and “Agricultural Economics Policy” have also been included under “Economics”. This has been done to capture more publications that fall within the broader scope of “Economics” as a subject but are categorised separately in the WoS database. This inclusion is not exhaustive and is limited to this exercise for the purpose of a representative evaluation of academic output.
55. Consistent with the approach adopted for Web of Science, only three document types from the Scopus database were considered for analysis - articles (including early access articles), book chapters and conference proceeding papers, in two broad subject domains; Economics and Microbiology. The Economics domain comprised *Economics, Econometrics and Finance*, while Microbiology encompassed *Immunology and Microbiology*. Within the Economics domain, exclusion of certain documents that fell outside the intended subject scope was also carried out.
56. Based on citation counts, the contribution of the top 1%, 5%, and 10% most cited papers to total citations has been calculated. This has been done to assess the degree of concentration in the quality of publications.
57. Another parameter widely used to assess the productivity and influential impact of research is the h-index developed by J. E. Hirsch. It is a metric of research impact, defined as the ‘h’ number of papers with citation number greater than or equal to ‘h’. This is a useful index to characterize the scientific output of a researcher, thereby balancing the quantity of publications with their quality (citations).
58. Two caveats seem to be in order. First, the number of publications reflected here may not be exhaustive, as this exercise is limited to the number of publications captured by two external databases and the citations therein. Second, any citation-based index has limitations, and only preliminarily reflect the quality of academic output.

## **b. Results**

59. The number of publications, citations and h-index from India and USA in the subjects of Economics and Immunology and Microbiology for the year 2020 is as below:

<b>Table 4: Citation Counts and h-index of publications made in 2020 in two subjects in India and the US</b>							
Data Source	Country	Economics			Immunology & Microbiology		
		No. of publications	Total Citations	h-index	No. of Publications	Total Citations	h-index
Web of Science	India	1413	19243	61	2181	40709	70
	USA	13211	252873	167	14885	444794	210
Scopus	India	3269	45760	90	4253	70848	87
	USA	14309	237541	167	20059	317560	189

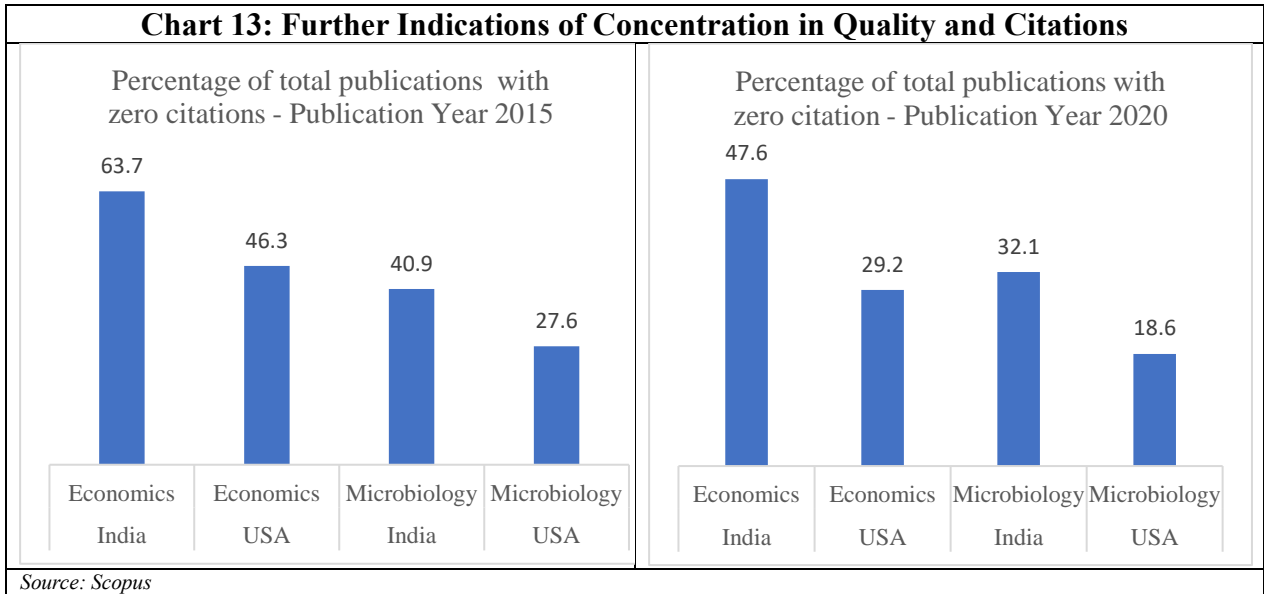
60. The results presented in the above table indicate that the USA is ahead in terms of both the number of research publications and the quality indicators in both the subjects for the year 2020. However, it is not clear as to how exhaustive is the coverage across countries in these databases. This may influence the observed differences. The average number of citations per publication is higher for Immunology & Microbiology than for Economics for both countries.

61. The share of the top 1%, 5%, 10%, and 20% most cited publications in total citations presents a similar picture with respect to research quality. The patterns visible in the case of both countries are broadly similar. The most obvious conclusion is that there are vast differences in the quality of academic publications in both the countries with 20% top-quality output accounting for the lion's share of citations; particularly in the case of the Economics discipline.

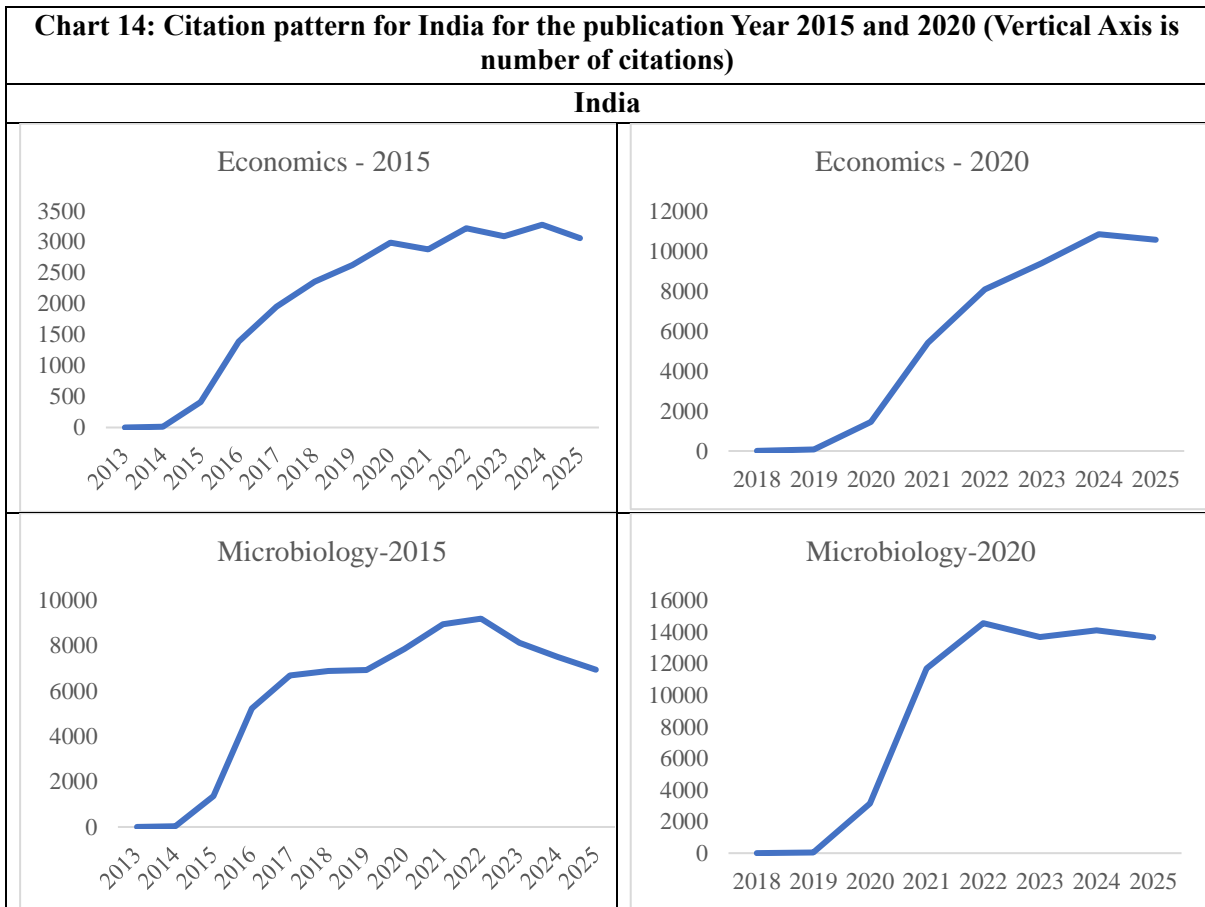
<b>Table 5: Concentration of citations of publications made in 2020 in two subjects in India and the US</b>									
Data Source	Country	Share of Top cited publications in total citations in Economics				Share of Top cited publications in total citations in Immunology & Microbiology			
		1%	5%	10%	20%	1%	5%	10%	20%
Web of Science	India	18%	41%	56%	73%	15%	32%	45%	61%
	USA	21%	42%	57%	74%	18%	36%	49%	64%
Scopus*	India	24%	50%	64%	80%	17%	35%	48%	65%
	USA	20%	41%	55%	71%	19%	38%	50%	65%

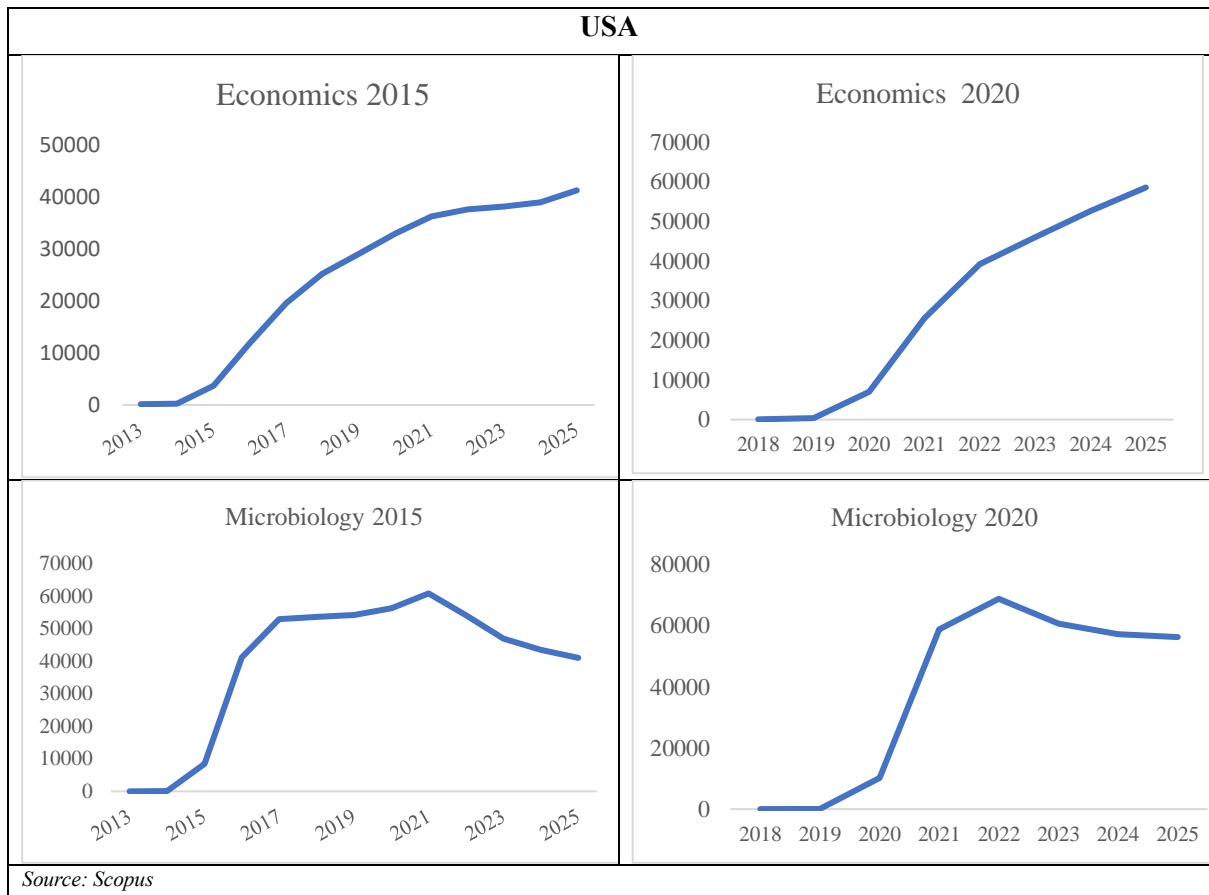
*Notes: \* Only top 10000 publications have been used in analysis.*

62. The distribution of publications produced in India exhibits a longer tail, suggesting that a considerable share of academic output receives relatively limited attention within the scholarly community. This may pose certain challenges for undertaking a more nuanced and comprehensive assessment of the quality and impact of academic research in India. Encouragingly, the size of the tail declined in 2020 (compared to 2015), prima facie indicating some improvements in quality of publications.



63. The eight panels in the Chart 14 are constructed to see if there is an annual pattern in citations, whether citations peak in some year after publication and taper off. Seeing the publications in 2015 and 2020 together suggests that there is no conclusive pattern of tapering off.





### iii. Alternative methods of evaluation

#### a. Altmetrics

64. With the increasing access of internet and social media, the Altmetric Attention Score (AAS) can also be an alternate measure for evaluation of academic output.<sup>63,64</sup> AAS is based on various sources including social media networks, online reference managers or bookmarking sites, blogs and, open access repositories. Altmetric attention score is assigned by different companies based on a combination of different sources and formulae to finally arrive at score. Some of the known providers are Altmetric.com, PlumX, Impactstory, and Article-level metrics-Public Library of Science.
65. Although Altmetrics are designed to reflect the evolving landscape of knowledge dissemination, empirical studies generally find a weak correlation between social media mentions such as tweets and subsequent citation counts. That said, altmetrics appear to be constantly evolving and expanding. Some studies have showed that there is a stronger correlation between the AAS, number of citations and Impact Factor for more recent articles. Nonetheless, since altmetric indicators largely reflect social media engagement, articles addressing more topical or widely appealing themes tend to attract

<sup>63</sup>González, P., Fors, M., & Torres, A. (2025). Altmetrics in the evaluation of scholarly impact: a systematic and critical literature review. *Frontiers in Research Metrics and Analytics*, 10, 1693304.

<sup>64</sup>García-Villar, C. (2021). A critical review on altmetrics: can we measure the social impact factor?. *Insights into Imaging*, 12(1), 92.

greater social attention, which may not be commensurate with their academic or scientific impact. Given these limitations, together with variations in data sources across Altmetric service providers and limited methodological transparency, Altmetric scores should be interpreted with due caution, particularly when they are used as alternatives to conventional indicators of scholarly impact.

## **b. Research impact matrix**

66. One alternative approach to assessing research impact is presented by Sarkies et al. (2021)<sup>65</sup> in “Applying a framework to assess the impact of cardiovascular outcomes improvement research”. The authors apply a research impact matrix developed by Rivera et al. (2017)<sup>66</sup>, which was derived from a systematic review of 24 existing methodological frameworks for evaluating healthcare research impact. This matrix identifies five major categories of impact, primary research-related impact, influence on policy-making, health and health systems impact, health-related and societal impact, and broader economic impact, encompassing 16 subgroups and 80 potential metrics. However, researchers are not required to address every aspect of the methodological framework, and can be customized for each project. Sarkies et al. (2021) has used this matrix to study how research impact can be examined beyond conventional bibliometric indicators to include policy, system-level, and economic dimensions.
67. The matrix utilizes multiple data sources, including documentation review, bibliometric searches, and structured discussions with centre investigators, allowing triangulation of evidence and the identification of impacts that are typically missed in traditional evaluations. However, the study acknowledges several limitations such as relatively short four-year evaluation period reliance on retrospective, self-reported information. Despite these challenges, the authors have argued in favour of more such bespoke research impact matrix analysis which can be utilized to assess the long-term impact of the research publications.

## **c. The ICMR-Impact of Research and Innovation Scale (ICMR-IRIS)**

68. The ICMR Impact of Research and Innovation Scale (ICMR-IRIS), is a novel framework developed by the Indian Council of Medical Research to assess the impact of publicly funded biomedical research and innovation. Conventional metrics mentioned above largely capture scientific visibility, but a comprehensive tool with multiple indicators is often complex and difficult to apply routinely. ICMR-IRIS addresses this gap by converting diverse research outputs into a single common/standardized unit called the Publication-Equivalent (PE).
69. Under this system, one peer-reviewed research publication equals one PE, while additional impact is rewarded with higher PE values. For example, publications influencing clinical or public health guidelines receive 10 additional PEs, granted

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<sup>65</sup>Sarkies, M. N., Robinson, S., Briffa, T., Duffy, S. J., Nelson, M., Beltrame, J., ... & Reid, C. (2021). Applying a framework to assess the impact of cardiovascular outcomes improvement research. *Health research policy and systems*, 19(1), 67.

<sup>66</sup>Cruz Rivera, S., Kyte, D. G., Aiyegbusi, O. L., Keeley, T. J., & Calvert, M. J. (2017). Assessing the impact of healthcare research: a systematic review of methodological frameworks. *PLoS medicine*, 14(8), e1002370.

patents earn 5 PEs, and commercialized health technologies receive up to 20 PEs. High scientific impact, measured through citations or journal impact factor, is also recognized. In total, eight indicators covering scientific, clinical, public health, and innovation outcomes are included.

70. This ICMR-IRIS has been implemented to assess intramural and extramural ICMR research programs, individual projects, institutions, and researchers over a five-year period. The scale allows impact to be standardized as PE per year, PE per Rs. crore of funding, and PE per scientist-year, enabling meaningful comparisons across institutions and programs. Early pilots show encouraging feedback and suggest that the framework can also guide proposal selection and the design of more impactful research. ICMR-IRIS is a flexible, transparent, and practical tool that provides a holistic assessment of research impact using verifiable data. While designed for biomedical research, the framework can be adapted to other disciplines and potentially automated using AI, with the broader aim of incentivizing research that delivers real-world societal benefits.

#### **d. Evaluation of Innovation Excellence Indicators**

71. The report on Evaluation of Innovation Excellence Indicators<sup>67</sup> provides a systematic assessment of publicly funded R&D organizations across multiple dimensions of innovation and research performance. It responds to the limitations of conventional publication- and citation-based metrics by proposing a broader framework that also captures organizational capacity, translational outputs, and socio-economic impact.
72. It adopts a comprehensive indicator-based approach covering R&D inputs, processes, outputs, and outcomes, including investment patterns, institutional capacity, and human resources, while underscoring the importance of public funding for sustaining research infrastructure and long-term inquiry. The framework measures outputs through publications, patents, technology development, and translational research, and cautions against reliance solely on bibliometric indicators.
73. It further evaluates socio-economic impact through policy influence, industrial uptake, commercialization, and contributions to national priorities, enabling comparison across institutions while recognizing diverse mandates. Overall, the report offers an evidence-based benchmarking framework to guide funding allocation, institutional reform, and outcome-oriented performance monitoring in publicly funded R&D systems.

#### **e. The Multidimensional Assessment of Scholarly Research Impact**

74. Moed and Halevi (2015)<sup>68</sup> argues that research impact is inherently multidimensional and cannot be adequately measured using single bibliometric indicators such as publications or citations. While citation metrics capture academic influence, they fail to reflect technological, economic, societal, and policy impacts. He distinguishes

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<sup>67</sup>Confederation of Indian Industry, (2025). Evaluation of Innovation Excellence Indicators.

<sup>68</sup>Moed, H. F., & Halevi, G. (2015). Multidimensional assessment of scholarly research impact. *Journal of the Association for Information Science and Technology*, 66(10), 1988-2002.

multiple impact dimensions and notes that they operate across different time horizons, stakeholders, and non-linear pathways, particularly in basic research.

75. The paper reviews alternative metrics such as social media and policy mentions but cautions about validity and manipulation risks. Moed and Halevi (2015) advocates a purpose-driven, multidimensional evaluation framework in which indicator choice depends on context and is complemented by qualitative assessment and expert judgment. He calls for pluralistic research evaluation systems that replace one-dimensional rankings with broader value-based assessment approaches.

## **VI. Attempts to quantify India’s digital economy**

### **i. OECD Approach**

76. The OECD has advanced a coherent approach to measuring the digital economy.<sup>69</sup> It recognises the fact that traditional industry-based classifications and administrative datasets are structurally not suited to capture digital activity comprehensively because they arrange firms by their productive activities, not by their digital functions, mode of transactions or business models. It emphasises the need to distinguish digital enablers (ICT infrastructure, software, data), digitally enabled business models (platforms, intermediaries, cloud and data-driven services), and the digitalisation of otherwise traditional industries. As traditional databases cannot throw full light on these attributes of firms, use of unconventional data sources would be necessary to estimate the size of the digital economy.

77. A subsequent publication (OECD, 2019)<sup>70</sup> “...provides new insights into the state of the digital transformation by mapping indicators across a range of areas, from education and innovation to trade and economic and social outcomes against current digital policy issues...”. Later, OECD went on to guide preparation of digital SUTs (OECD, 2023)<sup>71</sup> by extending conventional SUTs with three additional dimensions, “the nature of the transaction (the “how”), the goods and services produced (the “what”), and the new digital industries (the “who”). These lead to additional rows and columns within the Digital SUTs compared with the conventional SUTs”.

### **ii. ADB approach<sup>72</sup>**

78. The ADB has developed an input–output–based framework to measure the digital economy using a production-oriented definition of core digital products. Those products are grouped into five purely digital categories. Digitally enabling and digitally enabled products are excluded from the core definition but captured indirectly through sectoral linkages. A core digital GDP equation is formulated to incorporate both direct digital production and the digital requirements embedded in nondigital capital

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<sup>69</sup>OECD, (2014). Measuring the Digital Economy: A New Perspective.

<sup>70</sup>OECD, (2019). Measuring the Digital Transformation: A Roadmap for the Future.

<sup>71</sup>OECD, (2023). Handbook on Compiling Digital Supply and Use Tables.

<sup>72</sup>ADB, (2021). Capturing the Digital Economy: A Proposed Measurement Framework and Its Applications.

formation. Implementation requires detailed national input–output tables, often necessitating industry disaggregation and harmonization. ADB itself acknowledges that the framework has the limitations of relying on the narrowest definition of digital products and excluding the contributions of imports.

79. ADB also presents empirical results for 16 economies that show that core digital GDP accounts for about 2%-9% of total GDP. These shares tended to decline in current prices but continued to grow in absolute levels, reflecting falling prices and rising productivity in digital products. Following this narrow framework, India’s digital sector was estimated to have a share of 5.6% of GDP in 2014. When the digitally dependent economy is considered, the contribution rises substantially to 17%-35% of GDP, especially in service-oriented economies with strong forward linkages from digital sectors. The study finds that digital sectors exhibit stronger multipliers and global value chain integration than nondigital sectors, with rapid growth in cross-border digital services and data flows redefining globalization. The analysis highlights measurement issues, such as valuing “free” digital content and data assets, and notes that while COVID-19 temporarily reduced digital GDP shares, it accelerated e-commerce adoption.

**iii. MoSPI Study<sup>73</sup>**

80. The paper measures the digital economy using a Supply Use Table based framework, first compiling Gross Value Added (GVA) at a detailed activity level and then identifying digital contributions within it. Core digital industries are defined in line with OECD/ADB concepts (ICT, content and media sectors). Their digital GVA is estimated by applying labour-input proportions from PLFS 2017-18 to sectoral GVA derived from NAS and ASI data. Digitally dependent industries are identified indirectly through selected digital occupations from the National Classification of Occupations. Their GVA contribution is estimated using corresponding labour shares, with care taken to avoid double counting between core and dependent components. For 2017-18, the study estimates that the total digital economy contributed 7.38% of India’s GVA, while the core digital economy alone accounted for 6.23%.

**iv. MEITY-ICRIER Study<sup>74</sup>**

81. On behalf of the Ministry of Electronics and Information Technology (MEITY), the Indian Council for Research on International Economic Relations (ICRIER) estimated the GVA of India's digital sectors based on internationally accepted methodologies. Globally, the most widely used methodologies include those formulated by Asian Development Bank (ADB) and OECD. The ADB methodology is simpler and tailor-made to work well under conditions of constrained data availability in many developing

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<sup>73</sup>Anjoy, P. Kumar, R. and Sinha, D.K. Estimating Contribution of Digital Economy in India.

<sup>74</sup>MEITY/ICRIER, (2025). Estimation and Measurement of India’s Digital Economy.

economies. While the ADB approach considers only ICT industries, the OECD broadens the scope to include non-ICT industries.

82. OECD has recognized seven sets of industries/activities as digital. The two criteria used for inclusion of a non-ICT activity as ‘digital’ are: whether goods and services are digitally ordered or digitally delivered. Apart from these, it also includes digital platforms and digital intermediaries, e-tailers, and financial service providers that operate digitally in the digital category. These are described with a 7-fold classification in the table below.

83. In order to circumvent data limitations, the study employed a triangulative approach sourcing data from the national account statistics, MCA database, CMIE, Tracxn, EPFO, PLFS, ASI, market studies, industry reports, and company papers. Under the framework defined in table below, the ICRIER study made three estimates of digital GVA, one based on the ADB approach, another based on the OECD approach, and the third based on the OECD augmented approach to suit the Indian conditions.

<b>Table 6: Classification of Digital entities under the MEITY/ICRIER Study</b>			
Digital Industries	Description	Examples of Firms Operating in India	Databases employed to estimate GVA
OECD 1	Digitally enabling industries (DEI):	Broadly covers activities covered by ADB approach, Computer-related & telecom services, manufacture, trade & repair of ICT goods, services for motion pictures, video and television program production & broadcasting	Entirely based on NAS of MoSPI.
OECD 2	Digital Intermediary (DI) 1: Platforms that are primarily fee-based.	Amazon, Uber, Urbanclap, Makemytrip. They are classified primarily as DIs because they intermediate transactions between multiple independent sellers and buyers.	Database used is Tracxn; Reclassified firms into OECD categories using ICRIER; NIC verification using MCA records; revenues converted to GVA using NAS GVA output ratios; care taken to avoid double counting
OECD 3	DI-2: Platforms that are primarily ad revenue-based	YouTube, Meta, Sharechat	Mostly the same methodology as in OECD 2 above.
OECD 4	Firms dependent on Intermediary platforms	MSMEs selling online, Uber drivers, delivery partnhat areers, content creators	Combination of GMV data, platform commission rates, and survey-based profit shares; Sources include industry studies, primary surveys, platform disclosures, and secondary estimates
OECD 5	DI-3: E-tailers sell goods from their own inventory or controlled	In contrast to DI-1 and DI-2, Nykaa, Pepperfry and Lenskart are e-tailers.	Mostly the same methodology as in OECD 2 above.

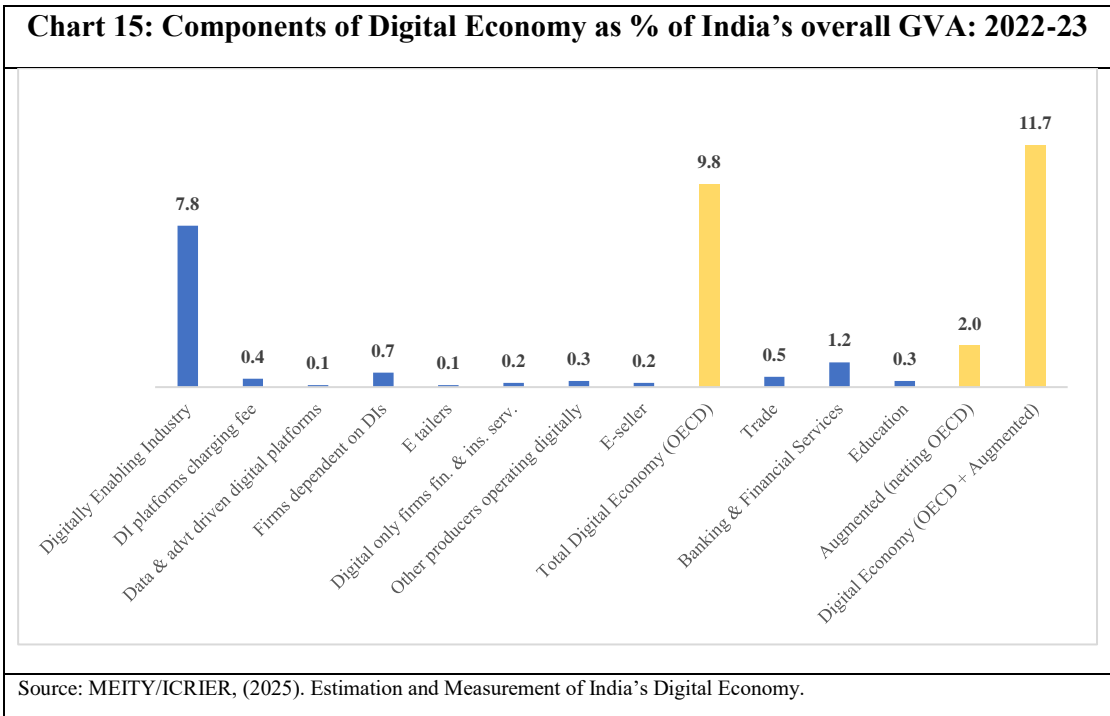
	brands through digital channels		
OECD 6	DI-4: Digital only firms providing financial and insurance services	Razorpay, Lending Kart, WazirX, Groww	Mostly the same methodology as in OECD 2 above.
OECD 7	DI-5: Other producers operating only digitally	Byju's, SonyLiv, Gaana, PlaySimple	Mostly the same methodology as in OECD 2 above.

84. The MeitY/ ICRIER study relied on Tracxn database and other data sources, even while MCA and NAS data were available. This was because, these public sources are not tailor-made to capture the functional and transactional information required by the OECD digital economy framework. MCA-based classifications (including NIC codes, MGT-7 and incorporation forms) describe companies in production-activity terms. They are not sufficient to provide quantifiable information on digital business models such as whether a firm operates as a platform or intermediary, runs a multi-sided market, earns commission-based revenues, or acts as a principal versus an agent. It is a challenge for public databases to catch up with dynamism of evolving business models. Consequently, firms cannot be reliably reclassified into OECD digital categories using MCA or NAS databases.

85. Tracxn database facilitates overcoming this limitation, not through statutory self-reporting, but by constructing business-model classifications ex-post. It aggregates information from company websites and apps, investor pitch decks, funding and regulatory disclosures, media reports, job postings, and observable usage and revenue patterns, and then applies human and algorithmic tagging to infer firms' digital roles (e.g., marketplace versus inventory-led, platform versus D2C, SaaS versus e-commerce). This functional and business-model metadata is available across 50+ countries in terms of global company coverage and digital tagging. However, the depth of structured numeric data reportedly varies among countries covered, depending on publicly available information.

86. The estimates for the digital economy derived from the study for 2022-23 are presented in the following chart.<sup>75</sup>

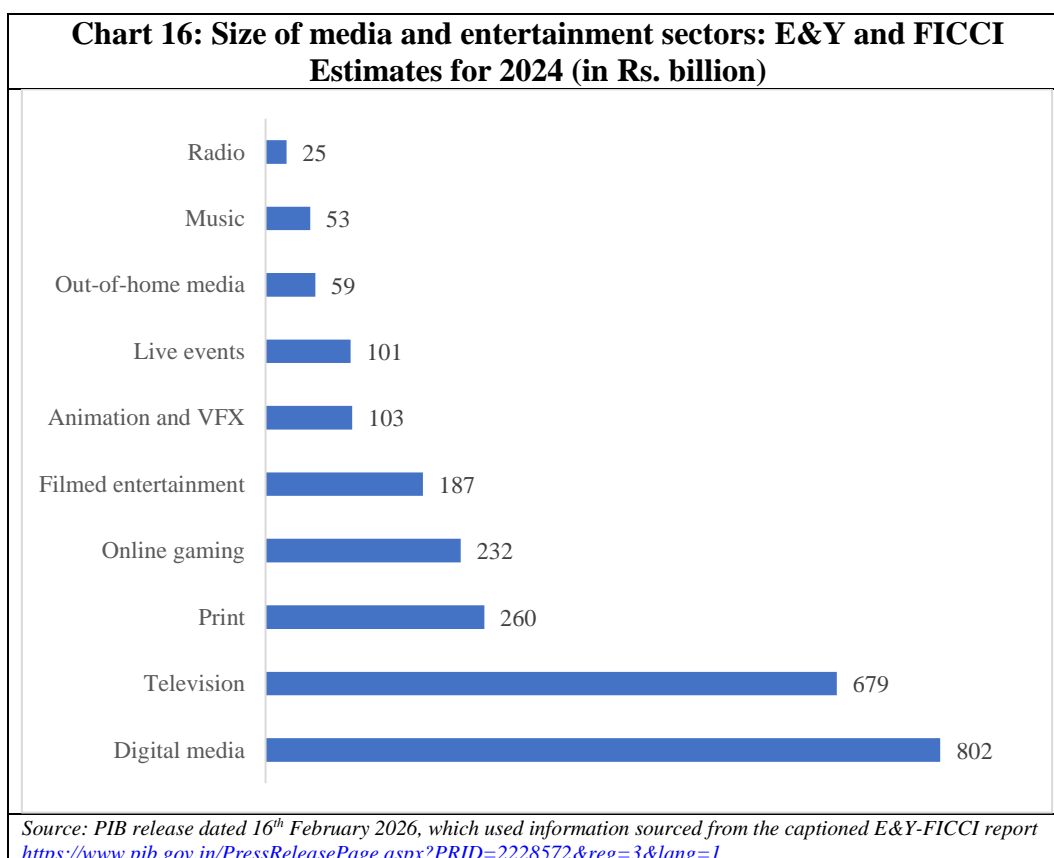
<sup>75</sup>Note: MEITY is of the view that the study represents a valuable and first-of-its-kind effort in the absence of structured or statutory data, there is a need to further expand sectoral coverage and strengthen the robustness of estimation methodologies.



## VII. Creative Sectors

87. Creative sectors generate values from culture, technology, creativity and intellectual properties and are highly knowledge-intensive. Media and entertainment sectors are essential components of creative economy. EY & FICCI, March 2025<sup>76</sup> has given some estimates/approximations of the size of media and entertainment sector in India. EY & FICCI report indicates that the estimates of the components of creative economy were prepared using a combination of primary and secondary research, discussions with industry stakeholders, company interactions, and cross-verification of multiple data sources to estimate the size and growth of India's media and entertainment sector. It further notes that revenues across segments were calculated using different methodologies specific to each sector. The report has estimated a total size of Rs. 2502 billion in 2024; the component-wise details are presented indicatively in the chart below.

<sup>76</sup>Shape the Future: Indian media and entertainment scripting a new story, March 2025. The report mentions, EY does not take any responsibility for the veracity of the underlying data".



## VIII. Conclusions

88. The chapter has attempted to present the available methodologies and the quantitative measures that can be derived from them. The available statistical products are not fully designed to capture knowledge products. Addressing this gap will require systematic data development from multiple sources and perspectives.
89. A review of the research and development information base indicates scope for improvement in both timeliness and granularity. A clear and up-to-date classification of R&D expenditure into current and capital components would further strengthen analysis. In the case of private sector R&D, greater use of sources such as the MCA database in addition to primary survey data, may be considered.
90. Beyond administrative data on applications, registrations, and the legal status of intellectual property rights, there remains limited understanding of the factors impacting the development of IPR markets in India. The broader market dynamics and structural challenges underlying this issue continue to be insufficiently documented. There exist measures of academic output valuation ranging from simple to highly complex. Simple indicators, such as citation indices, can be readily derived from well-curated databases, whereas multidimensional indices require extensive data across several dimensions. In India, an Indian Citation Index was initiated by a private entity but is no longer operational. Shodhganga, India's national digital repository of doctoral theses and dissertations, maintained by the INFLIBNET Centre under the UGC provides comprehensive thesis access but does not report citation counts. The

development of a comprehensive Indian database covering publications across subjects and years, along with citation and related metadata, would significantly strengthen research evaluation while also facilitating and encouraging further research. Such an infrastructure would be essential for extending ICMR-IRIS type evaluation frameworks to other disciplines.

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## Chapter 3

### India's Traditional Knowledge—Dimensions and Challenges

#### I. Introduction

1. Indian Traditional Knowledge (ITK) can be broadly understood as a cumulative body of knowledge, practices, beliefs, and skills that have evolved over centuries through the lived experiences of local communities across the Indian subcontinent. Such knowledge has been shaped through continuous interaction between people and their natural, social, and cultural environments. The traditional knowledge (TK) has typically been transmitted across generations through oral traditions, apprenticeship, and community practices, making it deeply embedded in everyday cultural lifeways. Indian traditional knowledge spans a wide range of domains, including medicine, agriculture, ecology, philosophy, education, architecture, and other cultural expressions, often weaving therewith social organizations. As such, it represents not merely a historical legacy but a dynamic system of knowledge that continues to inform contemporary practices and strategies for resilience, sustainability, and community well-being.
2. Within the broader framework of Indian Knowledge Systems (IKS), traditional practices encompass diverse fields such as traditional medical systems, most notably Ayurveda, Unani, Siddha, and Homeopathy, as well as environmental management, agricultural practices, water conservation techniques, linguistic traditions, and indigenous pedagogical methods. These knowledge traditions often integrate practical, ethical, and spiritual dimensions, reflecting a holistic worldview in which human health, ecological balance, and social harmony are closely interconnected. For instance, traditional medical systems emphasise preventive health and balance within the body, while indigenous agricultural practices often rely on ecological principles such as crop diversity, organic inputs, and sustainable resource use.
3. In the Indian context, traditional knowledge has been preserved through both textual and non-textual forms. A significant portion of this knowledge has been recorded in classical texts such as the Vedas, Upanishads, Ayurvedic treatises like the *Charaka Samhita* and *Sushruta Samhita*, and other philosophical and scientific works. However, a substantial share of traditional knowledge remains tacit, context-specific, and orally transmitted, particularly within rural and tribal communities. This orally transmitted knowledge is often closely tied to local ecological conditions, community institutions, and cultural practices, making it highly adaptive but also vulnerable to loss in the face of rapid socio-economic and cultural change.
4. Recognising this challenge, the existing literature has emphasised the need for systematic documentation, preservation, and analysis of both textual and oral knowledge traditions. Scholars have highlighted the importance of transcribing regional manuscripts, documenting oral histories, and recording community-based practices that

remain under-researched and insufficiently represented in formal academic discourse. Such documentation is crucial not only for safeguarding cultural heritage but also for enabling rigorous scholarly analysis and policy engagement with traditional knowledge systems.

5. The chapter is organized into seven sections. The second section, following this introduction, makes a brief review of research on India's traditional knowledge. The third section presents the available sources of documentation and classification of India's TK. Section 4 attempts to build preliminary quantities on TK, based on available economic data. This can serve as a precursor to developing comprehensive estimates based on new data. Section 5 provides details of the progress of geographical indications (GIs) of India, which are closely associated with India's TK. The sixth section briefly evaluates the available information on the progress of Ayush, an important policy focus connected closely with TK. Section 7 concludes the discussions with suggestions for future work.

## II. Literature review

6. This section presents the literature that has examined different dimensions of Indian traditional knowledge, including its historical evolution, institutional changes, contemporary relevance, and the challenges associated with its documentation, protection, and integration into modern economic and policy frameworks.
7. Gadgil et al. (1993)<sup>77</sup> conceptualise TK as a cumulative, experience-based system evolving through long-term interaction between communities and ecosystems, in contrast to the short-term orientation of modern scientific knowledge. They show that practices such as sacred groves, rotational harvesting, and community forest management form a knowledge-practice-belief complex, where ecological sustainability is embedded in cultural norms and social regulations. The authors argue that traditional conservation practices are not based on explicit scientific calculation but on keen observations and experiential science with adaptive "rules of thumb" refined through trial and error over long historical periods.
8. Barpujari (2018)<sup>78</sup> shows that British forest policies fundamentally altered the relationship between communities and natural resources by centralizing control in the state and criminalizing customary practices. Traditional systems of forest management, which were based on local knowledge and collective decision-making, were gradually replaced by bureaucratic and extractive models of governance. The author underscores the need to recognise community knowledge and customary rights in contemporary debates on sustainable development and ecological governance in India.

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<sup>77</sup>Gadgil, M., Berkes, F., & Folke, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio-Stockholm*-, 22, 151-151.

<sup>78</sup>Barpujari, I., & Sarma, U. K. (2018). Protection of traditional knowledge: role of the national IPR policy. *Economic and Political Weekly*, 29-34.

9. Ajeet Mathur (2003)<sup>79</sup> introduces a political economy perspective by examining the question of ownership of traditional knowledge. The author further argues that such knowledge has been increasingly appropriated by public agencies, corporations, and global markets, particularly in sectors like Ayurveda, medicinal plants, and agriculture. Mathur highlights that its erosion is not merely cultural but reflects struggles over rights, control, and economic benefits, linking traditional knowledge to debates on intellectual property, bioprospecting, and benefit-sharing.
10. Studies on tribal development highlight the gap between traditional knowledge systems and the formal education structure. Venkatarao and Murthy (2022)<sup>80</sup> argue that tribal communities in India possess extensive traditional knowledge across diverse domains such as arts, medicine, dance, painting, environmental management, and sustainable resource use. However, the mainstream education system often overlooks and marginalises these important traditional skills, leading to their gradual erosion among tribal youth. Integrating traditional knowledge with formal skill training can therefore play a critical role in improving socio-economic outcomes for tribal youth.
11. Moitra and Madan (2025)<sup>81</sup> examine the integration of Indian Knowledge Systems, particularly Ayurveda, into higher education. Using qualitative evidence, the authors find a clear gap between recognition of IKS's value and its actual implementation, with educators lacking confidence, students unsure of its relevance, and institutions constrained by dominant Western frameworks. The study highlights Ayurveda's potential to complement modern health sciences, provided, there is curriculum reform, faculty training, and evidence-based integration. Aligning with the NEP 2020, the authors propose the need for capacity building, curriculum redesign, and interdisciplinary research, and thus positioning IKS as a complementary system for addressing socio-economic challenges.
12. Sahana (2025)<sup>82</sup> critically examines Nature-Based Solutions in the Indian Sundarbans and argues that conservation efforts often reproduce "green colonialism" by marginalising local and traditional knowledge systems. Drawing on ethnographic evidence, the study shows that externally driven programmes undermine customary practices and livelihoods that have historically sustained mangrove ecosystems. Indian traditional ecological knowledge is posited as a living, place-based system of environmental governance, with practices such as species-specific mangrove management functioning as effective, locally adapted solutions.

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<sup>79</sup>Mathur, A. (2003). Who owns traditional knowledge? *Economic and political weekly*, 4471-4481.

<sup>80</sup>Venkatarao, N., & Murthy, R.S. (2022). Analysis of Tribal youth Perception towards Skill development YTC Training. *International Journal of Novel Research and Development*, 7(6).

<sup>81</sup>Moitra, P., & Madan, J. (2025). Stakeholder perspectives on integrating Ayurveda and Indian Indigenous Knowledge Systems into higher education: An exploratory study. *Social Sciences & Humanities Open*, 11, 101453.

<sup>82</sup>Sahana, M. (2025). Local and indigenous knowledge systems on nature-based solutions: Addressing Green Colonialism in Mangrove restoration of the Indian Sundarbans. *Political Geography*, 122, 103405.

13. Gebru (2015)<sup>83</sup> examines the protection of Indian traditional knowledge through the lens of intellectual property rights, highlighting the mismatch between community-based, cumulative knowledge systems and patent regimes based on novelty and individual ownership. The author argues that this gap has left traditional knowledge vulnerable to misappropriation and biopiracy. While initiatives like the Traditional Knowledge Digital Library (TKDL) have helped prevent illegitimate patent claims by documenting knowledge in patent-compatible formats, Gebru notes that such approaches remain limited. Hence, the issues related to community ownership and benefit-sharing are not adequately addressed.
14. Fredriksson (2023)<sup>84</sup> sees TKDL as a legal and institutional mechanism to prevent the misappropriation of Indian traditional medical knowledge. The author shows how the TKDL translates systems such as Ayurveda, Unani, Siddha, and Yoga into formats compatible with international patent classification, thereby strengthening India's ability to challenge illegitimate patent claims. At the same time, he argues that such documentation risks decontextualising living knowledge systems and shifting control from communities to state and expert institutions.
15. Similarly, Sen and Chakraborty (2014)<sup>85</sup> caution that documentation-based protection has limitations, as it may de-contextualise living knowledge systems and shift control away from local communities. The authors further argue that effective governance of traditional knowledge requires broader frameworks that ensure community participation, collective rights, and equitable benefit-sharing.
16. Bhatia (2014)<sup>86</sup> provides an integrative overview of ITK Systems, emphasising their historical depth, continuity, and relevance for development. The author highlights their wide scope across domains such as education, astronomy, Ayurveda, agriculture, architecture, and water management, all shaped by long-term interaction with local ecological and social contexts. He argues that these systems, transmitted through texts and oral traditions, offer sustainable and context-specific solutions, particularly in areas like health, farming, and resource management.
17. A common theme across the literature is the recognition that ITK is not merely cultural heritage or folklore, but a systematic and practice-oriented form of knowledge that has historically guided production, health, environmental management, and social organization. Issue-specific research will be reviewed in corresponding sections subsequently.

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<sup>83</sup>Gebru, A. K. (2015). International intellectual property law and the protection of traditional knowledge: From cultural conservation to knowledge codification. *Asper Rev. Int'l Bus. & Trade L.*, 15, 293.

<sup>84</sup>Fredriksson, M. (2023). India's traditional knowledge digital library and the politics of patent classifications. *Law and Critique*, 34(1), 1-19.

<sup>85</sup>Sen, S., & Chakraborty, R. (2014). Traditional Knowledge Digital Library: a distinctive approach to protect and promote Indian indigenous medicinal treasure. *Current science*, 106(10), 1340-1343.

<sup>86</sup>Bhatia, R. P. (2014). Traditional Knowledge Systems in India and their Relevance. *Journal of Indian Education*, 40(2), 58-69.

### **III. Documentation and Databases**

18. A number of institutions and organizations are dedicated to documenting and preserving Indian traditional knowledge.

#### **i. Traditional Knowledge Digital Library (TKDL)**

19. TKDL was set up by the Govt. of India through a collaboration between the Council of Scientific and Industrial Research (CSIR) and Department of Indian Systems of Medicine & Homeopathy (now Ministry of Ayush) in 2001. The TKDL represents an important initiative by the country to translate and systematise ITK from classical texts (e.g., Ayurveda, Siddha, Unani) into searchable formats to counter biopiracy and misappropriation of Indian TK through erroneous patent grants. TKDL has transcribed over 5.2 lakh of formulations and practices into multilingual digital records. While primarily designed to prevent misappropriation and biopiracy, TKDL has also enabled numerical assessments of the scale and diversity of codified traditional medical knowledge. Expansion into other subject areas for inclusion in the TKDL has been initiated.

#### **ii. People's Biodiversity Register**

20. Mandated under the Biological Diversity Act, 2002, the People's Biodiversity Register (PBR) is a locally maintained repository that documents flora, fauna, livelihoods, and traditional knowledge, particularly related to medicinal plants. The PBR is prepared through community participation, involving Biodiversity Management Committees, educational institutions, NGOs, and citizens, with guidance from national and state biodiversity authorities. Beyond conservation, the PBR promotes sustainable use of biological resources and ensures fair and equitable benefit sharing through the Access and Benefit Sharing mechanism, thereby supporting the rights of traditional knowledge holders. As per MoEFCC, 2023 data, around 2.67 lakh PBRs have been prepared in India, though many are not regularly updated.

#### **iii. Wealth of India**

21. *The Wealth of India*, published by the Council of Scientific and Industrial Research (CSIR), is an encyclopaedic series that systematically documents India's natural resources, including plants, animals, minerals, and other raw materials. It provides detailed information on their occurrence, distribution, composition, utilisation, and trade, serving as an authoritative reference on India's natural resources. The series compiles scattered knowledge into monographic entries covering scientific nomenclature, distribution, uses, and production patterns. It also plays an important role

in documenting traditional knowledge and biodiversity, helping prevent bio-piracy and support intellectual property claims.

**iv. National Report on Biodiversity**

22. The report provides an indicator-based assessment aligned with India's National Biodiversity Strategy and Action Plan (2024-2030) and the global biodiversity framework, using 142 indicators across 23 National Biodiversity targets and reflecting a whole-of-government approach. It highlights that all targets are on track, with notable progress in forest and tree cover, Ramsar wetlands, and protected areas, along with conservation of key species.

**v. National Report on Access and Benefit Sharing**

23. India's First National Report on the Nagoya Protocol, submitted in February 2026 reviews the country's progress in implementing Access and Benefit Sharing (ABS) from 2017 to 2025. India's ABS framework operates under the Biological Diversity Act, 2002 through a three-tier system of the National Biodiversity Authority, State Biodiversity Boards, and Biodiversity Management Committees (BMCs), with over 2.76 lakh BMCs enhancing decentralised governance. During this period, 2017 to 2025, 12,830 ABS approvals were granted, and 3,556 Internationally Recognised Certificates of Compliance were issued, accounting for a significant portion of the global total.

**vi. Indian Council of Forestry Research and Education (ICFRE)**

24. ICFRE is an autonomous body under the Ministry of Environment, Forest and Climate Change and serves as the apex institution for forestry research, education, and extension in India, with a focus on promoting ecological stability, sustainable development, and scientific management of forest resources. ICFRE supports policymaking, conducts need-based research aligned with national priorities, and disseminates scientific knowledge for sustainable forestry and livelihood enhancement.

**vii. Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA)**

25. The Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA) is a statutory body established under the Protection of Plant Varieties and Farmers' Rights Act, 2001 to protect plant varieties while safeguarding farmers' interests. It grants intellectual property rights to breeders for new plant varieties and maintains a system for their registration. At the same time, it uniquely recognises farmers' rights by allowing them to save, use, exchange, and sell seeds, and even register their own varieties. By balancing innovation with traditional practices, the PPVFRA promotes agricultural development, biodiversity conservation, and prevents biopiracy in India.

#### IV. Taxonomy of Indian Knowledge System

26. Ijatuyi et al., (2025)<sup>87</sup> shows how traditional knowledge and scientific knowledge are complementary. The former offers context-specific sustainability, while the latter provides scalable, empirical tools. They argue that such integration is constrained by epistemological differences and power imbalances, requiring collaborative frameworks with local communities as equal partners. Along similar lines, Kumar (2025)<sup>88</sup> argues that in Himachal Pradesh, traditional systems (like kuhls, gharats, handicrafts and sacred forests) sustain livelihoods and ecology. Despite their importance, they face decline and weak policy support, underscoring the need for integration with modern development for inclusive growth.
27. The Bhāratīya-jñāna-suśruta-kāryakramā (2024-25)<sup>89</sup> outlines an academic framework which attempts to align Indian Knowledge Systems (IKS) with modern academic disciplines. The framework maps with the following considerations.
- IKS is rooted in two core categories of knowledge: *Parā Vidyā* (philosophical, spiritual, consciousness-related knowledge) and *Aparā Vidyā* (knowledge of the material world, sciences, arts, society, technology). IKS also recognises the differences between *vidya* (structured, codified knowledge systems) and *kalas* (skills, arts, applied practices).
  - Knowledge is divided into 16 broad themes in IKS (presented below), under which different branches are organised.
  - Any knowledge system, including IKS, grows through three sequential stages; documentation (conservation, consolidation of existing knowledge, novel presentation), understanding (investigation into ‘how’, ‘why’ and ‘what’ questions) and applications (use in technology, policy, industry and society).
  - Lastly, mapping of each of the 16 themes of IKS is done with a multi-disciplinary set of modern disciplines that will help each IKS theme navigate the afore-mentioned three development stages.
28. The resulting mapping of IKS themes with the multi-disciplinary sets of modern disciplines is presented in the table below.

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<sup>87</sup>Ijatuyi, E. J., Lamm, A., Yessoufou, K., Suinyuy, T., & Patrick, H. O. (2025). Integration of indigenous knowledge with scientific knowledge: A systematic review. *Environmental Science & Policy*, 170, 104119.

<sup>88</sup>Kumar, R. (2025). Role of traditional knowledge in securing sustainable livelihoods in Himachal Pradesh. *EPR International Journal of Research and Development (IJRD)*, 10(5).

<sup>89</sup>Bhāratīya-jñāna-suśruta-kāryakramā भारतीयज्ञान सुश्रुत काययक्रमः (2024-25). A Document for Understanding IKS Minor Themes.

<b>Table 1: Thematic presentation of Indian Knowledge System</b>			
<b>S. No.</b>	<b>Theme</b>	<b>Indian Knowledge System</b>	<b>Contemporary Knowledge System</b>
<b>1.</b>	Vedic Philosophical and Cognitive Sciences	Darsanas, Upanishads, Prasthan Trayi, Yoga	<b>HSS:</b> Philosophy, Epistemology, Ontology, Philology <b>STEM:</b> Cognitive Science, Neuroscience, Psychology
<b>2.</b>	Historical and Civilizational Sciences	Purva Mimamsa, Samhita, Brahmana, Shrauta Sutras, Grihya Sutra, Shulba Sutra, Itihasa, Purana, Dharma sastra, Itihasa, Purana, Kavya	<b>HSS:</b> History, Archaeology, Anthropology, Manuscriptology, Epigraphy, Philology, Geography <b>STEM:</b> Data Science, Mathematics, Computer Science
<b>3.</b>	Contemporary Social / Cultural Sciences	Purva Mimamsa, Samhita, Brahmana, Shrauta Sutras, Grihya Sutra, Shulba Sutra, Itihasa, Purana, Dharma sastra, Itihasa, Purana, Kavya	<b>HSS:</b> History, Archaeology, Anthropology, Manuscriptology, Epigraphy, Philology, Geography <b>STEM:</b> Data Science, Mathematics, Computer Science
<b>4.</b>	Mathematical, Physical and Astronomical Sciences	Jyoutisha, Shulba Sutras	<b>HSS:</b> History of Science <b>STEM:</b> Astronomy, Algebra, Number theory, Geometry
<b>5.</b>	Speech and Linguistics	Siksha, Vyakaranam, Chandas, Nirukta, Mimamsa, Mantra Shastra	<b>HSS:</b> Comparative Linguistics, Lexicography <b>STEM:</b> Speech Science, Phonetics, Speech Signal Processing, Speech recognition, Natural Language Processing
<b>6.</b>	Political, Economic and Strategic sciences	Dhanurveda, Artha Sastra, Dandaniti, Rajaniti	<b>HSS:</b> Political Science, Modern military history, Strategic Affairs, Economics, Public policy, Management, Behavioural Science, Psychology <b>STEM:</b> Systems Science and Modelling, Econometry
<b>7.</b>	Medical and Health sciences	Ayurveda, Yoga, Sankhya	<b>HSS:</b> Public Policy, Psychology <b>STEM:</b> Medicine, Physiology, Anatomy, Statistics, Life Sciences, Systems Biology, Medical
<b>8.</b>	Culinary, Nutritional and Pharmacological Sciences	Paka sastra, Vrikshaayurveda, dravya vijnana, ayurvediya kalas, Siddha, Folk medicine	<b>HSS:</b> Home Science, Nutrition <b>STEM:</b> Pharmacology, Botany, Zoology, Biochemistry, Systems Biology

9.	Agricultural Science, Veterinary and animal husbandry	Krushi vijnana, vriksha-ayurveda, best practices in agriculture and animal husbandry	<b>HSS:</b> Public Policy <b>STEM:</b> Agriculture, Process Engineering, Botany, Zoology, Veterinary Science, Meteorology, Climate Science
10.	Performing Arts	Natya sastra, Gandharva kalas, Alankara Sastra, Sahitya/Kavya, Itihasa, Purana	<b>HSS:</b> Musicology, Animation, Computer graphics, Cinematography, Histrionics, Aesthetics <b>STEM:</b> Signal processing, Affective Neuroscience, Acoustics and Mechanics of instruments
11.	Mechanical & Digital Design & Engineering	Yantra Kala, Rasa shastra, Dhaatu Shastra, Vaastu Shastra, Purana, Itihasa,	<b>HSS:</b> History of Science, Animation, Digital design, UI design <b>STEM:</b> Mechanical Engineering and Industrial Design, Chemistry, Metallurgy, Data Science & ML, Natural Language Processing, Computer Vision, Embedded systems
12.	Civil and Architectural Science	Vaastu sastra, Shilpa sastra, Tantra, Shulba Sutras	<b>HSS:</b> Archaeology <b>STEM:</b> Architecture, Conservation, Structural Engineering, Town Planning
13.	Fine Arts and Sculpture	Shilpa sastra, Alekhyaaadi kalas, traditional styles across the country like Thanjavur, Madhubani	<b>HSS:</b> Fine arts, Sculpture, Art history <b>STEM:</b> Dyes, Organic paints, Chemistry, dating of Art
14.	Chemical, Metallurgical & Material Sciences	Rasayana sastra, Dhaatu sastra, Itihasa, Purana, Kavya	<b>HSS:</b> History, Archaeology <b>STEM:</b> Chemistry, Metallurgy, Material Science
15.	Fashion and Interior Design	Alankaara sastra, Alankaara kala, Natya sastra, Yoga, Tantra	<b>HSS:</b> Fashion, Interior Design, Aesthetics <b>STEM:</b> Materials, 3d printing, Marketing, Public policy, marketing
16.	Edutainment Sciences	Krīd ā in kalā, Itihasa, Purana, Darsana, Yoga, Sankhya	<b>HSS:</b> Educational Science <b>STEM:</b> Game design, Toy making, scalable manufacturing, Psychology

29. The rationale for the mapping above theme is presented in the larger table presented at Annexure. This alignment (or an expanded variant of it) can guide domain-focused and integrated development of traditional and modern knowledge spheres.

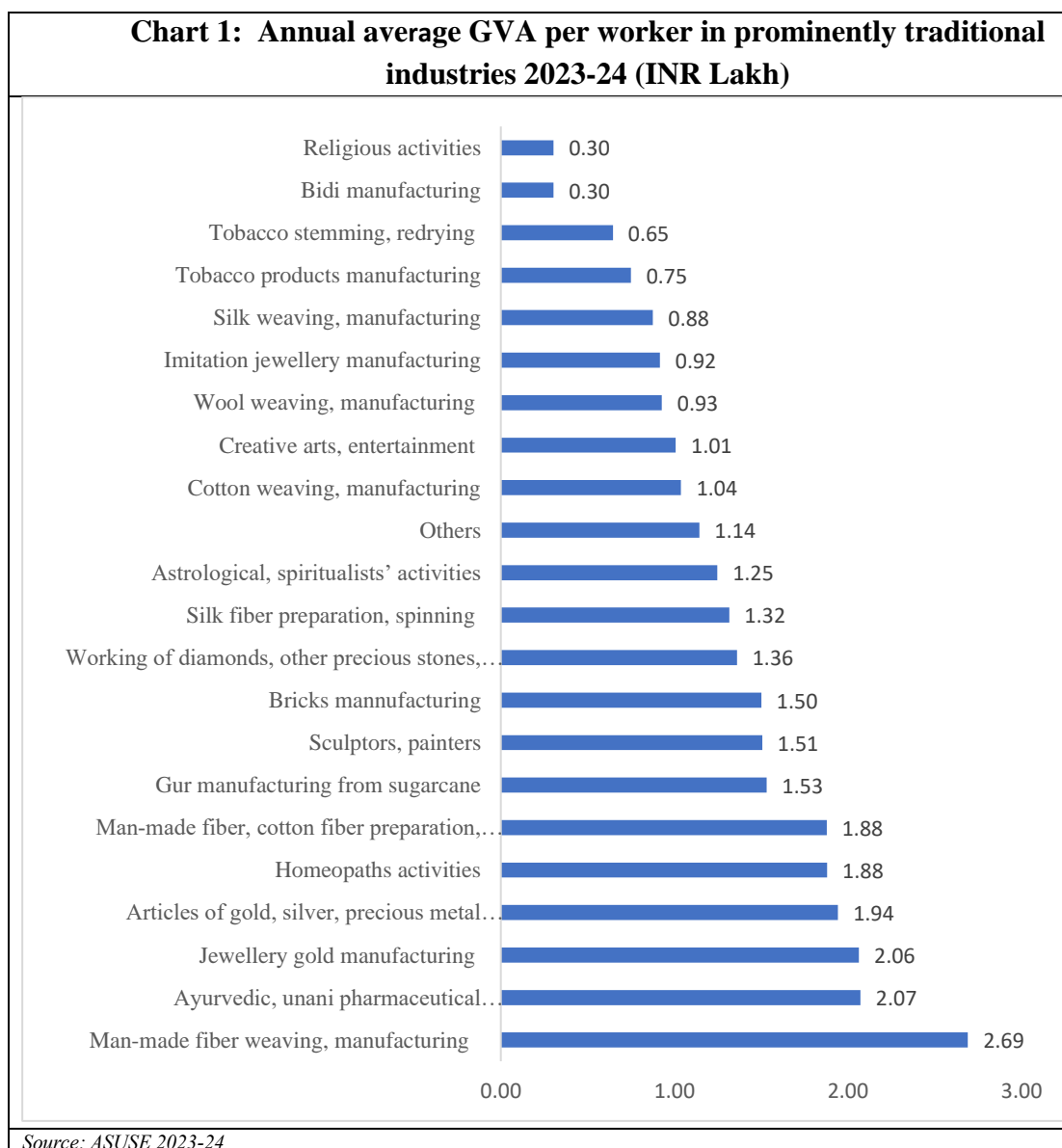
## **V. Valuation of Traditional Knowledge: - challenges, importance and possibilities**

30. Recognizing the importance of traditional activities is distinct from quantifying their economic value. There are conceptual and practical challenges in quantifying the economic value of traditional knowledge. The first is a definitional challenge; much of Indian traditional knowledge is tacit, context-specific, and orally transmitted, making it difficult to apply standard metrics. Second, conventional indicators rooted in modern science and economics often fail to capture the collective and cumulative nature of knowledge creation. A purely market-based assessment does not fully capture the overall contribution of traditional knowledge. Beyond measurable economic outputs, traditional knowledge systems generate a range of non-market benefits, including preventive healthcare practices, ecological sustainability through environmentally sensitive agricultural and resource management methods, and the strengthening of social and cultural cohesion within communities. These intangible contributions are often embedded in everyday practices and community institutions and therefore remain underrepresented in conventional economic measurements. Third, attempts at quantification risk reducing complex cultural systems to narrow economic measures, potentially reinforcing the very commodification concerns raised in ownership debates.
31. Nonetheless, quantification is necessary to assess and compare the state of development of traditional components of knowledge. The mapping attempted in the previous section leaves a gap in aligning traditional knowledge systems with formal economic sectors. This alignment is important because quantities and values are often generated based on economic activities following standard classifications. Aligning traditional knowledge to formats where data are available requires an activity-based approach, where the focus shifts from knowledge domains to the actual economic activities. In this section, we make two modest attempts at capturing the economic value of traditional sectors.

### **i. ASUSE-based approach**

32. We have narrowed the scope to prominently traditional sectors activities captured within the Annual Survey of Unincorporated Sector Enterprises (ASUSE). This delimitation is methodologically justified, as ASUSE provides evidence of economic activity of predominantly informal sector enterprises where traditional skills and methods continue to play an important role. We make use of the unit-level data from the ASUSE. Further, it is acknowledged that many economic activities include elements of both traditional and modern streams of knowledge. To address this in a limited way, we identify relevant National Industrial Classification (NIC) codes at the 5-digit level that correspond to economic activities prominently related to traditional knowledge. The selection of sectors is based on literature and informed judgements.

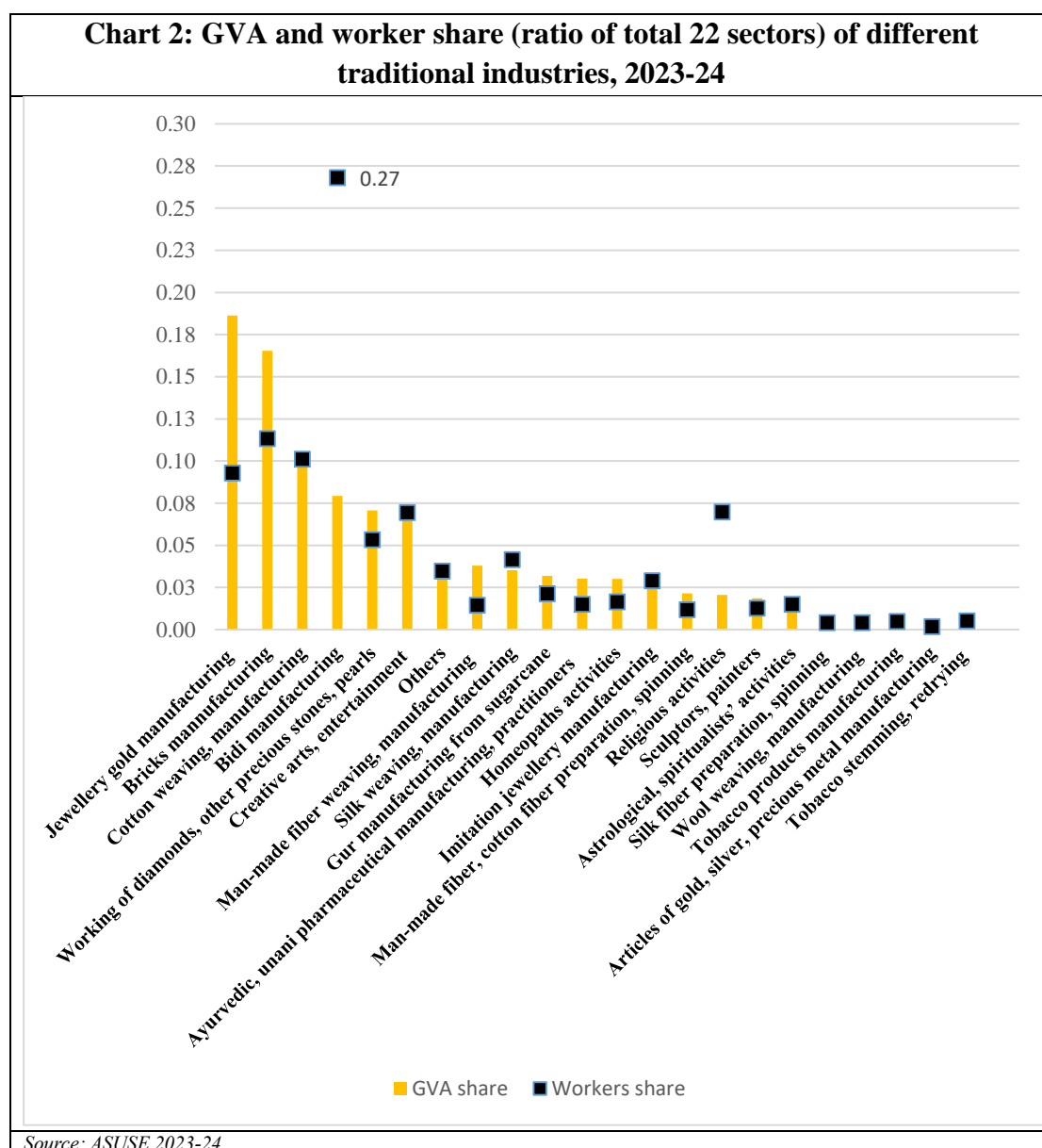
33. We focus on value addition and employment, and report gross value added per worker (worker productivity), GVA share, and employment share for the year 2023-24. We consider 31 traditional industries from the ASUSE 2023-24 survey, and the data are aggregated into 22 industry categories. A few industries have been merged in to single category owing to smaller sample size.



34. There is significant variability in the worker productivity in different traditional segments. The highest GVA per worker has been observed in Man-made fiber weaving, manufacturing industry and the lowest in religious activities. Ayurvedic medicines, herbal and natural products, yoga services, and wellness tourism have experienced significant growth in recent years, reflecting both increasing consumer interest in holistic health practices, policy focus on the area and the global popularity of Indian knowledge traditions. This growing market underscores the economic potential of

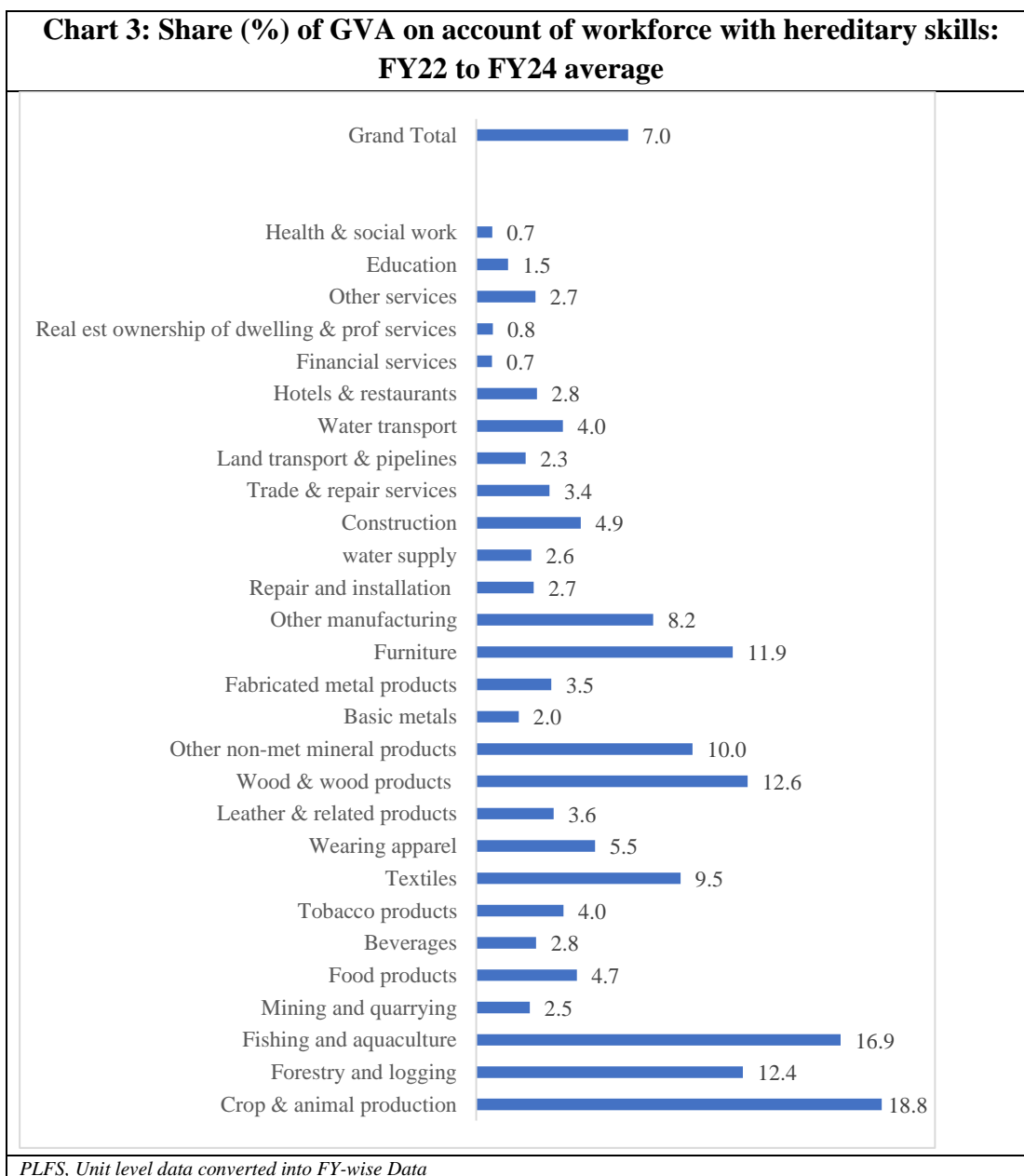
traditional knowledge systems in general and their role in emerging health, lifestyle, and cultural industries.

35. The figure below presents GVA share and workers share of different industries for the year 2023-24. The column bars represent GVA share, while the dots indicate the workers share, both expressed as a ratio of the total of 22 sectors. GVA shares are arranged in descending order, and the corresponding worker share of each industry is represented by dots. The chart echoes the same set of indications as at the chart above. The most striking point is the contrast between worker share and GVA share in segments like bidi manufacturing and religious activities. Bidi manufacturing, gradually waning in importance, still holds more than 20 lakh workers as per the ASUSE survey. This meant 27% of the workforce of the 22 sectors, but they produce only 8% of the GVA. Similar is the case of religious activities.



## ii. PLFS-NAS approach

36. The foregoing analysis considered only the unorganized segment of the traditional activities. Here we attempt to present certain base quantities for the traditional sector using available official databases, namely the Periodic Labour Force Survey (PLFS) and the National Account Statistics (NAS). As a matter of caution, it must be emphasized that the quantities presented here are only indicative and should not be viewed as conclusive measures of the contribution of the traditional sector to the economy.
37. We are leveraging a question asked in the PLFS respondent questionnaire. While recording information on vocational education, the PLFS provides an option to identify whether a worker is only hereditarily trained. However, equating the hereditarily trained workforce with the workforce that carries Indian systems of knowledge involves limitations. For instance, in sectors that are relatively well developed, such as Ayurveda, production and value chains are not based solely on hereditarily inherited skills. Many Ayurveda-based enterprises and practitioners operate in the formal sector with formally trained doctors and technicians generating substantial turnover. Conversely, a non-negligible portion of hereditarily inherited skills, for instance, in the farm sector may not necessarily be based on Indian traditional knowledge. These dynamics are not adequately captured by this approach. However, this is presented as reference statistic for future studies attempting refinements and further detailing.
38. We first estimated the sector-wise share of hereditarily trained workers within the total workforce of each sector using unit-level data from the PLFS. A comparison of workforce shares with income shares (both derived from the PLFS) revealed significant differences in the marginal productivity of hereditarily skilled workers, as reflected in their earnings. In light of this, the sector-wise income shares of hereditarily skilled workers also derived from the PLFS, provides a more appropriate measure. Multiplying these income shares by the corresponding sectoral GVA from the NAS yields an approximation of their contribution to GVA. These GVA shares of the hereditarily skilled workforce are presented in the following chart.



39. The overall GVA share of hereditary skills in the national GVA is 7% during FY22 to FY24, as seen above, with wide-ranging sector-specific dispersion.
40. There are several ways in which the base study can be extended. For instance, in the crop sector, the national accounts provide output values for nearly 130 crops. A comprehensive meta-study of major crops could enable a more meaningful classification. One possible approach is to group crops into broad categories such as: (a) predominantly indigenous crops, characterised by low use of hybrid seeds and reliance on traditional agronomic practices; (b) crops largely shaped by the Green Revolution, using hybrid or high-yielding variety (HYV) seeds developed through formal R&D systems; (c) plantation crops introduced through global plantation systems; and (d) horticultural crops associated with high-value, commercial cultivation methods.

41. However, several major pan-Indian crops may not fit neatly into these categories. For example, paddy cultivation exhibits substantial regional variation in practices. In such cases, geographically disaggregated meta-studies would be necessary to identify and quantify the extent of traditional content with greater precision. Besides, the forthcoming section shows that there are 225 GIs in the country that are agriculture-based. There exists a substantial body of dispersed studies on GIs and crop-specific agronomic practices. Synthesising this literature will also help to arrive at a useful basis for classifying crops according to the extent of their traditional content.

## **VI. Geographical Indications (GIs)**

42. The Controller General of Patents, Designs and Trademarks (CGPDTM) define GIs as a category of industrial property that identifies goods as originating from a specific country, region, or locality, where a given quality, reputation, or other characteristic of the product is essentially attributable to its geographical origin. A GI tag for the goods serves not only as a mark of origin but also as an assurance of distinctiveness, authenticity, and quality, arising from the unique combination of local natural factors and human skills embedded in that region.

43. India, as a member of the World Trade Organization (WTO), enacted the Geographical Indications of Goods (Registration & Protection) Act, 1999 which provides a legal framework for the registration, protection, and promotion of GI-tagged goods in the country. As of 31st December 2025, India has registered 724 products, out of which 684 GI products are from India, with over 30,000 authorized users associated with these goods. The Indian GIs cover a wide range of agricultural products, handicrafts, textiles, and food items that reflect the country's rich cultural and regional diversity.

44. A quick examination of the registered GI goods by TKDL reveals that a significant majority (>95 percent) are closely associated with traditional knowledge, either directly in their production processes or indirectly through associated practices and further use. Thus, GIs emerge as a significant bridge between traditional knowledge and formal intellectual property regimes. This not only safeguard traditional knowledge but also enhance the economic value of such products.

### **i. GIs and the Economy**

- a) GIs have the potential for yielding higher market value, premium pricing and employment generation in local industries, particularly in rural and semi-urban areas.
- b) GIs contribute to exports and international trade. Many Indian GI products have strong reputation in global markets. GI protection helps strengthen branding and

prevents unauthorized use of product names. This improves the credibility of Indian products abroad and helps expand niche export markets.

- c) Many GI products are closely linked with centuries-old skills, artisanal techniques, and indigenous knowledge systems. By legally protecting the association between the product and its place of origin, GIs help preserve traditional knowledge and cultural heritage.
- d) GIs promote regional branding and tourism. Regions known for particular GI products often attract visitors interested in local culture, crafts, and traditional industries.

45. However, the economic benefits of GIs in India are not always fully realized due to challenges like limited awareness among producers and consumers, weak enforcement against counterfeit products, and inadequate marketing and branding strategies. In many cases, small artisans and farmers lack the institutional support and market access needed to make full use of GI recognition.

## ii. Literature Review on GI valuation

46. Bansal and Singh (2024)<sup>90</sup> examine whether the registration of GIs has a measurable impact on India's agricultural exports and whether there are changes in cropping patterns following GI registration. The paper uses a novel dataset combining state-product-year level export data with information on registered agricultural GIs in India for the period 2004 to 2016. The study highlights the rapid expansion of GI registration, a total of 123 agricultural products received GI status across 23 states between 2004 and 2016.

47. Using a difference-in-differences approach, the study finds that GI registration has a significant positive effect on exports, increasing state-product level exports by an average of 67.7%. This suggests that GI acts as a quality signal, enhancing product reputation, and enabling better access to international markets. The export effect of GI protection is stronger in states with more efficient courts and better transport infrastructure.

48. The study also finds a measurable shift in cropping patterns, with the share of GI-tagged crops increasing by about 2% in district-level cropping area after registration. This reflects a reallocation of resources toward higher-value GI crops.

49. Radhika et al (2018)<sup>91</sup> examines the role of GIs in improving the yield, income, and the quantity of produce sold by farmers cultivating traditional rice varieties in Kerala-Navara, Pokkali, Jeerakasala, Gandhakasala, Palakkadan Matta and Kaipad - using a

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<sup>90</sup>Bansal, M., & Singh, R. (2024). Blessing of geography: Impact of geographical indications on agricultural exports in India. *IIMB Management Review*, 36(4), 353-367.

<sup>91</sup>Radhika, A. M., Thomas, K. J., Kuruvila, A., & Raju, R. K. (2018). Assessing the impact of geographical indications on well-being of rice farmers in Kerala. *International Journal of Intellectual Property Rights*, 9(2), 1-11.

sample of 300 farmers (50 from each category) along with data from market intermediaries and producer societies.

50. The impact is estimated using treatment effect analysis, focusing on key outcome variables such as yield per hectare, net income, marketed income, and marketed surplus. The study finds significant variation in production and income across different GI rice varieties. In terms of productivity, Palakkadan Matta records the highest yield, followed by Jeerakasala and Gandhakasala, while Pokkali exhibits the lowest yield. However, higher yield does not necessarily translate into higher income. The ranking of net income differs, with Navara farmers earning the highest income, followed by Palakkadan Matta and Gandhakasala, while Pokkali farmers earn the least.
51. The findings highlight important structural insights. Despite lower yields, Navara generates higher income and surplus due to premium pricing and its medicinal value, whereas Palakkadan Matta, despite having the highest yield, generates relatively lower income because it is often sold at normal procurement prices without GI premium realization.
52. Jamal et. al (2024)<sup>92</sup> analyses the role of GI in the Darjeeling tea industry, focusing on its impact on economic outcomes and workers' welfare. Tea is cultivated across about 20,800 hectares and produced in 87 tea estates, employing nearly 1.2 lakh workers, most of whom are women.
53. The GI tag has helped in strengthening the global identity of Darjeeling tea and protecting it from misuse in international markets. It has contributed to enhancing the product's reputation and securing premium prices. However, the paper finds that the benefits arising from GI protection are not evenly distributed across stakeholders. The gains are largely captured by exporters, traders, and estate owners, while plantation workers have not experienced corresponding improvements in their living conditions.
54. Subba et. al (2024)<sup>93</sup> examines the sustainability of Small Tea Growers (STGs) in the Darjeeling hill region using a comprehensive framework covering environmental, economic, and social dimensions of tea farming. The study is based on a primary survey of 927 households across 20 tea-growing villages in Darjeeling.
55. The study highlights that around 52,000 tea growers are engaged in tea cultivation, of which 36,559 are small tea growers, typically operating on landholdings of less than 10 hectares. These smallholders form the backbone of the Darjeeling tea industry.

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<sup>92</sup>Jamal, S., Upadhyay, A., & Moin, K. (2024). Impact of geographical indications on revitalisation of local economy: A case study of Darjeeling Tea. *Journal of Intellectual Property Rights (JIPR)*, 29(5), 443-456.

<sup>93</sup>Subba, B., Mondal, S., Mandal, U. K., & Tamang, L. (2024). Small-scale tea farming sustainability: A case study of Darjeeling hill region, India. *Farming System*, 2(2), 100080.

56. At the farm level, the average landholding is 0.32 hectares, with an average annual production of 464.51 kg of tea. Most growers depend heavily on tea as their primary livelihood, with only 17% having an additional source of income. In terms of livelihood distribution, more than 77% of growers rely primarily on tea cultivation, while 11.43% are engaged in service-related occupations and only 1.40% depend mainly on tourism. Economic sustainability emerges as the most critical challenge. This is largely due to structural constraints such as small landholdings, limited diversification of income sources, and heavy dependence on tea cultivation. Social sustainability is relatively better but marked by disparities. Educational attainment among growers is generally low, often limited to primary schooling. At the same time, women play a crucial role in the sector, with more than 90% directly involved in tea cultivation.
57. Sukthankar et. al (2025)<sup>94</sup> investigates the factors influencing the adoption of GI certification among Cashew Feni producers in Goa, a region where Feni represents both a cultural symbol and an important economic activity. The study reports that Goa has over 55,000 hectares under cashew cultivation, which forms the raw material base for cashew feni production.
58. The findings show that the Feni industry is dominated by experienced producers, with 76.35% having more than 15 years of experience and 75% of respondents aged 45 years and above, while only 14.86% are below 35 years. This indicates limited participation of younger generations in the sector. In terms of education, a large share of producers have schooling only up to the secondary level (43.24%), while a smaller proportion have higher education.
59. The study emphasises that behavioural factors play a crucial role in the adoption of GI certification. Among these, attitude emerges as a strong predictor, significantly influencing producers' willingness to adopt GI. Perceived economic benefits also play a central role, shaping both attitudes and adoption decisions. Awareness is another key factor, as informed producers are more likely to develop favourable attitudes and respond to social influences.
60. Malini (2023)<sup>95</sup> analyses the role of GI in India with a specific focus on Kanchipuram silk sarees, a traditional product deeply rooted in the cultural and economic fabric of Tamil Nadu. In India, GI protection has expanded significantly, with 475 GI-registered products as of 2023-2024, and Tamil Nadu emerging as a leading state with 57 GI tags, followed by Uttar Pradesh and Karnataka.
61. The study shows that silk sarees form a significant share of handicraft production in the district. Their contribution to total handicrafts increased over time, reaching 32.52% in

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<sup>94</sup>Sukthankar, S., Fernandes, R., Korde, S., Gaonkar, S., & Sharma, V. (2025). Drivers of Geographical Indication (GI) Tags' Adoption Among Cashew Feni Producers: Extending the Theory of Planned Behaviour Using PLS-SEM. *World*, 6(3), 119.

<sup>95</sup>Malini, S. (2023). An Analysis of Geographical Indications in India and Tamil Nadu with Special Reference to Kanchipuram Silk Sarees. *Quing: International Journal of Commerce and Management*, 3(3), 330-336.

2021-22, compared to lower shares in earlier years such as 9.02% in 2016-17 and 9.4% in 2017-18, with some fluctuation in between. In terms of value, silk sarees also account for a substantial portion of total handicraft output. Their contribution reached 34.24% in 2021-22. The paper further highlights the involvement of households in the sector, showing that 31.8% of families engaged in handicrafts were involved in silk saree production in 2021-22, underlining its importance as a livelihood source. Statistical analysis also reveals a relationship between the value of silk sarees produced and the number of households engaged.

62. Torok et. al (2020)<sup>96</sup> provides a systematic review of empirical literature on the economic impact of GIs, focusing on three main aspects: market size, price premium, and regional development. It is based on a structured literature review using major databases such as Scopus, Web of Science, JSTOR, ProQuest, and Science Direct.
63. The paper highlights that research on GIs has increased over time, with more than one-third of empirical studies published after 2017, indicating growing academic interest in the field. In terms of sectoral focus, 73% of the studies examine GI food products, while 17% focus on wines and spirits, and the remaining studies cover other product categories.
64. Regarding market size, the paper notes that GI-labelled products constitute only a small share of total agri-food production in the European Union, around 7% in 2017, despite the EU being the most developed GI market. It also highlights that GI registrations are concentrated in specific product categories, with sectors such as fruits and vegetables, cheeses, fresh meat, oils and fats, and meat-based products accounting for more than 80% of total registrations.
65. The findings on price premiums are mixed. While some GI products, particularly wines and certain high-value products can achieve higher prices, the evidence is not consistent across products and regions. The paper also notes that higher production and compliance costs associated with GI certification may offset these price gains, and it cannot be assumed that increased value translates into higher income for primary producers.
66. In terms of regional development, the evidence is inconclusive. The paper emphasises that there is a lack of clear and comprehensive data on key indicators such as market size, price premiums, and net producer income, which limits the ability to draw general conclusions. However, it identifies several potential channels through which GIs may contribute to regional development, including employment generation, especially in labour-intensive production systems, and positive spillover effects through linkages with tourism and other local industries.

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<sup>96</sup>Török, Á., Jantýik, L., Maró, Z. M., & Moir, H. V. (2020). Understanding the real-world impact of geographical indications: A critical review of the empirical economic literature. *Sustainability*, 12(22), 9434.

67. At the same time, the paper cautions that GI strategies can also have negative outcomes. In some cases, efforts to access external markets may reduce local benefits, and income gains may not accrue to primary producers but rather to actors higher up the value chain.

### iii. Summary of GI registrations in India

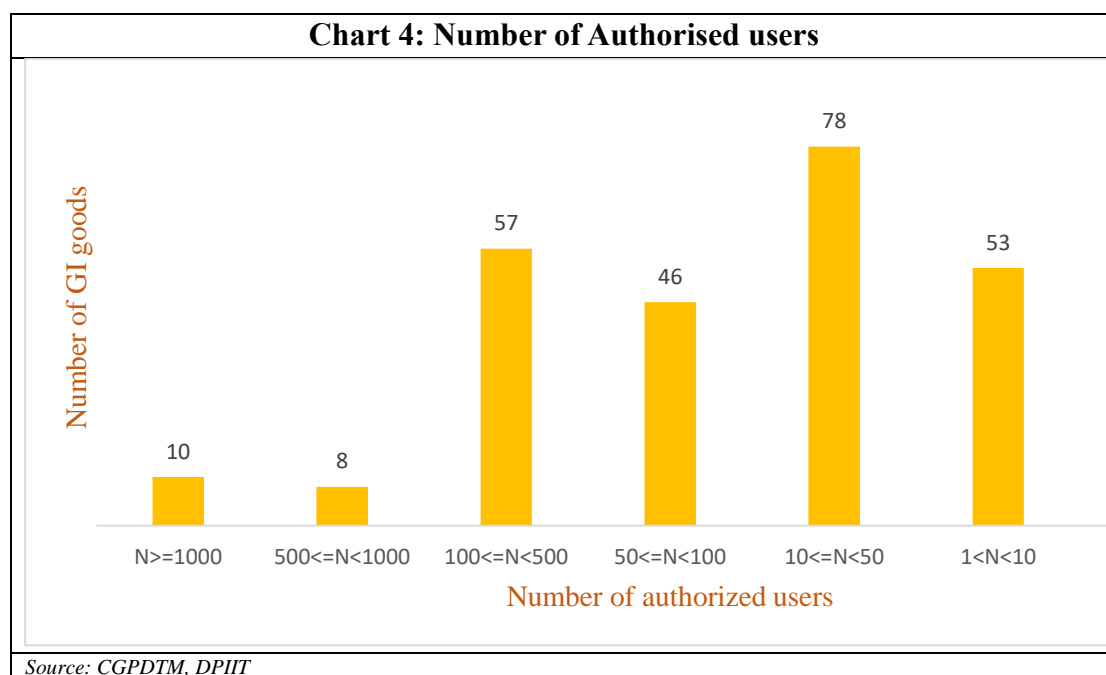
68. As per the latest available data, a total of 724 goods have been granted GI registration, of which 684 are from India. The GI regime in India not only provides recognition to goods but also allows registration of authorized users of the GI-tagged goods. These users are legally entitled to produce and market GI-tagged goods, ensuring traceability, quality assurance, and protection against unauthorized use. The status of authorized user registrations across categories is presented in the table below.

<b>Table 2: Registered GIs and Authorised Users</b>				
<b>Goods</b>	<b>Number of Registered GIs</b>	<b>Number of GIs with registered users</b>	<b>Number of registered Users</b>	<b>Proportion of Total Registered Users</b>
Agricultural	225	105	17878	51.7
Handicraft	375	168	15945	46.1
Food Stuff	54	16	536	1.6
Manufactured	27	7	192	0.6
Natural	3	2	18	0.1
<b>Grand Total</b>	<b>684</b>	<b>297</b>	<b>34569</b>	
<i>Source: CGPDTM, DPIIT</i>				

69. Handicraft and agriculture together account for approximately 88% of all registered GIs in India. Only 43.4 per cent of the registered GIs have at least one registered authorized user. While this does not necessarily imply the absence of production or trade in these goods, it points to a structural gap in the formal utilization of GI protection mechanisms. The low number of registered users can have several implications such as increased vulnerability to counterfeiting, misuse of the GI label, and dilution of the product's brand value. Moreover, without authorized users, the economic benefits of GI registration such as premium pricing and export opportunities may not be fully realized by local producers.

70. The following chart illustrates the highly skewed distribution of the legally registered GI usership. Out of the 297 GIs that have registered users, the top 10 (Alphonso, Solapur Pomegranate, Sangli Raisins, Ilkal Sarees, Nagpur Orange, Jalna Sweet Orange, Gulbarga Tur Dal, Kashmir Pashmina, Jalgaon Banana and Kashmir Sozani Craft) account for 40% of the total usership (top 10 GIs account for 13763 users); the top 60 GIs account for close to 80%. Most active GI-tagged goods have a relatively

small number of registered users. This raises concerns about limited community participation in majority of GIs and potential monopolization.



71. The table below shows that the registration of authorized users has accelerated significantly in the recent years. The slow progress in the early years was partly due to the timelines in instituting GI framework in India. Though the Geographical Indications of Goods (Registration and Protection) Act was passed in 1999, GI Rules were notified only in 2002.

<b>Table 3: Number of GI user registrations by Year</b>				
<b>Grand Total</b>	<b>2009-14</b>	<b>2015-19</b>	<b>2020-24</b>	<b>Grand Total</b>
	1258	4232	29079	<b>34569</b>

72. Ghosh et al. (2025)<sup>97</sup> critically evaluates the effectiveness of the GI legal framework in India. The paper highlights significant quantitative progress in GI registration in India. As of mid-2023, more than 500 products have been successfully registered as GIs. This marks a substantial increase compared to earlier years and reflects growing recognition of GI protection. However, the authors argue that despite this numerical growth, the actual economic impact remains limited, as market reach and exports related to many GIs is limited.

73. The paper further highlights scope for improvement in the legal framework regarding territorial scope and ownership. The paper also shows that even when GIs generate

<sup>97</sup>Ghosh, J., Banerji, O., Samanta, N., & Bhargava, A. (2025). Geographical indication (GI) laws in India and its implementation: A critical appraisal. *Journal of Intellectual Property Rights (JIPR)*, 30(3), 304-313.

initial economic benefits, these are sometimes not sustained. In the case of Alphonso mangoes (GI since 2018), producers initially benefited from higher prices, but adulteration diluted the value of the GI tag over time. Likewise, lesser-known GIs such as Nakshi Katha and Madur Kathi demonstrate structural problems: lack of awareness, improper categorization, and disconnect between registered proprietors and actual producers, leading to minimal economic gains for artisans.

74. Kavya et al. (2025)<sup>98</sup> examines the evolution, economic relevance, and challenges of the GI regime in India within the broader framework of intellectual property rights under the TRIPS Agreement. A key focus of the study is the growth trajectory of GIs in India between 2004 and 2024. The data shows a significant expansion with highly uneven distribution across sectors. Handicrafts constitute the largest share (around 51%-55%), followed by agricultural and natural goods (around 29%-33%), while manufactured goods (7.15%), food articles (7.31%), and other goods (0.48%) account for much smaller proportions. This distribution indicates that the GI regime in India is heavily concentrated in traditional and rural sectors, with nearly 85% of labour engagement linked to handicrafts and agriculture, highlighting its potential for rural employment and livelihood generation.
75. The temporal pattern of GI registrations further reflects growing institutional support and awareness. Registrations have increased steadily over time, with peaks in 2020-21 (highest registrations), followed by 2016-17 and 2007-08. This trend suggests an increasing policy push towards cultural preservation, product differentiation, and market expansion through GIs.
76. The study highlights significant structural and institutional challenges. One major issue is the ambiguity in identifying actual beneficiaries. The GI Act defines “producers” broadly to include not only cultivators but also processors, traders, and packers. The paper argues that this expanded definition dilutes the share of benefits accruing to primary producers.
77. This problem is illustrated in the paper through the case study of Pokkali rice (GI registered in 2008). Although the GI tag was expected to benefit traditional farmers in Kerala, the study argues that very few farmers are registered as authorized users, largely due to lack of awareness. Intermediaries such as traders and processors get benefitted, while farmers continue to sell at regular market prices.
78. Overall, the study concludes that although India has achieved significant progress in terms of 658 GI registrations, its effectiveness is constrained by issues of unequal benefit distribution, weak producer participation, and climate vulnerability. The paper emphasizes the need for a producer-centric governance framework, improved

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<sup>98</sup>Kavya, S., Gummadi, S., & Karun, S. (2025). Geographical Indications Regime in India: Commitments and Consequences. *South India Journal of Social Sciences*, 23(1), 305-319.

awareness, better enforcement mechanisms, and adaptive policies that balance traditional practices with environmental sustainability.

79. The analysis of GI goods above shows that GI registration has progressed in terms of numbers, its grassroots adoption remains uneven and limited in many cases. The analysis highlights a gap between GI recognition and its effective economic and commercial utilization. Initiatives like generating greater awareness among producers, artisans, and farmer groups about the benefits of GI registration and authorized user status, capacity building and market development initiatives will help realize greater economic benefits.
80. Enhancing the participation of local communities as authorized users will not only improve the economic viability of GI goods but also ensure the preservation of traditional knowledge, cultural heritage, and regional identities. In doing so, GI registration can evolve into a powerful instrument for inclusive growth and rural development.

## VII. Ayush

81. The ancient systems of medicine constitute a vital component of India’s traditional knowledge. These systems include Ayurveda, Yoga & Naturopathy, Unani, Siddha, Sowa Rigpa, and Homoeopathy. To ensure systematic development and propagation of Ayush systems, the Government of India elevated the erstwhile Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy (Ayush) to the status of a full-fledged Ministry in 2014.

### i. Reach and growth

82. The widespread reach of Ayush is clearly reflected in the NSS 79th Round (2022–23). About 95% of individuals are aware of Ayush system of medicine, while about 50% of all persons reported using Ayush.

<b>Table 4: Proportion of persons aware of Ayush and used Ayush services</b>		
	<b>% of persons* aware of Ayush</b>	<b>% of persons used Ayush during last 365 days</b>
<b>Rural</b>	94.8	46.3
<b>Urban</b>	96.0	52.9
<i>* age 15 years and above</i>		
<i>Source: NSS 79th round Survey on Ayush: 2022-23 Fact Sheet</i>		

83. The Research and Information System (RIS) report titled “Ayush Sector in India: Prospects and Challenges”<sup>99</sup> estimates the size of the Ayush industry at US\$ 18.1 billion

<sup>99</sup>“Ayush Sector in India: Prospects and Challenges” by Research and Information System for Developing Countries, 2021

in 2020-21, indicating a significant expansion over the past decade. The estimates of Ayush industry by various studies over the years is produced in table below.

Study	Year	Size of Industry
Ved and Goraya, 2017 (Ayurveda)	2014-15	USD 2.85 Bn
CII, 2018 (Ayurveda)	2016	USD 3 Bn
RIS Report (Ayush)	2020	USD 18.1 Bn

*Source: RIS report on Ayush*

84. The high growth rates in value-added segments show that India is gradually moving beyond raw material dependence toward higher levels of value addition.

Segment	Share (%)	Growth Rates (2014-2020)
Nutraceuticals	42.3	20.5
Pharmaceuticals	~30	15.8
Herbal Plants	13.8	14.3
Others	~14	N/A

*Source: RIS report on Ayush*

85. The global herbal medicine market provides a strong external demand base, but India's participation leaves scope for growth and improvement.

Global Market Size (2020)	Projected Global Size (2022)	Export Potential in herbal plants and extracts sector	Actual Exports in herbal plants and extracts sector	Export potential Utilisation
USD 657.5 Bn	USD 746.9 Bn	USD 2.2 Bn	~USD 830 Mn	<40%

*Source: RIS report on Ayush*

86. While the global market is large and growing, India is realising less than 40% of its export potential. This may be due to structural constraints such as limited standardisation, weak global integration, and insufficient value addition in export baskets. The sector's expansion is increasingly supported by large-scale participation from established FMCG and pharmaceutical firms, indicating growing commercial viability and mainstream acceptance of Ayush products.

Year	Export-to-Sales (%)	Indicator	Value
2010	6.6	Total Turnover (Top 6 Firms)	~₹74,000 crore
2020	2.2	Ayush Segment	~₹15,000 crore

*Source: RIS report on Ayush*

87. The RIS report clearly demonstrates that the Ayush sector is at a critical inflection point, characterised by high growth, structural transformation, and strong policy backing. However, its evolution into a globally competitive industry depends on addressing the core challenges.
88. The ancient systems of Indian medicine have demonstrated their efficacy over centuries and continue to remain highly relevant to modern healthcare, particularly in addressing the growing burden of lifestyle diseases. However, accurately valuing the Ayush sector within the modern economy remains a complex task due to its largely unorganised structure. A significant challenge arises from the widespread presence of informal practitioners, especially in rural areas, which makes systematic data collection and assessment difficult. At the same time, the Ayush industry has experienced substantial growth, particularly in classical and value-added segments such as formulations, extracts, derivatives, nutraceuticals, and fast-moving consumer goods.
89. Despite this progress, there is significant scope for realising the full economic potential of the sector. One key issue is the limited clinical validation of Ayush products and their lack of recognition as pharmaceutical drugs in several countries. These challenges stem partly from the public availability of medicinal knowledge in ancient texts. As a result, firms may be less inclined to undertake costly clinical trials when the scope for exclusive commercialisation of validated products is limited, thereby affecting the expected returns on investment.

**Box 1: Government's focus on promoting traditional knowledge**

To encourage the use of traditional knowledge and practices, Government of India has launched many schemes that covers sectors like health, agriculture, culture etc.

**AYURGYAN Scheme:** The scheme aims to develop capacity in the Ayush healthcare sector. It seeks to improve health practices through sustainable Ayush methods, encourage professionals to undergo professional orientation, update knowledge of teachers and doctors, and promote use of information technology for disseminating Ayush developments. The scheme also focuses on encouraging R&D in priority areas to validate claims and enhance the acceptability of Ayush in the global market.

**Ayurswasthya Yojana:** This aims to address health challenges by merging and expanding two existing schemes - Public Health Intervention and Centre of Excellence. It has three main components: Ayush and public health, Ayush for sports medicine, and upgradation of facilities to the Centre of Excellence.

**Information, Education & Communication:** The aim is to propagate Ayush systems of healthcare through Information, Education, and Communication activities. The scheme aims to create awareness about the efficacy of Ayush, disseminate information on research outcomes, facilitate interaction among stakeholders, and organize events for propagation of Ayush systems through IEC channels.

**International Co-operation:** This is focused on strengthening international awareness in Ayush Systems and promoting its development and recognition through fostering stakeholder interaction, supporting international exchange of experts and information, boosting global trade in Ayush

products and services, and promoting knowledge through the establishment of Ayush academic chairs in foreign countries.

**Ayush Oushadhi Gunvatta Evam Utpadan Samvardhan Yojana:** This aims to regulate Ayurveda, Siddha, Unani, and Homeopathy medicines under the framework of the Drugs & Cosmetics Act. The components include enhancing manufacturing capabilities and exports of traditional medicines, supporting infrastructural and technological upgradation for standardization, quality manufacturing and testing, strengthening regulatory mechanisms for quality control and safety monitoring.

**Conservation development and Sustainable management of medicinal plants:** It aims to enhance the conservation and availability of medicinal plants for the Ayush industry and traditional medicine. It focuses on conserving plant habitats, engaging in eco-task force activities, supporting joint forest management committees, and fostering international collaborations. The emphasis is on sustainable cultivation practices, promoting the use of quality planting material, and strengthening supply chain.

**National Ayush Mission:** This mission aims to provide better access to Ayush services by increasing Ayush hospital and dispensaries, and upgrading the existing ones, operationalizing Ayush health and wellness centres by upgrading existing Ayush dispensaries and sub centres. To improve quality of education, existing Ayush educational institutions will be upgraded and new colleges will be established.

**National Mission on Cultural Mapping (NMCM) and Roadmap:** Started in in 2017, NMCM aims to preserve and promote cultural heritage by creating a map outlining cultural landscape, mechanisms to meet the needs of the artist community, and fostering cultural vibrancy. A database will be developed with an inventory of cultural assets and resources. “Mera Gaon Meri Dharohar” survey will document various art forms, cultural practices, and the socio-economic conditions of artisans and craftsmen.

**National Mission on Natural Farming (NMNF):** It was launched in November 2024 to strengthen sustainable and scientific agriculture practices, climate resilience and safe food. It aims to improve soil health, restore ecosystems and reduce input cost to the farmer to achieve greater climate resilience. The Mission supports farmers to transition to natural farming. It has a scientifically designed extension strategy focussed on on-farm knowledge.

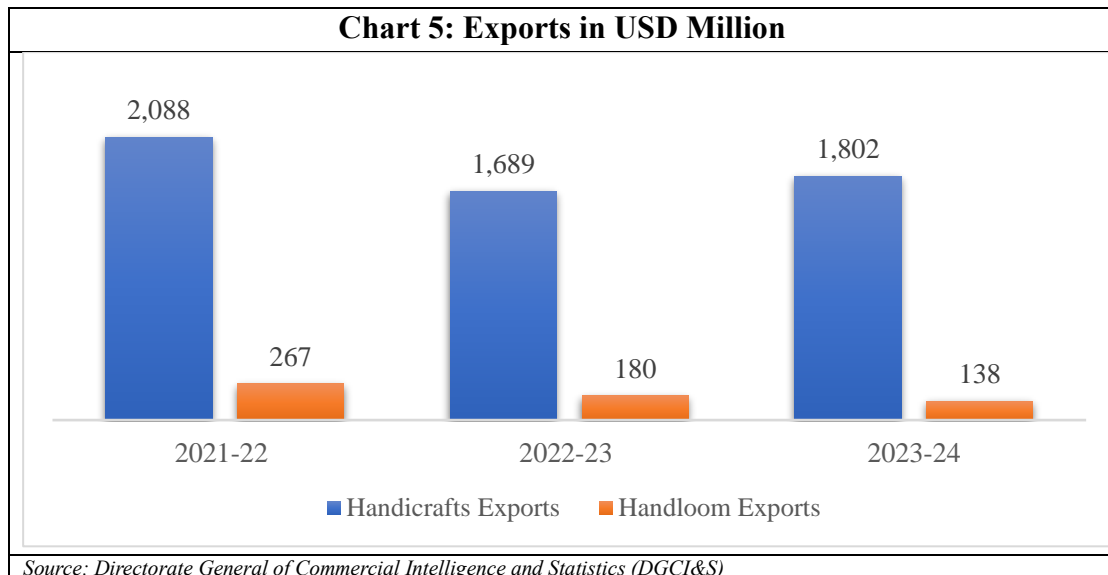
**Rashtriya Gokul Mission:** This aims to develop and conserve indigenous bovine breeds for enhancing milk production and bovine productivity.

**National Mission for Sustainable Agriculture (NMSA):** This focuses on enhancing agricultural productivity especially in rainfed areas through integrated farming, water use efficiency, soil health, resource conservation and sustainable agriculture through adaptation measures.

## VIII. Handicrafts & Handlooms

90. Within the domain of traditional knowledge, the handicrafts and handlooms sectors constitute a substantial component of economic activity. The handloom and handicrafts sector hold considerable importance for the national economy. These sectors employ a large number of artisans, particularly in rural and semi-urban areas. In addition to generating substantial foreign exchange earnings, they play an important role in preserving the country's rich cultural heritage.

91. According to the Ministry of Textiles Annual Report 2023-24, a total of 32.03 lakh artisans have been issued “Pahchan” cards by the Development Commissioner (Handicrafts), of whom 64% are women. Further, the handloom sector engages approximately 35.23 lakh persons, with women accounting for nearly 72% of the workforce. Exports from handicrafts and handlooms also make a notable contribution to foreign exchange earnings.



92. Further insights in to the employment generation by handloom sector can be drawn from handloom census 2019-20<sup>100</sup>. The census reveals that 43% of the handloom workers are in the age group of 18-35 years, underscoring the sector’s continued relevance in employment creation. However, the socio-economic conditions of handloom worker households remain modest. Nearly 79% lack a ‘pucca’ house, indicating low income levels. This is further substantiated by the fact that about 67% of these households earn less than INR 5,000 per month. A key factor underlying this low income can be limited market access, with 64.1% of households selling their products primarily in local markets.

93. The estimation of size of the handicrafts and handloom sectors remains challenging due to their predominantly informal nature. Government of India initiatives in recent years such as the issuance of ‘Pehchan’ cards, expanded credit support, and export promotion measures have attempted to formalize the sector to some extent; however, significant gaps persist. The absence of comprehensive data further complicates efforts to arrive at a robust economic valuation. While export data is relatively well documented, detailed estimates of the sector’s overall economic contribution remain limited.

94. In this context, conducting a regular and comprehensive census, and extending it to include the handicrafts sector would be a critical step. Such an exercise should

<sup>100</sup>Fourth All India Handloom Census, (2019-20). Ministry of Textiles. <https://handlooms.nic.in/assets/img/Statistics/3736.pdf>

incorporate granular economic indicators including income levels, value addition, supply chains, and market linkages, so as to generate a more precise and evidence-based assessment of the sector's economic valuation.

## **IX. Conclusions**

95. Indian traditional knowledge has long been a way of life and a source of livelihood for millions of the people in the country. Yet, as the preceding discussion indicates, assigning an exact economic value to this knowledge remains a complex and challenging task.
96. One of the approaches for valuation of crop sector can be grouping crops into broad categories such as: (a) predominantly indigenous crops, characterised by low use of hybrid seeds and reliance on traditional agronomic practices; (b) crops largely shaped by the Green Revolution, using hybrid or high-yielding variety (HYV) seeds developed through formal R&D systems; (c) plantation crops introduced through global plantation systems; and (d) horticultural crops associated with high-value, commercial cultivation methods.
97. Additionally, an approximate valuation of the broader TK sector may be approached by focusing on three key domains that substantially rely on traditional knowledge *viz.* Ayush, GI-registered goods, and handloom & handicrafts. While these sectors are not exhaustive, they together represent a significant share of the traditional economy.
98. The estimate of Ayush industry by RIS report highlights its growing potential. However, the estimate does not adequately capture the services component of the sector. In this context, an updated and more comprehensive study by RIS, may be undertaken in coordination with the Ministry of Ayush. The updated study should incorporate both manufacturing and service dimensions. Further, consolidating data on registered Ayush practitioners would help in assessing the true scale of practice across the country. Such data could also be triangulated with ASUSE estimates to arrive at a more robust measure of value addition in the Ayush sector.
99. In the present analysis, GI goods have been used as a proxy to estimate the traditional goods market. It is well accepted that not all traditional products are covered under the GI regime. However, with the gradual expansion of GI registrations and the increasing economic relevance of such products, it is reasonable to expect that a larger share of traditional goods will come within its ambit over time. To strengthen valuation efforts, a comprehensive meta-study of all registered GI products could be undertaken to better understand their aggregate economic contribution. This study then furthered by product-based survey to estimate the impact of GI registration and size of economy of such goods.

100. The valuation of handicrafts and handlooms presents an even greater challenge due to the predominantly informal nature of these sectors. The data for these sectors is limited. In order to estimate these sectors, a comprehensive census for both the sectors may be conducted at regular intervals. The census may also incorporate granular economic data across all major stakeholders to enable a comprehensive and robust assessment of the sector's economic dynamics.

## Annexure

<b>Table: Classification of IKS and CKS in themes</b>				
S. No.	Theme	Indian Knowledge System	Contemporary Knowledge System	Rationale
1.	Vedic Philosophical and Cognitive Sciences	Darsanas, Upanishads, Prasthanas Trayi, Yoga	<b>HSS:</b> Philosophy, Epistemology, Ontology, Philology <b>STEM:</b> Cognitive Science, Neuroscience, Psychology	Cognitive Science, Neuroscience, and Psychology help study and validate the mental and behavioural aspects described in Vedic traditions.
2.	Historical and Civilizational Sciences	Purva Mimamsa, Samhita, Brahmana, Shrauta Sutras, Grihya Sutra, Shulba Sutra, Itihasa, Purana, Dharma sastra, Itihasa, Purana, Kavya	<b>HSS:</b> History, Archaeology, Anthropology, Manuscriptology, Epigraphy, Philology, Geography <b>STEM:</b> Data Science, Mathematics, Computer Science	Data Science, Mathematics, and Computer Science enable digitisation and structured analysis of historical texts, inscriptions, and archaeological data. They support chronology modelling, geo-spatial mapping, statistical validation, and computational reconstruction of civilizational patterns and trends.
3.	Contemporary Social / Cultural Sciences	Purva Mimamsa, Samhita, Brahmana, Shrauta Sutras, Grihya Sutra, Shulba Sutra, Itihasa, Purana, Dharma sastra, Itihasa, Purana, Kavya	<b>HSS:</b> History, Archaeology, Anthropology, Manuscriptology, Epigraphy, Philology, Geography <b>STEM:</b> Data Science, Mathematics, Computer Science	Data Science, Mathematics, and Computer Science help analyse social patterns, cultural trends, and behavioural data using computational and statistical methods. They enable modelling of social networks, demographic changes, and value systems, and support predictive analysis of societal dynamics in contemporary contexts.
4.	Mathematical, Physical and Astronomical Sciences	Jyotisha, Shulba Sutras	<b>HSS:</b> History of Science <b>STEM:</b> Astronomy, Algebra, Number theory, Geometry	Algebra, Number Theory, and Geometry help interpret and reconstruct mathematical principles found in Jyotiṣa and Śulba Sūtras. They support analysis of astronomical calculations, geometric constructions and indigenous numerical methods, linking traditional mathematics with modern theoretical frameworks.
5.	Speech and Linguistics	Siksha, Vyakaranam, Chandas, Nirukta, Mimamsa, Mantra Shastra	<b>HSS:</b> Comparative Linguistics, Lexicography <b>STEM:</b> Speech Science, Phonetics, Speech Signal Processing, Speech recognition, Natural Language Processing	Natural Language Processing (NLP) enables computational analysis of Sanskrit and other Indian languages. It supports automatic parsing, machine translation, text-to-speech, speech recognition, and creation of digital lexicons, helping preserve and modernise traditional linguistic knowledge.
6.	Political, Economic and Strategic sciences	Dhanurveda, Artha Sastra, Dandaniti, Rajaniti	<b>HSS:</b> Political Science, Modern military history, Strategic Affairs, Economics, Public policy, Management,	Systems Science and Modelling help analyse governance structures, policy dynamics, and strategic interactions using formal models. Econometrics enables quantitative evaluation of economic principles

Table: Classification of IKS and CKS in themes				
S. No.	Theme	Indian Knowledge System	Contemporary Knowledge System	Rationale
			Behavioural Science, Psychology <b>STEM:</b> Systems Science and Modelling, Econometry	from Arthaśāstra, supporting data-driven policy design and empirical validation of economic and administrative theories.
7.	Medical and Health sciences	Ayurveda, Yoga, Sankhya	<b>HSS:</b> Public Policy, Psychology <b>STEM:</b> Medicine, Physiology, Anatomy, Statistics, Life Sciences, Systems Biology, Medical	Subjects from HSS like public policy and psychology can be leveraged to promote and encourage the adoption of effective health practices within communities.
8.	Culinary, Nutritional and Pharmacological Sciences	Paka sastra, Vrikshaayurveda, dravya vijnana, ayurvediya kalas, Siddha, Folk medicine	<b>HSS:</b> Home Science, Nutrition <b>STEM:</b> Pharmacology, Botany, Zoology, Biochemistry, Systems Biology	HSS helps document and interpret traditional dietary practices and medicinal food knowledge in their cultural context. STEM enables scientific validation of medicinal plants and nutritional principles through pharmacological, biochemical, and laboratory research.
9.	Agricultural Science, Veterinary and animal husbandry	Krushi vijnana, vriksha-ayurveda, best practices in agriculture and animal husbandry	<b>HSS:</b> Public Policy <b>STEM:</b> Agriculture, Process Engineering, Botany, Zoology, Veterinary Science, Meteorology, Climate Science	Public Policy helps frame sustainable agricultural practices within socio-economic and governance contexts. STEM supports scientific study of crops, livestock, climate resilience, and indigenous farming systems through agriculture, veterinary science, and environmental research.
10.	Performing Arts	Natya sastra, Gandharva kalas, Alankara Sastra, Sahitya/Kavya, Itihasa, Purana	<b>HSS:</b> Musicology, Animation, Computer graphics, Cinematography, Histrionics, Aesthetics <b>STEM:</b> Signal processing, Affective Neuroscience, Acoustics and Mechanics of instruments	Signal Processing helps analyse sound patterns, rhythm, and musical structures digitally. Affective Neuroscience studies emotional responses (rasa) and audience engagement. Acoustics and Mechanics of Instruments examine sound production and structural design of traditional musical instruments.
11.	Mechanical & Digital Design & Engineering	Yantra Kala, Rasa shastra, Dhaatu Shastra, Vaastu Shastra, Purana, Itihasa,	<b>HSS:</b> History of Science, Animation, Digital design, UI design <b>STEM:</b> Mechanical Engineering and Industrial Design, Chemistry, Metallurgy, Data Science & ML, Natural Language Processing, Computer Vision, Embedded systems	Data Science & ML support design optimisation and predictive modelling of traditional engineering systems. NLP helps digitise and analyse technical texts, while Computer Vision enables reconstruction and analysis of ancient tools and structures. Embedded systems assist in prototyping and recreating traditional mechanical devices using modern technology.
12.	Civil and Architectural Science	Vaastu sastra, Shilpa sastra, Tantra, Shulba Sutras	<b>HSS:</b> Archaeology <b>STEM:</b> Architecture, Conservation, Structural	Architecture, Conservation, Structural Engineering, Town Planning supports structural analysis, conservation engineering,

Table: Classification of IKS and CKS in themes				
S. No.	Theme	Indian Knowledge System	Contemporary Knowledge System	Rationale
			Engineering, Town Planning	sustainable design, and modern architectural modelling based on Vāstu and Śilpa principles.
13.	Fine Arts and Sculpture	Shilpa sastra, Alekhyaaadi kalas, traditional styles across the country like Thanjavur, Madhubani	<b>HSS:</b> Fine arts, Sculpture, Art history <b>STEM:</b> Dyes, Organic paints, Chemistry, dating of Art	Dyes and Organic Paints help recreate and preserve traditional colour techniques. Chemistry enables analysis of pigments and materials, while scientific dating methods help determine the age and authenticity of artworks.
14.	Chemical, Metallurgical & Material Sciences	Rasayana sastra, Dhaatu sastra, Itihasa, Purana, Kavya	<b>HSS:</b> History, Archaeology <b>STEM:</b> Chemistry, Metallurgy, Material Science	This theme connects Rasāyana and Dhātu Śāstra with modern chemistry and material science. It supports study of traditional metallurgical practices, sustainable materials, and indigenous technological innovations.
15.	Fashion and Interior Design	Alankaara sastra, Alankaara kala, Natya sastra, Yoga, Tantra	<b>HSS:</b> Fashion, Interior Design, Aesthetics <b>STEM:</b> Materials, 3d printing, Marketing, Public policy, marketing	Materials science supports development of sustainable and traditional textiles and ornamentation. 3D printing enables innovative design prototyping and scalable production. Marketing and Public Policy help promote traditional designs, support artisans, and integrate cultural products into modern markets.
16.	Edutainment Sciences	Krīd ā in kalā, Itihasa, Purana, Darsana, Yoga, Sankhya	<b>HSS:</b> Educational Science <b>STEM:</b> Game design, Toy making, scalable manufacturing, Psychology	Game Design and Toy Making help develop culturally rooted learning tools based on traditional games. Scalable manufacturing enables wider production and accessibility, while Psychology supports understanding of child development, cognition, and experiential learning outcomes.

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## Chapter 4

### Valuation of the Knowledge Contribution to the Economy A Framework Primer

1. Having explored the conceptual considerations on the contribution of knowledge and knowledge products to the economy in Chapter 1, the available estimates and quantities in Chapter 2, and the possibilities for quantifying the impact of India's traditional knowledge in Chapter 3, we now turn to the essentials for a framework that will facilitate capturing the contribution of knowledge to the economy. The following sections will consider a pragmatic approach for consolidating the evidence, moving beyond anecdotal accounts.

#### II. The Approach

2. Knowledge impacts the economy through various complex and interactive transmission channels that are difficult to account for. A significant part of this impact is through changes like improvement in the skill levels of the workforce including the managerial personnel, addition to the technologically superior vintages of capital (machinery, structures and intellectual properties) and improved quality of intermediate inputs. This is robustly aligned to the economic theory of embodied knowledge; the idea that knowledge and technological progress are embodied or internalised in factors of production.
3. At the same time, efficiency gains may also arise through mechanisms like organisational learning and innovations, inter-firm learning spill-overs through interactions and improved co-ordination. Much of this, occurring independent of embodied knowledge, is the impact of disembodied knowledge diffusion and learning.
4. Both embodied and disembodied effects are captured through growth accounting analysis or regressions based on production function frameworks. Production functions express output as a function of capital, labour and intermediate inputs. Productivity analysis based on production function approach reflects the effect of disembodied knowledge in total factor productivity (TFP), while the effect of embodied knowledge is captured through factor quality measures.
5. There are many caveats to these measures. Estimation errors in the quantity and quality of inputs and omission of relevant variables also get reflected in TFP, making its interpretation challenging. Nonetheless, as a baseline exercise, our effort in the following sections will be to suggest reliable, objective and intelligible indicators of quality of capital, labour and intermediate inputs, which can be subsequently integrated into a growth accounting framework. We, however, do not attempt any quantitative estimation of the effect of quality of capital, labour and other inputs on the economy, in this paper.

### III. Assessing Knowledge Embodied in Labour

#### i. Defining Skills

6. OECD<sup>101</sup> defines skills as the ability and capacity to carry out processes and to be able to use one's knowledge in a responsible way to achieve a goal. Skills form part of overall competency, involving the mobilisation of knowledge, attitudes and values to meet complex demands. As per International Standard Classification of Occupations (ISCO), skill level is a function of the complexity and range of tasks and duties to be performed in an occupation. Skill level is measured operationally by considering one or more of: (i) the nature of the work performed in relation to the characteristic tasks and duties (ii) the level of formal education required for competent performance and (iii) the amount of informal on-the-job training and/or previous experience in a related occupation required for such performance.
7. MSDE-NCAER<sup>102</sup> delineated three types of skills:
  - a) Cognitive skills are basic skills of literacy and numeracy, applied knowledge, problem-solving aptitudes and higher-order skills such as experimentation, reasoning, and creativity.
  - b) Technical and Vocational Education and Training skills (TVET) are the physical and mental abilities to perform specific tasks using tools and methods in any occupation.
  - c) Social and behavioural skills include working well with others, communicating and listening well, and being agreeable and outgoing.

#### ii. Labour Skills and Economic Growth: - Literature

8. Mankiw et al. (1992)<sup>103</sup> examines how well could traditional Solow growth model explains differences in GDP across countries. It finds that while saving rates and population growth explain a significant portion of income variation, the model performs much better when human capital (skills and education) is included. By augmenting the production function to incorporate human capital, the authors show that nearly 80% of cross-country differences in income can be explained, compared to about 60% with the basic model. The cross-country analyses by Barro (1991<sup>104</sup>; 1992<sup>105</sup>) provide strong evidence on the role of human capital in economic growth. The 1991 study covered 98 countries over the period 1960-1985, and found that differences in human capital, along with policy and institutional factors, explained a significant portion of variations in economic performance across countries. Barro (1992) demonstrates that average years of schooling has a positive and significant effect on GDP growth. Higher education levels also improve a country's capacity to adopt new technologies.

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<sup>101</sup>OECD, The Future of Education and Skills, Education 2030 project.

<sup>102</sup>NCAER, (2018). Skilling India: No time to lose.

<sup>103</sup>Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, 107(2), 407–437.

<sup>104</sup>Barro, R. J. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics*, 106(2), 407–443.

<sup>105</sup>Barro, R. J. (1992). Human capital and economic growth. *Proceedings – Federal Reserve Bank of Kansas City Symposium*, pp. 199–224.

9. Hanushek and Woessmann (2008)<sup>106</sup> argue that cognitive skills, rather than just years of schooling, are the key drivers of economic growth and earnings. Measures like school attainment are misleading because they ignore differences in education quality. Improving education quality will interact with institutions and technology to drive economic performance.
10. Acemoglu and Angrist (2000)<sup>107</sup> investigate whether increases in average education generate **spill-over effects** that raise overall wages and productivity, using U.S. census data. The paper concludes that while education increases individual productivity significantly, its spillover effects on others are modest.
11. Caselli (2004)<sup>108</sup> finds that differences in capital accumulation and education explain only around 35%-40% of global income variation; such differences are majorly driven by total factor productivity. Even after incorporating measures like quality of education, health and composition of capital, the unexplained portion remained large. Efficiency differences do not affect all factors equally; poor countries may use physical capital more efficiently, but lag in utilizing human capital. However, development accounting identifies only the proximate causes of income differences and does not fully explain the structural factors like institutions, technology, and policies that ultimately drive productivity.
12. Oltulular (2025)<sup>109</sup> found that there exists a long-run relationship (cointegration) between human capital and economic growth. But the impact is relatively limited and varies across education levels, with master's degree having a comparatively stronger explanatory power than doctoral and undergraduate levels. Economic growth influences demand for higher education positively, especially at undergraduate and master's levels, whereas doctoral education remains relatively stable and less responsive to economic fluctuations. The study concludes that merely increasing the quantity of higher education is insufficient; instead, quality, relevance to labour markets, and integration with innovation systems are crucial.
13. Lalon and Menon (2023)<sup>110</sup> show that traditional crafts support skill-based education in line with NEP 2020. Modules using activities like block-making and clay work, tested with tribal children in Gujarat, show that learning through local materials and community interaction enhances experiential skill development. Nature-linked processes and peer learning make indigenous crafts an effective pedagogical tool. In a similar vein, Das et al. (2025)<sup>111</sup> argue that in Northeast India, tribal dropout rates stem, to an extent, from cultural

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<sup>106</sup>Hanushek, E. A. & Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of Economic Literature*, 46(3), 607–668.

<sup>107</sup>Acemoglu, D. & Angrist, J. (2000). How large are human-capital externalities? Evidence from compulsory schooling laws. *NBER Macroeconomics Annual*, 15, 9–59.

<sup>108</sup>Caselli, F. (2004). Accounting for Cross-Country Income Differences, NBER Working Paper No. 10828.

<sup>109</sup>Oltulular, S. (2025). Human capital dynamics are the key to economic growth: Source of value of the future. *Economies*, 13(8), p.235.

<sup>110</sup>Lalon, L. & Menon, G. (2023). Traditional indigenous practices to enrich systems for skill-based education. *Proceedings of Relating Systems Thinking and Design (RSD12)*.

<sup>111</sup>Das, T. M. Medhi, M. & Banerjee, S. (2025). Indigenous knowledge systems and sustainable learning: A comprehensive regional analysis of Northeast India. *International Journal of Environmental Sciences*, 11(16s), 1999-2011.

disconnects in formal education. According to them, integrating traditional ecological knowledge, covering agriculture and social systems, can improve engagement, reduce dropouts, and align education with NEP 2020 goals through culturally relevant learning. Dagar (2022)<sup>112</sup> indicate that women prefer locally rooted training. A participatory approach is needed to enable relevant skill development, and sustainable rural livelihoods. The common thread in these papers is that indigenous knowledge strengthens skilling through education, sustainability, and livelihoods when integrated with formal systems, but requires cultural alignment, participation, and institutional recognition.

### **iii. Trends emerging from LinkedIn Reports<sup>113</sup>**

14. India has more than 55 million professionals on LinkedIn, along with over 1 million company pages, 350,000 active job listings, and 50,000 skills added by users to highlight their professional strengths. This data offers valuable insights into workforce trends, and helps employers, graduates, and policymakers better understand and respond to the evolving job market.
15. The LinkedIn reports examined from 2019 to 2025 depict a professional labour market shaped by rapid technological change, increasing integration of AI, continued strong demand for software-related roles, and a rising need for adaptability and strategic thinking.
16. Several clear patterns appear across the reports. The major messages are the following:
  - a) Software engineering continues to be at the core of India's labour market.
  - b) Soft skills related to management and leadership remain consistently important.
  - c) At the same time, AI is changing skill requirements, increasing the need for both basic AI literacy and advanced AI expertise.
  - d) Employers are also placing higher value on hybrid skill profiles that combine technical knowledge with strategic and managerial capabilities.
  - e) Talent movement is largely concentrated in major metropolitan cities within India, while the United States and Germany continue to be major international destinations for professionals.
  - f) Overall, the reports indicate a rapid transformation in skills, with projections suggesting that as much as 70% of job skills could change by 2030.
17. As per LinkedIn data, the top hiring sectors in India are software & IT services, manufacturing, finance, corporate services, and education. Software engineers are consistently in highest demand across industries, including wellness sector. Business and management roles like business analysts and development managers are also widely recruited across sectors like consumer goods, healthcare, logistics, and retail, while in legal and healthcare fields, demand for data analysts has increased. Among soft skills, management, team management, and leadership are in highest demand, alongside customer

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<sup>112</sup>Dagar, P. (2022). Vocational education and training for indigenous women in India: Toward a participatory planning approach. *International Journal of Training Research*, 20(1), 43–57.

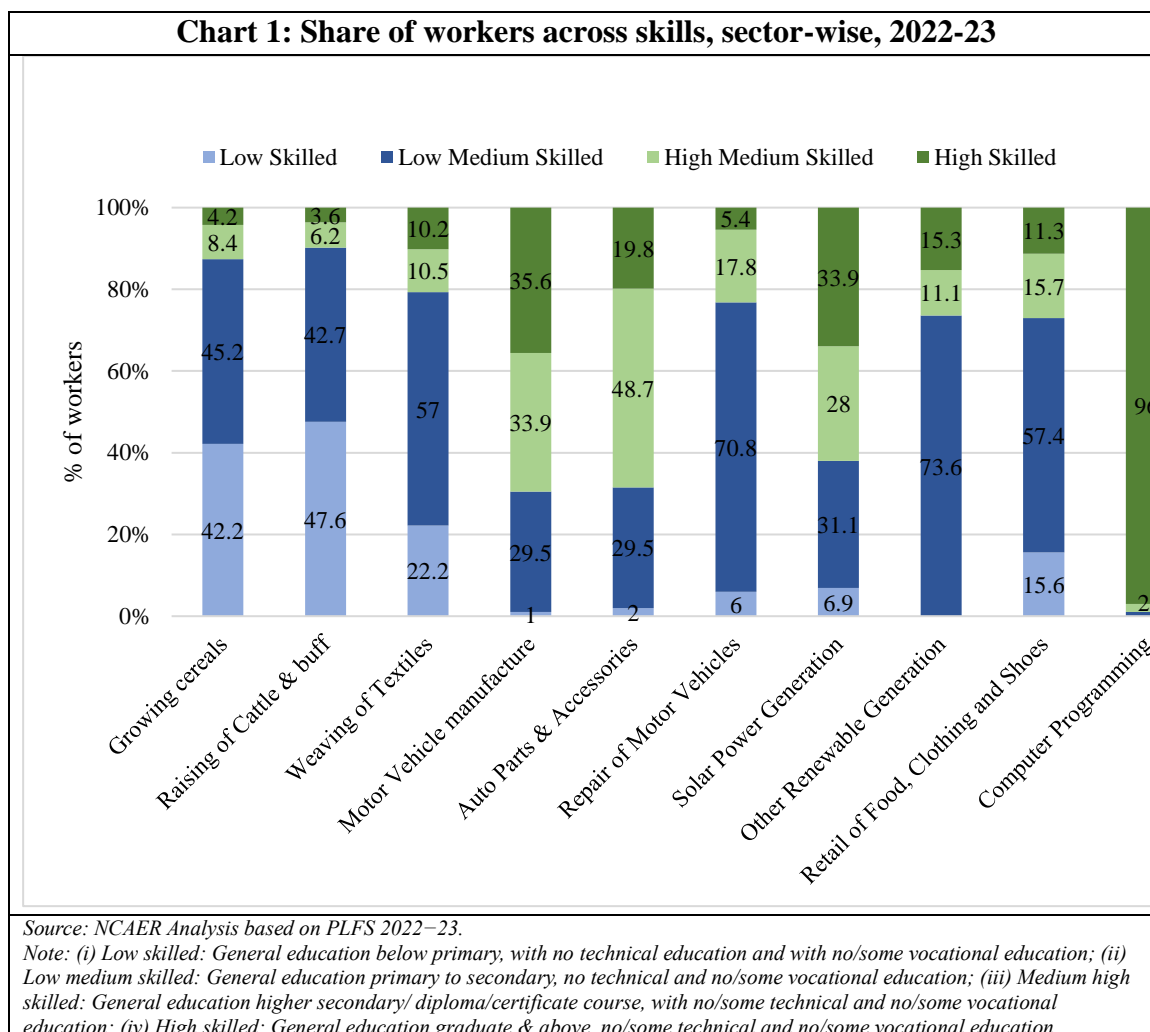
<sup>113</sup>Accessed from the public reports of LinkedIn.

service and project management. Technically, SQL, Java, and C were prominent in IT and finance, while AutoCAD was necessary in manufacturing and design-related sectors. Overall, these reports emphasize India's strong global presence as a supplier of technical talent, especially in programming and web-related skills.

**iv. The National Skill Gap Study for High Growth Sectors, 2025-- MSDE-NCAER Assessment**

18. The National Council of Applied Economic Research (NCAER), on behalf of the Ministry of Skill Development and Entrepreneurship, estimated future employment demand and assessed skill gaps across selected high-growth sectors and states. The study identified seven high-growth sectors: agriculture (crops), animal husbandry, textiles, automotive industry, renewable energy, retail, and information technology. Sectors were selected based on qualitative and quantitative inputs like GVA and employment shares and corresponding multipliers, sunrise sectors and policy-makers' feedback. The quantitative framework was based on Input–Output analysis that enabled estimation of sectoral growth, inter-industry linkages, and employment generation up to the year 2026-27. This macro-level modelling was done by using PLFS and National Accounts Statistics, and occupational classifications like the National Classification of Occupations (NCO-2015), allowing the translation of sectoral employment projections into occupational demand. These projections were used to estimate labour demand across different categories of workers based on education, skills, and experience levels. The qualitative component included stakeholder consultations with employers, industry representatives, training providers, and Sector Skill Councils. By combining these two approaches, the study made employment projections.
19. The study identifies the presence of both skill gaps and skill shortages across sectors. Skill gaps are observed where workers, despite being available and often formally qualified, lack the necessary cognitive skills, technical or vocational skills, and social or behavioural skills required for effective job performance. For example, one is looking for accountants and finds several with the appropriate degree and qualifications but not the appropriate skill set.
20. Skill shortages, on the other hand, arise when employers are unable to find suitable candidates altogether. For example, one is looking for accountants but is unable to find any with the appropriate degree, qualifications, experiences and skills.

**Chart 1: Share of workers across skills, sector-wise, 2022-23**



21. The findings reveal that:

- Technical and vocational skills need to be further developed in many sectors, particularly in emerging and technology-intensive roles. Deficiencies in foundational cognitive abilities and soft skills impact worker productivity.
- Key areas requiring greater alignment include bridging the gap between educational outcomes and industry requirements, enhancing practical exposure within training systems, and fostering better convergence between employer expectations and worker wage aspirations.
- Alongside employment generation there is a need to improve the quality and relevance of skills in the workforce to meet evolving economic demands.

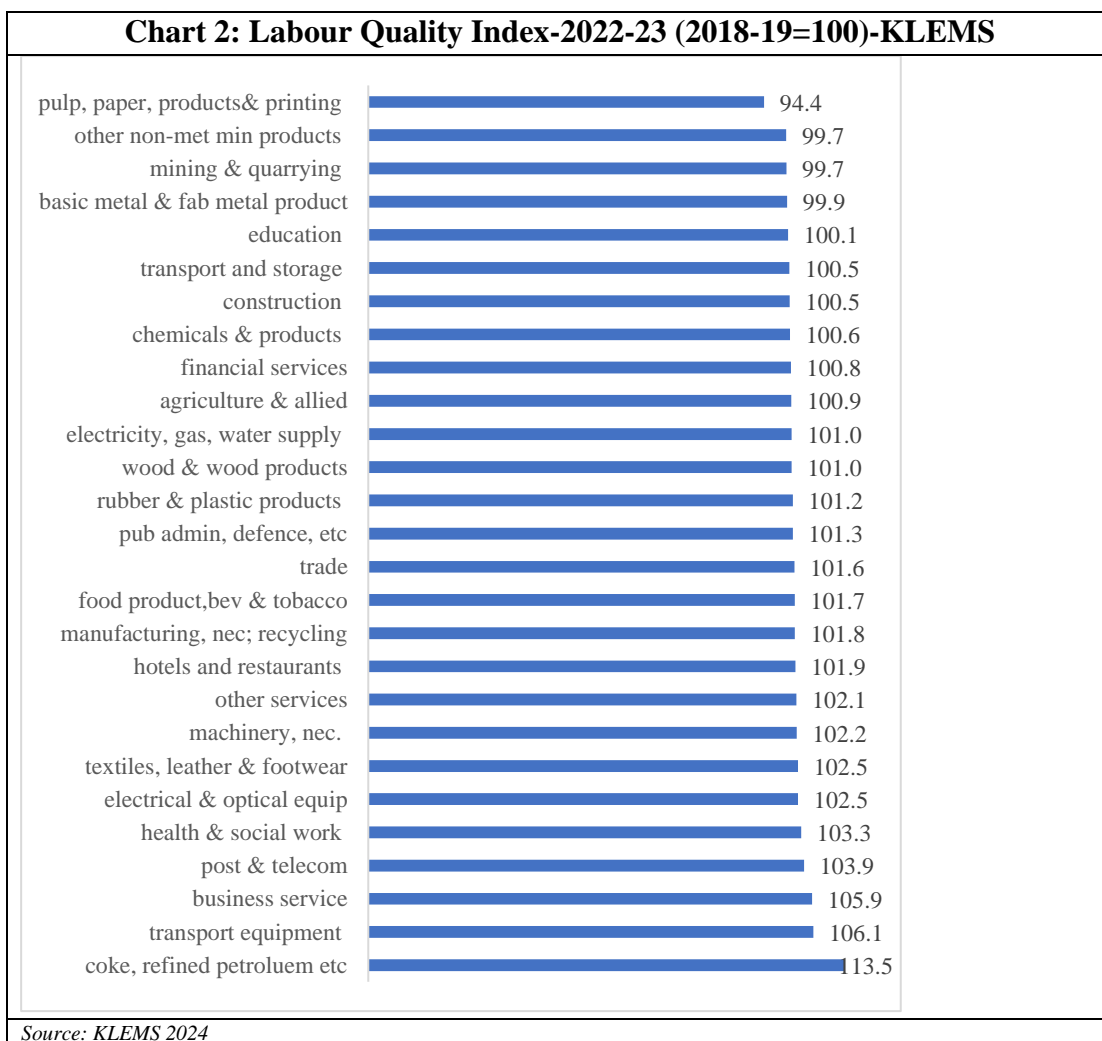
**v. Methodology followed by India KLEMS to Estimate Labour Quality**

22. The India KLEMS Data Manual (2024)<sup>114</sup> outlines the conceptual framework, data sources, and methodology used to construct measures of labour input in production. This captures not only the quantity of labour (i.e., number of workers) but also the quality of labour i.e., skills, education, and human capital. This approach enables a more accurate assessment of

<sup>114</sup> RBI, July 2024, Measuring Productivity at the Industry Level – The India KLEMS Database.

labour contribution to productivity and economic growth, consistent with growth accounting framework.

23. From 2017-18, the estimation of labour input is primarily based on data from the Periodic Labour Force Survey (PLFS). The estimation methodology draws upon the reputed Jorgenson-Gollop-Fraumeni approach. The framework should ideally consider multiple characteristics such as age, experience, gender, and employment status. However, constrained by data availability, the India KLEMS database uses education as the primary proxy for labour quality. The methodology for construction of labour quality index in India KLEMS follows the following steps:
- a) The workforce is classified into five education categories: - up to primary, primary, middle, secondary and higher secondary, and above higher secondary. Changes in labour composition across these categories form the basis of the labour quality index.
  - b) The distribution of workers across these categories is estimated for each industry using PLFS data. Corresponding earnings information is used to assign weights.
  - c) The labour quality index follows trans-log aggregation framework, where the growth in labour input is expressed as a weighted sum of growth rates of different labour types.
  - d) Labour input is calculated as the product of total employment and the labour quality index. In growth terms, labour input growth is decomposed into the sum of employment growth and labour quality growth.
  - e) The difference between aggregate labour input growth and growth in total employment represents the change in labour quality, reflecting shifts in workforce composition towards higher-skilled labour.
  - f) This methodology captures both increases in the number of workers and improvements in their skill composition, and hence, allows for an assessment of the contribution of labour to economic growth.



24. The chart 2 is derived using Labour Quality Index of KLEMS data for 2022-23 across 27 sectors with 2018-19 as the base year (LQI = 100). Most sectors recorded an improvement in labour quality (meaning the index value in 2022-23 was more than 100). Overall, the chart highlights uneven progress in labour quality across industries. The KLEMS measure of labour quality is on sound theoretical footing and provides a summary measure of labour quality for each sector. However, this summary index does not facilitate analysis beyond the headline numbers. The following section attempts to analyse the different ways in which labour quality changes over time.

**vi. Dynamics of Educational Attainments of India’s Workforce**

25. Broadly, the formal channels for improvements in labour quality in terms of knowledge and skills are education (including technical education) and vocational training. NSS’s PLFS surveys provide insights into these channels of improving competencies.

Category of workforce	Share of different educational groups in workforce in 2018-19					Share of different educational groups in income in 2018-19				
	Grd /dipl & <	S&H S	M, P&B P	Oth	Total	Grd /dipl & <	S&H S	M, P&BP	Oth	Total
<b>Total workforce</b>	<b>14.8</b>	<b>21.0</b>	<b>41.1</b>	<b>23.1</b>	<b>100</b>	<b>30.8</b>	<b>22.8</b>	<b>32.4</b>	<b>14.0</b>	<b>100</b>
Self-employed	9.6	22.4	44.0	24.0	100	16.7	26.2	40.2	16.9	100
Salaried	35.8	26.1	29.7	8.4	100	56.1	22.4	17.7	3.7	100
Casual wage	1.4	12.8	48.5	37.3	100	1.7	14.3	50.1	34.0	100

*Source: PLFS, Unit level data converted into FY-wise Data (CWS)*  
*Note: Grd /dipl & <: Diploma, graduates and above; S&HS: Secondary & sr. secondary; M,P&BP: middle, primary and below primary; Oth: others, mostly illiterate.*

Category of workforce	Share of different educational groups in workforce in 2023-24					Share of different educational groups in income in 2023-24				
	Grd /dipl & <	S&H S	M, P&B P	Oth	Total	Grd /dipl & <	S&H S	M, P&BP	Oth	Total
<b>Total workforce</b>	<b>16.3</b>	<b>21.7</b>	<b>41.1</b>	<b>20.9</b>	<b>100</b>	<b>32.9</b>	<b>22.4</b>	<b>32.3</b>	<b>12.4</b>	<b>100</b>
Self-employed	10.6	22.7	43.0	23.7	100	18.5	26.3	39.3	15.8	100
Salaried	38.6	25.7	28.8	7.0	100	60.1	20.2	16.7	3.0	100
Casual wage	2.0	14.7	51.9	31.4	100	2.2	16.1	54.1	27.7	100

*Source: PLFS, Unit level data converted into FY-wise Data (CWS)*  
*Note: Grd /dipl & <: Diploma, graduates and above; S&HS: Secondary & sr. secondary; M,P&BP: middle, primary and below primary; Oth: others, mostly illiterate.*

26. The pattern exhibited in the two tables above in essence of the KLEMS measure of labour quality; as education increases, the income share becomes disproportionately higher than the corresponding workforce share. While we split the total workforce into categories, this pattern holds strongly for self-employed and salaried classes; but is much less pronounced in the case of casual wages because the capabilities required for casual wage earners are generally different from those that can be captured by education. As already noted, while the India KLEMS measure is an acclaimed measure of labour quality that is widely employed in productivity literature, there are a few aspects, relevant to embodied knowledge in labour, that is missed in this measure. Some of them are the following.

Sector	(TE_WF in the sector) / (TWF of the sector) %			(TE_WF in the sector) / (TE_WF total) %
	2018-19	2023-24	Change	2023-24
Transport equipment	24.0	34.9	10.9	2.7
Business services (include ICT)	20.6	34.8	14.2	19.8
Health and social work	26.1	30.6	4.5	8.6
Electricity, gas & w. Supply	19.4	24.4	5.1	2.1
Education	19.2	23.6	4.4	15.8
Machinery, nec	13.1	23.2	10.0	1.0
Coke, refined petro, nucl. Fuel	15.0	20.2	5.2	0.2
Electrical & optical equip	13.1	17.2	4.0	2.9
Chemicals& chem product	13.3	16.4	3.1	1.8
Financial intermediation	10.2	13.3	3.1	3.0
Paper products, printing	9.8	12.5	2.7	0.8
Post & telecom	10.1	12.0	1.9	0.6
Public ad & defence	7.3	10.3	2.9	3.0
Mining & quarry	8.2	9.4	1.2	0.5
Basic metal & fab metal prod	8.7	9.1	0.4	2.0
Rubber & plastic prod	8.9	8.7	-0.2	0.4
Trade	3.1	4.5	1.4	9.8
Other non-met min prod	4.9	3.1	-1.8	0.5
Other manuf., recycling	3.1	3.1	0.0	0.9
Transport and storage	2.2	2.8	0.5	2.4
Other services	2.3	2.5	0.2	1.7
Construction	1.6	2.3	0.7	5.9
Hotel and restaurants	1.8	2.2	0.3	0.9
Textiles, leather & footwear	1.7	2.1	0.4	1.8
Food prod, beverage, tobacco	1.8	2.0	0.2	0.8
Wood products	0.5	1.4	0.9	0.1
Agriculture, etc	0.6	1.0	0.3	9.7
<b>Total</b>	<b>3.6</b>	<b>4.6</b>	<b>1.0</b>	<b>100.0</b>

*Source: PLFS, Unit level data converted into FY-wise Data (PS+SS)*

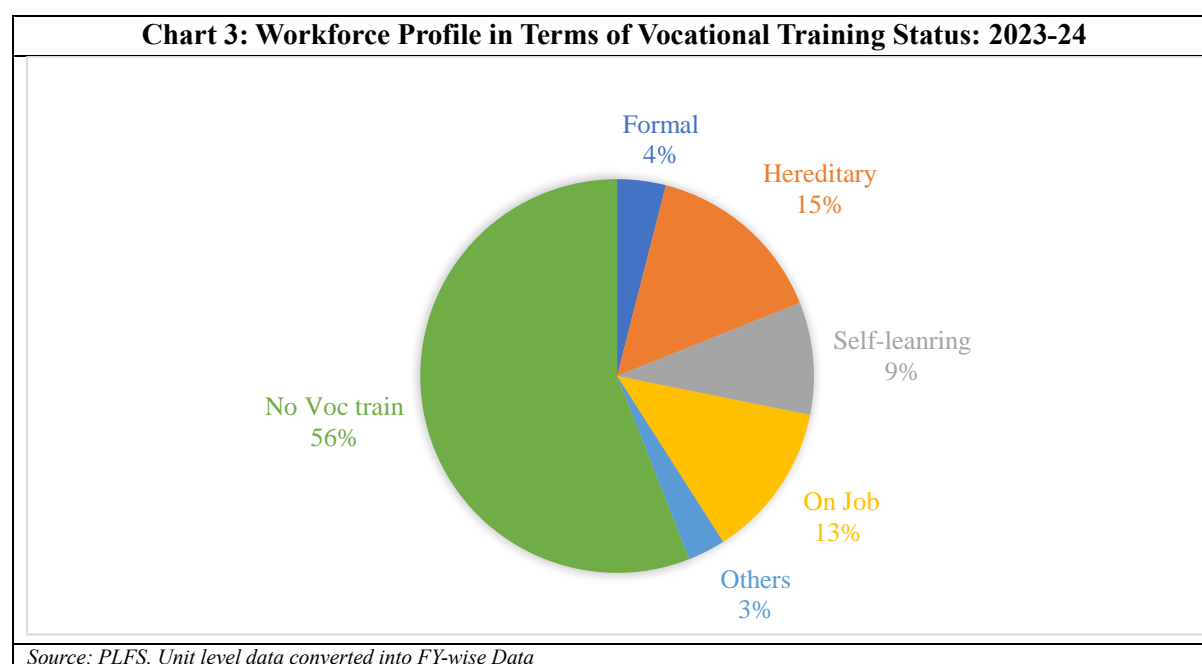
27. One important aspect, which does not become explicit in KLEMS calculations is the status of technical education of the workforce. These are subsumed under different educational categories, but not explicitly and separately considered as a distinct category. The total technically qualified workforce in India is only 4.6% in 2023-24. However, it has a stark sector-wise pattern. First, out of 27 sectors under consideration, 13 sectors had at least 10% of their workforce technically qualified and accounted for 62.5% of such workforce in the country; the first 5 averaged about 30%. Second, the sectors that had higher proportion of technically qualified manpower in the base year (2018-19) generally increased their share much more than the others. (The correlation coefficient between the 2018-19 and the percentage change in 2023-24 is as high as 0.8). Hence the technically qualified manpower in the country is becoming increasingly concentrated.

Sector		% share in TE_WF
agriculture	technical degree	0.5
engineering/ technology		24.4
medicine		3.6
crafts		0.1
other subjects		14.9
agriculture	diploma or certificate (below graduate level)	0.3
engineering/ technology		19.5
medicine		3.4
crafts		0.6
other subjects		15.0
agriculture	diploma or certificate (graduate and above level)	0.2
engineering/ technology		6.0
medicine		2.8
crafts		0.2
other subjects		8.5

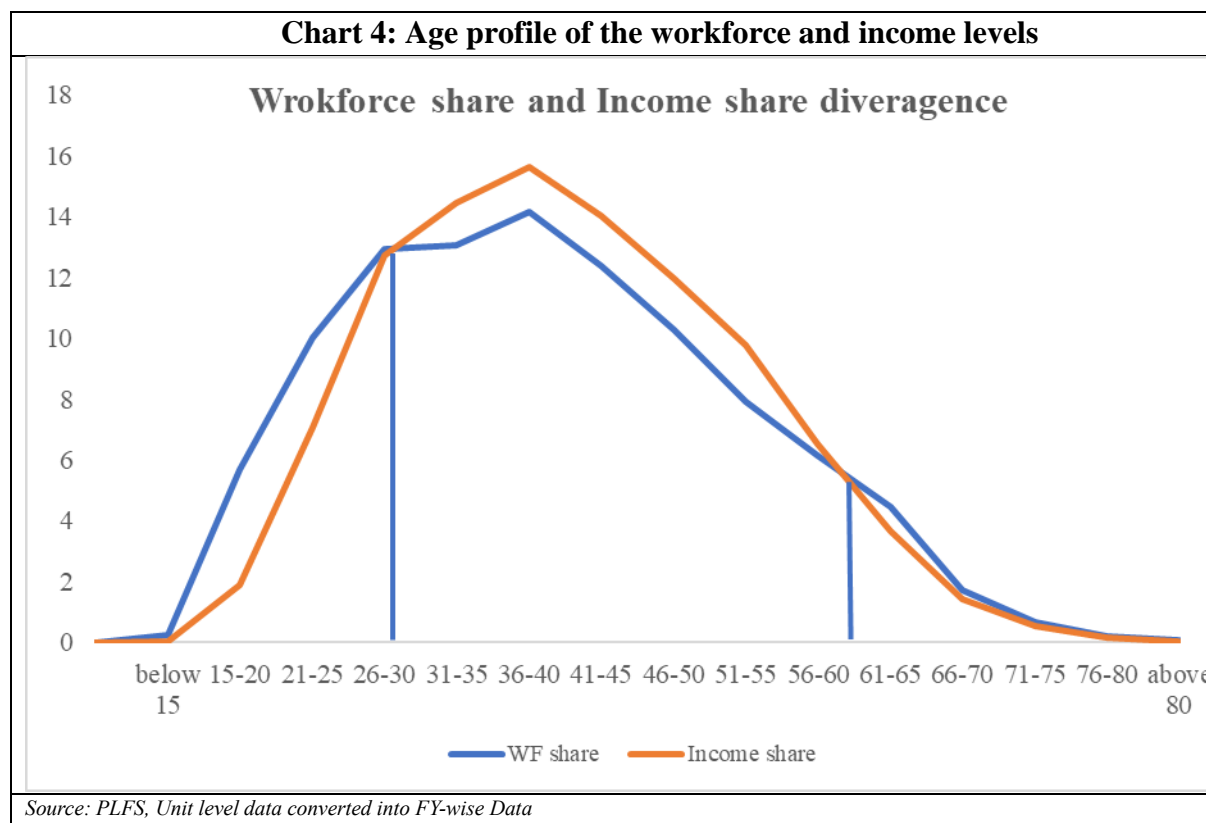
*Source: PLFS, Unit level data converted into FY-wise Data (PS+SS)*

28. However, the technically qualified workforce is highly heterogeneous. The categories presented in PLFS survey are presented in the table above. Out of total such workforce about 50% are in the engineering/technology segment, followed by medicine, 10%. In a labour market still dominated by the agricultural sector, the technical workforce needs to improve further.

29. Another dimension that is substantially missed by KLEMS measure, is vocational education. The chart below distributes the total workforce into different vocationally trained groups.



30. Of those workers formally trained in vocations, more than 80% are in 10 (out of 27) sectors. Those sectors include: education (around 15%), agriculture, textiles & leather, business services and trade (around 9%-10% each) health & social work (around 7%), transport & storage, construction, financial intermediation and other services (4%-5% each). The vast majority (90%) of the formally vocationally trained workforce are with education levels up to higher secondary category.



31. Experience is a crucial determinant of worker productivity and their incomes. Chart 4 presents the age distribution of workforce and their corresponding share in income. The share of workforce in the age group below 30 and above 60 in total workforce is more than their corresponding income share. Younger workers' (below 30) share in workforce is 28.9% and share in income is 21.7%. Elderly workers (above 60) also exhibited similar patterns. In contrast, the income share (72.4%) exceeds workforce share (64%) for the age group 30-60, indicating higher productivity and the resulting income premium. Overall, it reflects a life-cycle pattern where earnings peak in the middle age, suggesting that labour quality analysis should necessarily consider the age profile of the workforce.

	Share of different educational categories in the total workforce of sectors				Comments	Share of the sector in total workforce: 2023-24
	2023-24			Change in the share of Grad & < from 2018-19 to 2023-24		
	Grad & <	HS/S/Mid/Prim	Illite-rates			
machinery, nec	38.7	58.1	3.2	10.4	Sharply positive	0.2
coke, refined petrol & nuclear fuel	43.7	54.4	1.9	9.9		0.0
rubber and plastic products	25.5	67.9	6.6	9.6		0.2
transport equipment	50.6	48.0	1.4	8.1		0.4
business services	67.3	30.2	2.5	7.8		2.6
electrical & optical equip	31.7	62.7	5.7	6.1		0.8
financial intermediation	75.4	23.9	0.7	5.1		1.1
health and social work	55.0	42.8	2.2	5.1		1.3
public ad & defence	47.0	49.4	3.6	4.3	Reasonably positive	1.4
electricity, gas & water supply	41.1	57.9	0.9	4.2		0.4
trade	20.3	70.9	8.8	3.2		10.2
other services	14.2	65.6	20.1	2.6		3.1
post and telecommunication	41.9	57.4	0.6	2.3		0.3
textile products, leather & ftwear	9.2	79.6	11.2	2.2		4.0
mining and quarrying	20.6	66.2	13.3	2.0		0.3
transport and storage	10.9	80.2	9.0	1.6		4.1
construction	5.7	72.7	21.6	1.4		12.0
agriculture & allied	5.1	59.4	35.5	1.2		46.3
hotel and restaurants	10.0	77.8	12.3	0.7	More or less unchanged	2.0
basic metal & fab metal prod	18.8	73.7	7.5	0.7		1.0
wood and products of wood	5.5	74.3	20.3	0.7		0.4
chemicals and chemical products	40.2	54.3	5.5	0.6		0.5
manufacturing, nec; recycling	10.4	80.5	9.1	0.3		1.4
education	69.6	27.0	3.4	-0.3		3.1
food prod, beverages & tobacco	8.4	73.1	18.5	-0.5		1.9
paper, printing & publishing	33.0	55.1	11.8	-2.1	Moderation	0.3
other non-metallic min products	8.2	61.4	30.3	-2.6		0.7
total	14.5	62.6	22.9	1.0	Positive	100.0

*Source: PLFS, Unit level data converted into FY-wise Data (PS+SS)*

32. This table summarises the dynamics of India's labour market outcomes in terms of the composition of the education of workforce between 2018-19 to 2023-24. Methodology for knowledge-augmented quality and sample table of sectors with highest educated workforce is in annexure 1.

**vii. Insights from NIRF data**

33. The National Institutional Ranking Framework (NIRF) provides ranked data for the top academic institutions in India for different disciplines. Discipline-wise, institute-level data was collected from NIRF reports on the number of students graduated and placed, and the median salary offered. A placement ratio was computed for each institution by dividing the number of students placed by the number of students graduated for a standardized measure of placement performance across institutions.
34. The institutions are divided into four equal groups of institutions each, or quartiles, based on their ranks. The descriptive statistics for the fresh MBAs being placed from these top institutions are presented below. The details of other disciplines are appended as Table to the Annexure 3. The weighted average assigns weights based on the number of students placed, thereby giving more importance to institutions with larger placement volumes.

**Table 6: Placement and salary details of top 100 NIRF ranked Management Institutions: 2023-24**

	Number placed institution-wise		Placement ratio		Starting median salary range (annual, Rs. Lakh)		Average: Annual Rs. Lakh	
	Max	Min	Max	Min	Max	Min	Weighted	Unweighted
Quartile 1	633	79	1	0.96	33.0	15.0	25.1	23.6
Quartile 2	898	44	1	0.39	25.7	6.0	12.2	12.7
Quartile 3	852	22	1	0.19	15.6	3.3	10.1	9.6
Quartile 4	504	2	1	0.13	13.0	5.8	8.9	8.8
Overall	898	2	1	0.13	33.0	3.3	15.2	13.7

*Source: NIRF Ranking 2025, Ministry of Education*

35. Quartile-1 institutions report significantly higher average salaries and near-complete placement ratios for their graduates, while lower quartiles show progressively declining salary levels and placement performance. Graduates from higher-ranked institutions are able to secure **better-paying and more stable jobs**, reflecting stronger market valuation of their skills, along with institutional reputation and job roles. However, overall, this information of about 28000 fresh MBAs (estimated to represent about 3%-4% of the net addition to the managerial workforce of around 1.55 crore as per PLFS assuming a normal fresh addition of 10% and attrition of 5% and that all fresh MBAs join the Indian workforce), coupled with the variability indicators presented below, will give a glimpse of the change in managerial quality at its top tier.
36. While NIRF outcomes represent the upper tail of the skill and earnings distribution, reflecting elite institutions and high-end labour market placements, PLFS data on managerial workforce, presented below, provides a more representative picture of the overall economy. PLFS captures heterogeneity in employment types, sectors, and income levels. The summary evidence from PLFS also shows that the NIRF outcomes are not generalizable to the entire workforce. The analysis is based on the Current Weekly Status

from managerial workforce identified from PLFS unit level data using the National Classification of Occupations. The managerial workforce was then further split between salaried and self-employed persons working in two broad sectors; industry and services. Sample limitations make further detailing probably unreliable.

	Maximum income (annual, Rs. Lakh)	Average: annual income, Rs. Lakh
	Max	
Industry: Salaried	36.0	5.8
Services: Salaried	36.0	5.2
Salaried	36.0	5.3
Industry: Self-Emp	60.0	4.1
Services: Self-Emp	60.0	3.7
Self-Emp	60.0	3.8
Overall	60.0	4.2
<i>Source: NIRF Ranking 2025, Ministry of Education &amp; PLFS Unit level data converted into FY-wise Data</i>		

37. The results indicate that salaried managers, on average, earn more stable incomes compared to their self-employed counterparts, because the latter has a longer tail of low-level incomes. The PLFS-based analysis of managers shows much lower average earnings overall, capturing the entire managerial workforce, including both salaried and self-employed managers across industries. The NIRF outcomes reflect more stable and compressed salary distributions at entry levels in managerial positions. PLFS data also reveals that sectoral differences are quite significant.
38. Variability in the quality of fresh managerial workforce in any particular discipline is calculated as the cross-sectional variance of the log of an index combining placement rates (number placed divided by number passed out) and median wages across institutions.

Category	Course	Total Placements 2023-24	Median salary, (Annual, Rs. Lakh): 2023-24		SD(X)	
			Max	Min	2021-22	2023-24
Agriculture	UG Courses	5131	13.0	0.7	1.1	0.8
Architecture		1621	12.3	0.0	0.8	0.6
Dental		1672	15.5	0.0	0.9	0.6
Distance		6846	3.5	0.0	0.5	0.5
Engineering		74533	32.0	3.4	0.7	0.6
Law		3721	20.0	3.0	1.5	0.9
Medical		4203	18.0	0.0	1.3	1.1
Pharma		3218	13.7	1.7	1.0	1.1
Skill		133	6.0	5.0	0.2	0.1
Agriculture	PG Courses	3509	19.5	0.8	1.0	0.9
Architecture		1191	18.4	4.0	0.4	0.5
Dental		1022	35.0	3.8	0.5	0.5
Distance		16153	3.5	0.0	1.6	2.1
Engineering		16185	28.0	3.6	0.7	0.6
Law		1106	15.0	0.0	0.8	0.5
Management		28096	33.0	3.3	0.7	0.7
Medical		6571	93.7	1.5	0.9	0.9
Pharma		4434	33.0	2.2	0.5	0.4
Skill	149	6.1	3.1	1.3	0.5	

*Source: NIRF Ranking 2025, Ministry of Education*

39. Table 8 constructs a measure of placement outcomes across the top 100 NIRF-ranked institutions and placements from multiple disciplines by combining both placement probability and earning potential, following the steps below.

- A placement ratio (P) is computed as the proportion of placed students to total graduates.
- Placement adjusted salary is derived by multiplying placement ratio (P) and median salary (S) of each institution, which reflects both employability and anticipated productivity levels.
- The log transformation of placement adjusted salary ( $X = \ln(P \times S)$ ) is done to reduce the influence of extreme salary values and enable proportional comparisons.
- Finally, the standard deviation of X is computed to assess the dispersion across institutions, capturing the combined effect of variability in placement and earnings outcomes within and across different fields of higher education.

#### **viii. Working Measures of Knowledge and Skills Embodied in Labour**

40. Change in the share of graduates and above in the workforce of different sectors, coupled with the share of technically qualified workforce, can serve as the operational proxy of the

change in knowledge embodied in India’s workforce. Because of its ease in computation and understanding, this indicator will provide useful priors.

- a) The findings may be investigated with supplementary information from:
  - at least one reliable job portal,
  - big data analysis,
  - the MSDE-NCAER-type modelling on skills gaps and shortages,
  - NIRF data analysis, and,
  - progress in vocational training & the information from Sector Skill Councils.
- b) Wherever necessary, i.e., when there is a deeply-felt data gap on particular sectors, sector-specific sample surveys, for instance like those suggested by NCAER (annexure 2), can be conducted for diagnostic purposes.
- c) For quantitative modelling purposes (to monitor the contribution of change in labour quality to GDP growth), the India KLEMS measure, possibly augmented with the details of the share of technical workforce, can be used.

#### **IV. Knowledge embodied in capital**

41. Knowledge and advanced technology content are embodied in the new capital through different channels: - (i) design stage R&D and innovation, (ii) global technology diffusion through import of capital goods and FDI, (iii) improvement in the skill levels and capabilities of the workforce in the domestic capital goods sectors, and (iv) structural change in the composition of capital stock in favour of technologically superior assets. The following discussion makes a brief review of the available measures and further possibilities.

##### **i. KLEMS measure of capital quality**

42. The Reserve Bank of India estimates capital quality as part of the India KLEMS (Capital, Labour, Energy, Materials, and Services inputs) database. This is the most comprehensive, credible measure available. The estimation of capital services for 27 industries required for productivity analysis is presented. This section outlines the Jorgenson-Griliches framework for deriving asset specific capital inputs and the capital services from physical capital. All the productivity calculations in KLEMS use capital services as an input to production. Capital services differ from capital stock as they take into account the differential marginal productivities of various assets. The methodology is as below:

- The KLEMS methodology computes capital stock, capital service growth and capital composition growth.
- The capital stock is estimated for three asset types: construction, machinery (including ICT/non-ICT), and transport equipment using the Perpetual Inventory Method (PIM) with the geometric depreciation rates of 2.5% (construction), 8% (machinery), and 10% (transport). The capital stock ( $S_{k,t}$ ) is given as:

$$S_{k,t} = (1 - \delta_k)S_{k,t-1} + I_{k,t}$$

where  $\delta_k$  is depreciation rate for asset k and  $I_{k,t}$  is the real investment in asset type k in period t.

- Using the capital stock, capital services growth is computed as a weighted average of individual asset stock growth rates, with weights derived from each asset's share in total capital compensation:

$$\ln K_t = \sum \bar{v}_{k,t} \Delta \ln S_{k,t}$$

where,  $\Delta \ln S_{k,t}$  is growth rate of capital stock of asset k and  $v_{k,t}$  is the average share of each asset in the value of total capital compensation in two periods; and

$$\bar{v}_{k,t} = 0.5 \times (v_{k,t} + v_{k,t-1}), \text{ and } v_{k,t} = P_{k,t}^K S_{k,t} / \sum_k P_{k,t}^K S_{k,t}$$

where  $P_{k,t}^K$  is the rental or user cost of capital asset type k in year t.

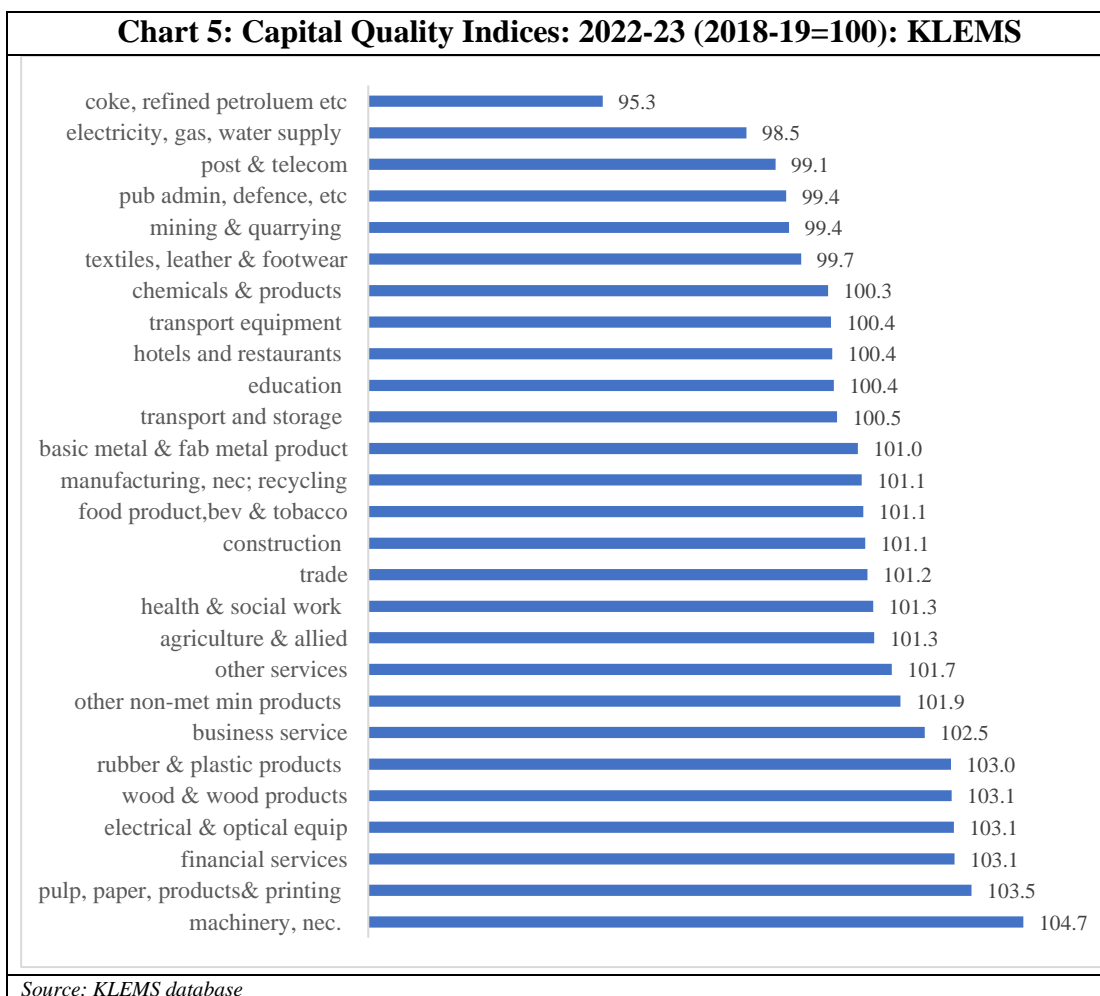
- The rental price reflects the price at which the investor is indifferent between buying and renting the capital good for a one-year lease in the rental market. The rental price equation can be derived as the sum of the nominal rate of return, the nominal cost of depreciation.

$$P_{k,t}^K = P_{k,t-1}^I * r_t + P_{k,t}^I * \delta_k$$

where  $P_{k,t}^I$  is the investment price (or acquisition price) of asset k in year t and r is the real rate of return i.e. nominal interest rate (average of return on government securities and prime lending rate obtained from the Reserve Bank of India) adjusted for consumer price inflation rate. The capital composition effect ( $\Delta \ln KQ_t$ ) - or the effect of changing asset composition of capital stock can be obtained as:

$$\Delta \ln KQ_t = \Delta \ln K_t - \Delta \ln S_t$$

- The database reports constant-price capital stocks and growth rates, capital services growth rates and indices, and a capital composition effect (services growth minus stock growth) all indexed to 1980. The capital composition effect measures the shift toward higher productivity assets such as machinery and away from the unweighted sum of capital stocks. The capital quality index for 27 industries with base 2018-19=100 is present in chart below.



43. The chart above presents a Capital being a durable asset, its quality has an inertia and changes only gradually. The major capital-asset producing segment of the economy, (machinery sector) recorded the highest measure of capital quality growth during the five-year period. One constraint with the KLEMS measure of capital quality is that it does not facilitate further diagnosis beyond the indications contained in the headline numbers. Hence, these numbers should be followed up with other possible measures.

**ii. Skill Improvements in Capital Goods Sectors (CG sectors)**

44. Capital quality can also be inferred from the skill level of labour involved in its production. A more skilled workforce tends to design and manufacture more advanced and efficient capital goods. These measures are also in line with the theory of embodied technical progress. The tables below present the distribution of the workforce across sectors by levels of general, technical, and vocational education.

Type of capital goods	2018-19			2023-24			Change in share of Grad & <
	Grad & <	HS/S/Mid/Prim	Illite-rates	Grad & <	HS/S/Mid/Prim	Illite-rates	
Computer, electronic & optical product	51.7	44.6	3.7	63.8	36.2	0.0	12.1
Electrical equipment	27.7	66.6	5.7	40.6	55.5	3.9	12.9
Other machinery & equipment	28.3	63.0	8.7	38.7	58.1	3.2	10.4
Other transport equipment	42.6	54.3	3.2	50.6	48.0	1.4	8.1
Total	35.3	59.0	5.6	46.8	50.9	2.3	11.5

*Source: PLFS, Unit level data converted into FY-wise Data (PS+SS)*

45. The section on labour quality shows that the CG sectors are among the ones that witnessed highest levels of labour quality as per the KLEMS index. The table above confirms this with a double-digit increase in the percentage of graduates (and above) in the workforce, the growth being evenly distributed across the four components.

Type of capital goods	(TE_wf) / (Twf of sector) %			(TE_wf) / (TE_wf of CG industry) %		
	2018-19	2023-24	Change	2018-19	2023-24	Change
Computer, electronic & optical product	26.0	37.7	11.7	17.8	14.7	-3.0
Electrical equipment	18.4	24.3	5.9	26.2	20.7	-5.5
Other machinery & equipment	13.1	23.2	10.0	20.4	18.1	-2.3
Other transport equipment	24.0	34.9	10.9	35.6	46.5	10.9
Total	19.4	29.8	10.4	100.0	100.0	0.0

*Source: PLFS, Unit level data converted into FY-wise Data (PS+SS); TE-wf=technically educated workforce; Twf=Total workforce*

46. Technical qualifications, presented in Table 10 are subsumed under different educational categories in Table 9. CG sectors structurally require technically equipped workforce. About 30% the workforce in the capital goods sector is technically qualified. Of them, 84% are graduate (or above) engineers.

Type of capital goods	% of workforce formally trained in vocations	
	2018-19	2023-24
Computer, electronic & optical product	11.0	11.9
Electrical equipment	7.6	12.1
Other machinery & equipment	8.6	11.7
Other transport equipment	9.8	19.1
Total	9.0	14.8

*Source: PLFS, Unit level data converted into FY-wise Data (PS+SS)*

47. The proportion of vocationally trained workforce is also gradually increasing in all the CG sectors. However, the education-based (general, technical, vocational or combinations of them) approach to skill assessment has limitations. These are only partial measures. Marginal improvements in workforce quality may not lead to visible capital quality gains.

### iii. Quality of Imported Capital Goods

48. Import of capital goods accounted for more than 45% of the machinery and equipment segment of India's gross fixed capital formation in 2023-24.

49. There is no direct measure of the quality of capital goods imported into India. Hence, an attempt has been made to approximate the quality of capital goods imported into India annually. The three international databases utilised for this purpose are:

- a) Harvard Growth Lab,
- b) The database of the Quality of Government (QoG) Institute, located at the University of Gothenburg, Sweden, and,
- c) The World Integrated Trade Solution (WITS) database of the World Bank.

50. Harvard Growth Lab releases the Economic Complexity Index (ECI)<sup>115</sup>, constructed based on the Hidalgo and Hausmann (2009)<sup>116</sup> method. The ECI captures both the diversity of a country's export basket and the ubiquity of those products across countries. Economies that export a wide range of sophisticated goods tend to have higher ECI scores, reflecting deeper productive capabilities. Using international trade data, the Revealed Comparative Advantage of exporting nations is calculated, based on which measures of country diversity (number of products a country exports competitively--the higher, the better--) and product ubiquity (number of countries exporting each product--the lower, the better--) are arrived at ECI for each country is finally derived by combining both these metrics and transforming them.

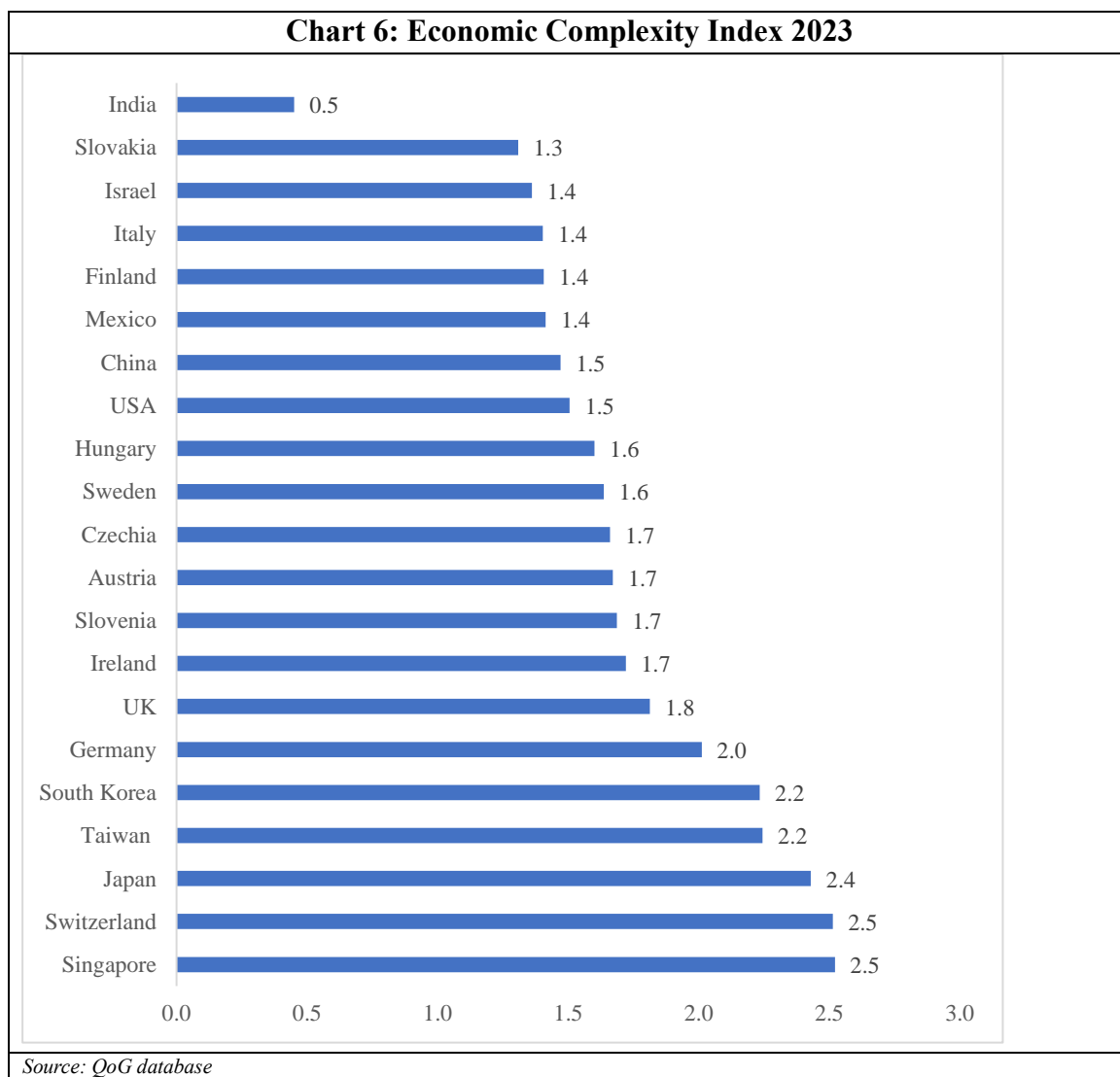
51. Higher ECI ranking for a country is widely regarded as a measure of its production capabilities and know-how. Countries ranked higher in ECI are closer to the production frontier and likely to produce high-quality capital goods. In our analysis, it is postulated that higher the import of capital goods to India from high ECI-ranked countries, the better is the quality of imports. The data have been sourced from the QoG database<sup>117</sup>, which, in turn, sources the original index from the Harvard Growth Lab's Atlas of Economic Complexity database and standardises it before hosting. To illustrate the index numbers for 2023 for top 20 countries and India are presented in the Chart below.

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<sup>115</sup>Complexity Rankings and Growth Projections available at <https://atlas.hks.harvard.edu/rankings>.

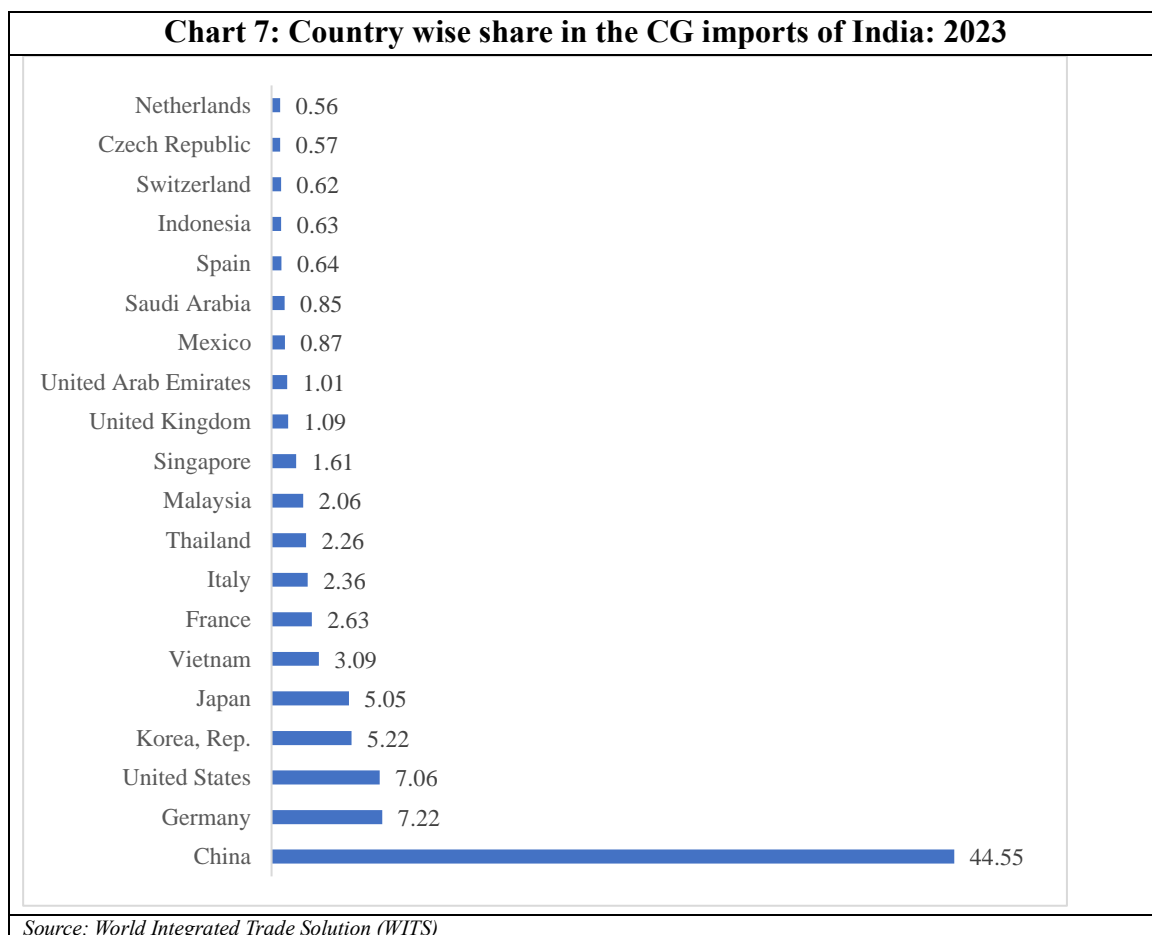
<sup>116</sup>Hidalgo, C. A. & Hausmann, R. (2009). The Building Blocks of Economic Complexity. PNAS / Harvard CID Working Paper.

<sup>117</sup>[https://datafinder.qog.gu.se/downloads?download=gpcr\\_eci](https://datafinder.qog.gu.se/downloads?download=gpcr_eci).



52. The WITS database of the World Bank<sup>118</sup> presents harmonised international trade statistics. This database allows access to India’s capital goods imports, year-wise, segregated by source countries and as per UNCTAD Stage of Processing (SoP) classification. The source country-wise data on India’s import of capital goods in 2023 is presented below.

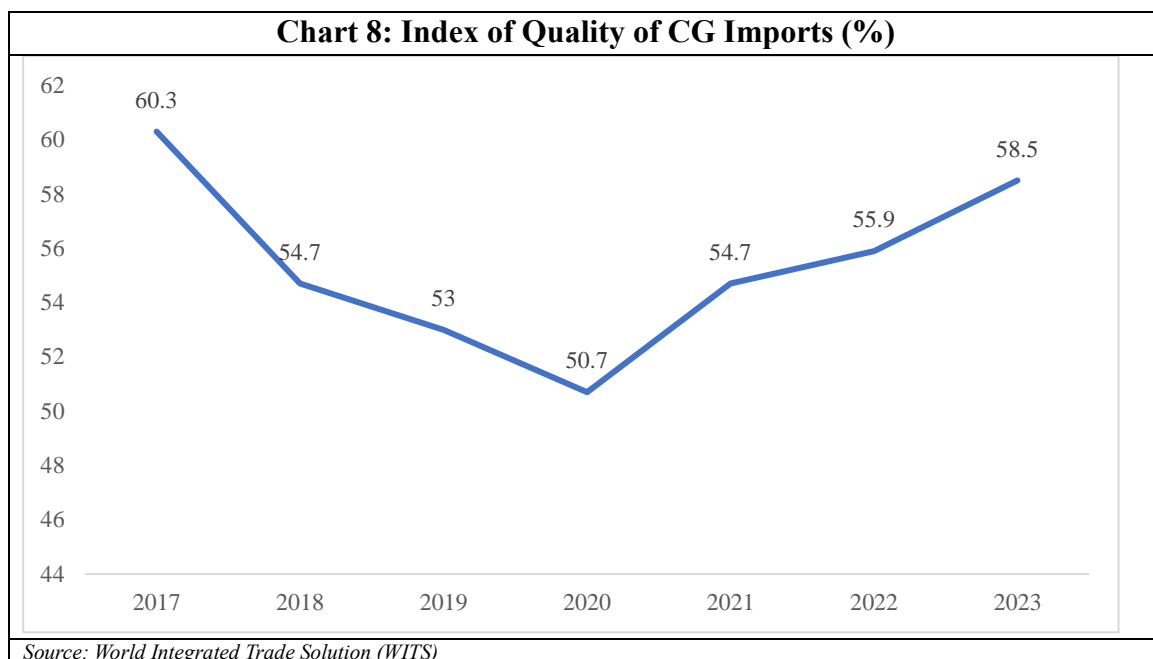
<sup>118</sup><https://wits.worldbank.org/countrystats.aspx?lang=en>



53. ECI ranking of a country can work as a proxy for its relative strength of embodied knowledge imported by India through capital goods. The ECI values can be normalised by indexing the highest ranked country as 1 and then pegging other countries in descending order to that ratio. This ratio, when multiplied with the corresponding import ( $M_{i,CG}$  = import of capital goods from  $i^{\text{th}}$  country) values, and aggregated across trading partner countries will represent the quality adjusted imports (Quality Augmented Sum of Capital Good Imports =  $\sum (\text{Normalized ECI}_i \times M_{i,CG})$ ). The following ratio will finally capture the index of quality of imported capital (the strength of embodied knowledge or technology diffusion through import of capital goods) in year ‘t’:

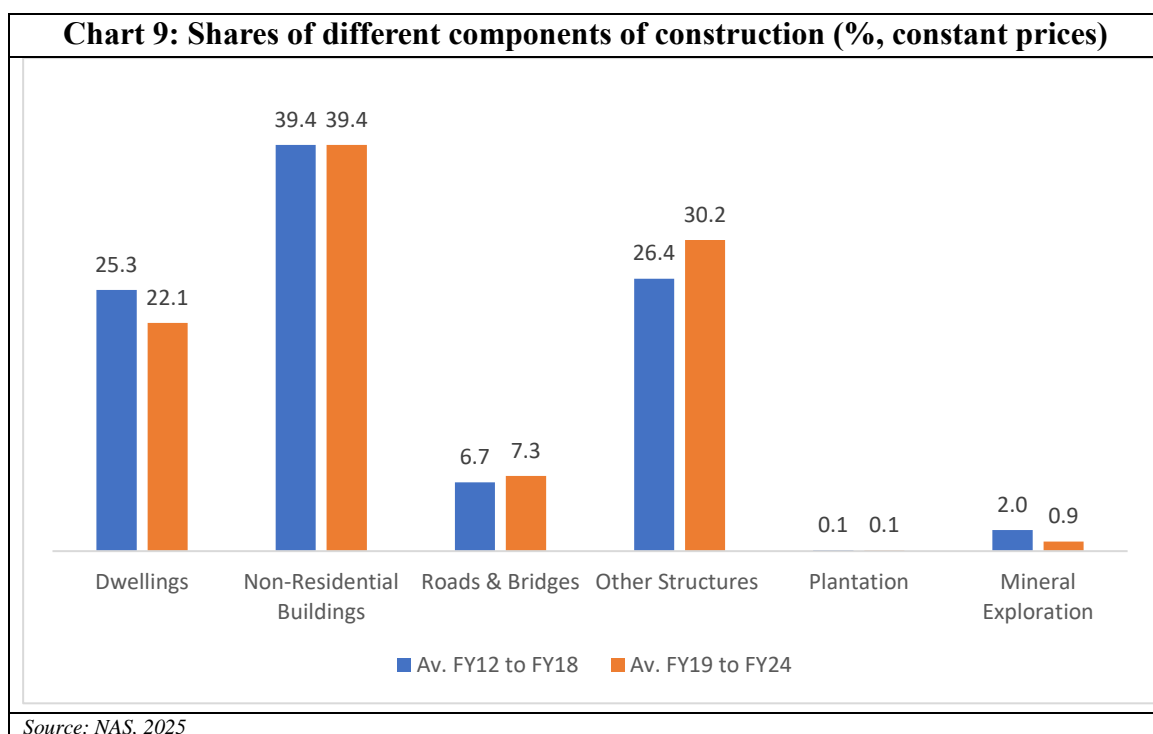
$$IQ_{CG,t} = \frac{\sum (\text{Normalized ECI}_i \times M_{i,CG})_t}{\sum M_{CG,t}}$$

54. As the numerator tends to be a value less than the denominator, the ratio is always less than 1. This Index for 7 years (2017 to 2023) is presented in the following chart.



**iv. Compositional Quality of Construction: - Is this measure possible?**

55. Overall, buildings and structures accounted for around 56 per cent of GFCF in India during FY 19 to FY24. These assets are segregated into dwellings, plantations, non-residential buildings, roads & bridges, other structures & land improvements and mineral exploration. Empirical research indicates that the inter-se composition between these assets will partially define the productivity gains from new construction.



56. The higher productivity impact of infrastructures, particularly in relation to residential construction, is well documented. However, productivity gains from different construction classes (dwellings, non-residential buildings, roads & bridges, other structures, etc) are not the same as their knowledge embodiment/technology content. Second, a workforce skill-based approach cannot work effectively in construction, a sector that is dominated by informal and less educated workforce. Hence, the variability in construction quality that can be explained by labour quality differentials is limited. As of now, there is no conclusive empirical evidence that helps making a pecking order among these construction classes—neither the National Accounts, nor survey data or empirical research helps to build such reliable pecking order.

**v. AI and the Economy-Need for an Evaluation Framework**

57. Artificial intelligence (AI) is emerging as a key component of intangible capital in its advanced form. Globally, AI is creating significant waves across economies. At the same time, India is assessed among the top global contributors to AI research output and to have a deep pool of AI talent.<sup>119</sup> While notable progress has been made, there remains considerable scope to strengthen access to computing infrastructure, enhance resources for large-scale model training, and encourage greater private participation in foundational AI research. Given this, and the empirical finding that worker productivity increases more rapidly when intangibles are counted as capital<sup>120</sup>, it is important that we develop a mechanism to evaluate the contribution of AI to the economy.

58. Measurement is key in appreciating the impact of AI, a general-purpose technology. Its measured productivity impact is time-variant. At the initial phases, significant investments are required in data, hardware, organizational change, and skills. This sometimes goes under-measured, and often bunched together with other forms of capital formation. These investments begin to give returns later, and then the estimated output rises without a commensurate increase in accounted costs, resulting in overestimation of productivity growth at that stage. Thus, the ongoing technological transformation leads to a temporal mismatch in measurement of productivity, biasing productivity estimates across phases of adoption.<sup>121</sup>

59. Globally, measurement of AI is still in its early stages. An assessment of AI penetration would need to take stock of at least four stages: - (i) development, (ii) adoption and complementary investments, (iii) diffusion and use, and, (iv) impact. AI development and adoption entail different types of investment, resource flow to physical capital (computing

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<sup>119</sup>Economic Survey 2025-26, quoting Country Activity Tracker by Emerging Technology Observatory, Georgetown University & The Global AI Talent Tracker 2.0, Paulson Institute.

<sup>120</sup>Corrado, C., Hulten, C., & Sichel, D. (2009). Intangible capital and US economic growth. *Review of income and wealth*, 55(3), 661-685.

<sup>121</sup>Brynjolfsson, E., Rock, D., & Syverson, C. (2021). The productivity J-curve: How intangibles complement general purpose technologies. *American Economic Journal: Macroeconomics*, 13(1), 333-372.

power and other physical infrastructure) and intangible capital (software, data and skills). Given this intrinsic composition of AI, a finer and contextually relevant distinction is that, while AI substantially embodies knowledge through data, models, and algorithms, but it is not knowledge per se. The study of the degree of knowledge embodiment in AI requires data on the different stages of investment in AI.

60. In the account framework of National Accounts Statistics, these investments are spread across different expenditure categories, some portion in R&D, some in ICT, some in machinery and equipment and construction, and perhaps, a few items in intermediate consumption. Research has analysed the coverage of AI-related investment in different forms under the National Accounts Statistics of different countries.<sup>122</sup> As of now, it is difficult to isolate and aggregate AI investment from NAS.

61. Kathuria et al. (2020)<sup>123</sup> attempted a firm level panel regression study on 1553 firms for the period 2007-08 to 2016-17. In the absence of any other data, the study took investment in software, databases and computer machinery as a proxy of AI. They estimated the determinants of total factor productivity in the Indian economy by introducing AI as an explicit determinant and found a positive and significant relation. However, AI is only a fraction of investment in software, databases and computer machinery. *Systematic and direct accounting of investment in AI, its knowledge content and impact require reorienting the company databases, R&D survey of the Department of Science and Technology, MEITY's estimation of digital GDP, and the unorganised sector data.*

## vi. Working Measures of Knowledge Intensity in Capital Formation and Stock

62. As already noted, the KLEMS measure, while being theoretically well-founded and analytically robust, does not lend itself to further diagnostic analysis in this context. This necessitates working with simple, monitorable, and diagnosable indicators of capital quality. Concluding the discussions above, we suggest the following measures.

### a) R&D and ICT intensity in Capital Formation

63. This is a direct measure of knowledge intensity in capital; both its stock and flow. The flow measure is the ratio of the sum of R&D investment and ICT used by different sectors at constant prices to the GFCF. ICT should include both hardware and software and R&D investment should include both revenue and capital expenditures. The ICT measure can be constructed to a large extent with the help of Supply Use Tables. The R&D investment should be sourced from R&D survey data of the Department of Science and Technology.

a) A knowledge intensity measure in the GFCF of sector 'i' in time 't',

$$I_{i,t} = (R\&D_{i,t} + ICT_{i,t}) / (GFCF_{i,t})$$

<sup>122</sup>Corrado, C., Haskel, J., & Jona-Lasinio, C. (2021). Artificial intelligence and productivity: an intangible assets approach. *Oxford Review of Economic Policy*, 37(3), 435-458.

<sup>123</sup>Kathuria, R., Kedia, M. & Kapilavai, S. (2020). Implications of AI on the Economy, NASSCOM.

- b) This is a flow measure. The corresponding stock measure estimated through perpetual inventory method,

$$I_{i,t}^S = (R\&D_{i,t}^S + ICT_{i,t}^S)/(K_{i,t}^S)$$

64. The construction of the R&D capital stock ( $R\&D^S$ ) and total capital stock ( $K^S$ ) have been established through perpetual inventory method in Chapter 3 of this document. These ratios can be observed with a particular focus on CG sectors and construction to understand the technology penetration into these sectors.

65. Possible issues and clarifications:

- When ICT measure is taken as investment in software plus hardware, it does not represent pure knowledge. It mixes quality (majorly software) and quantity (to an extent, computers, servers, telecom equipment). However, it is important to have a full, uncomplicated measure of technology exposure through ICT, especially with AI penetration.
- Another weakness of this measure is that it ignores embodied knowledge in non-ICT capital. This is not an issue that can be easily overcome. How does India KLEMS capture embodied knowledge? It takes only a four-fold split of machinery, transport equipment, construction and IPP. It is just broad, omnibus compositional quality. It does not capture embodied knowledge in different types of machinery. This will require sector-specific studies detailed on capital composition, beginning with sector-specific meta studies.
- Another issue is that R&D does not immediately result in embodied knowledge, its impact will be gradual and may be partial. The stock measure proposed above will address this issue to an extent with its inertia, but not fully.
- Yet another issue is that the capital composition of different sectors is structurally different. For instance, manufacturing may have higher machinery intensity (and less ICT intensity) in its capital stock than in services. However, given that our purpose is to track improvement in capital quality (knowledge embodiment in capital) in each sector over time, not to undertake comparison sectors in a given year, this is fine.

#### **b) Balance Between Machinery & Equipment to Dwellings, Other Buildings and Structures**

66. One measure of the capital quality can be the ratio of Gross Fixed Capital Formation in Machinery & Equipment to Dwellings, Other Buildings Structures across the industry groups as reported in National Account Statistics<sup>124</sup>. A higher ratio indicates a greater share of investment directed toward higher-quality, productivity-enhancing assets such as machinery and equipment, relative to construction. For our analysis we have considered the average ratio of 2011-12 and 2012-13 and compared it with the average ratio of 2022-23 and 2023-24, to observe the decadal change. The table below presents the comparison of this ratio across NAS industry groups.

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<sup>124</sup>National Account Statistics 2025 available at <https://www.mospi.gov.in/publications-reports/innerpage/432>

<b>Table 12: Ratio of Machinery to Constructed Structures in capital formation</b>		
<b>Economic Activity</b>	<b>Av FY12 to FY16</b>	<b>Av FY20 to FY24</b>
Agriculture & allied	0.4	0.4
Mining & quarrying	3.2	3.7
Manufacturing	2	1.6
Electricity and other utility	2	1.1
Construction	0.7	1.0
Trade & repair	0.2	0.4
Hotels & restaurants	0.2	0.3
Railways	0.5	0.7
Road transport	4	3.8
Water transport	9.4	3.9
Services incidental to transport	0.9	0.6
Storage	0.1	0.3
Communication & broadcasting services	4.7	1.6
Financial services	1.4	1.7
Real estate & professional services	0.1	0.2
Pub admin & defence	0.3	0.2
Other services	0.3	0.3
Total	0.6	0.6
<i>Source: NAS, 2025</i>		

67. Economic sectors cannot be compared in relation to this ratio in a given year, because they are structurally different, requiring different combinations of machines and structures; however, temporal change in the ratio in each sector is indicative of change in the incremental technology embodiment in the sector. The Economic Survey 2023-24, while discussing the growth strategy for Amrit Kaal suggests, "India's private gross fixed capital formation must accelerate in Machinery & Equipment and Intellectual Property products so that quality jobs can be created." The ratio has improved for agriculture, construction, trade & repair, hotels and restaurants, financial services, and real estate, ownership of dwelling and professional services while others witnessed a decline over the same period. The patterns seen in some sectors call for a more even alignment of investment across machinery and structures to strengthen capital quality across the sectors and improve the capital productivity. A diagnostic enquiry whether the structural changes within sectors during the decade warranted such changes in balance will throw greater light into this dynamic.

### **c) Changing Patterns in Depreciation Rates**

68. National Accounts provide sector-wise information on the consumption of fixed capital. This indicator needs to be interpreted with caution. It is not empirically possible to establish

a universally applicable relation between technological sophistication of assets and their temporal depreciation rates. However, asset classes that witness rapid technological change; for instance, some types of machinery & equipment exhibit higher depreciation due to faster technological obsolescence. In contrast, structures typically possess longer service lives; hence, the embodied technology stays longer without accommodating fresh knowledge. However, this measure can only be interpreted in combination with other measures and in relation to the specific sectoral context.

#### **d) Temporal Movements in the Skill levels of Workforce in CG sectors**

69. The brief study of educational and technical qualifications of the workforce in CG sectors presented in this section will only serve as a reference point for analysing the changing skills in these sectors. This analysis needs to be augmented with specific skill gap analysis based on modelling (for instance, the MSDE-NCEAR skill gap study detailed above) and labour market developments from job portals.

#### **e) Quality of CG imports**

70. The analysis above on the quality of imported CGs based on an evaluation of the source composition of imports, or a variant thereof, can be used for this purpose.

### **V. The Next Stages**

71. The attempt in this chapter has been two-fold: (a) suggest a framework grounded in established research methodologies, to assess the impact of knowledge on the economy, and (b) identify indicators that reflect the channels of transmission of knowledge into production and output. We explored the possibilities and suggested indicators to capture knowledge embodied in capital and labour (and a preliminary method to proxy the quality of intermediate services, placed at Annexure 1). These measures are simple and objective by design, rendering them suitable for policy assessment, evaluation and course corrections.

72. As we mentioned at the outset, this is only a baseline exercise. The suggestions for the next stages are the following:

- a) Refining the suggested measures through an exploration of more data;
- b) Coherently aggregating them into composite quality measures for each input;
- c) Conducting pilot estimations and evaluating results for their robustness and interpretability;
- d) Deploying the insights gained from these stages, refine the methodology, identify the data gaps and inform policy about the contours of a database to be developed.

## Annexure-1

### Service Input Quality: - An option

One can construct a proxy a knowledge-augmented quality of intermediate service inputs in the following steps:

- a) Rank intermediate service sectors by the proportion of graduates in their workforce;
- b) Normalise this proportion such that the highest value equals one;
- c) These normalised values serve as weights reflecting service quality. This is exemplified in the following table with PLFS data. These normalised values can be taken as proxies for the embodied knowledge in these services. This approach has limitations, but this can be a first approximation.

<b>Table: Sectors with highest share in educated workforce and normalised value</b>		
<b>Sector</b>	Share of graduates and above in the total workforce of sectors: 2023-24	Normalised value
financial intermediation	75.4	1.0
education	69.6	0.9
business services	67.3	0.9
health and social work	55.0	0.7
public ad & defence	47.0	0.6
post and telecommunication	41.9	0.6
trade	20.3	0.3
other services	14.2	0.2
transport and storage	10.9	0.1
hotel and restaurants	10.0	0.1
construction	5.7	0.1
Source: PLFS, Unit level data converted into FY-wise Data (PS+SS)		

- d) For each sector  $i$ , compute a weighted value of total service inputs by multiplying the aforementioned normalised proportions with the values of the corresponding intermediate services used in the sector. The difference between the growth in the weighted aggregation of these service inputs and the growth in their simple sum can be taken as the growth in the quality of these intermediate services used in sector ' $i$ '.

## **Annexure 2**

### **Summary of Major Suggestions Made in MSDE/NCEAR Study on Skills for Building Up Information**

National skill gap study for high growth sectors by Ministry of Skill Development & Entrepreneurship gives analysis and recommendations to identify skill gap in seven sectors. Most of methodological recommendations are common in each sector. Agriculture sector requires involvement of farmers and agri-businesses to identify local skill needs. While livestock sector focuses on technological advancements (AI in breeding, feed optimization, cold-chain logistics) and addressing shortages in refrigeration and processing skills. The textiles and Cotton Ginning sector focus on managing the transition from traditional (handloom) to modern (power loom and mills) and improving data collection through Handloom Census and surveys. The Manufacture of Transport sector emphasizes expanding its scope beyond manufacturing to include R&D and dealerships. The Electricity sector focuses on clearly defining sub-sectors like solar and wind (including manufacturing) and addressing skill shortages in new technologies. The Retail Trade sector highlights the coexistence of traditional, modern, and online retail channels, each with different skill needs. There is strong demand for multi-skilled workers, especially in e-commerce, data analytics, digital marketing, and customer engagement. The Computer Programming sector requires continuous and rapid updating of job roles and skills due to fast innovation.

Overall, Sectors, to assess skill gaps follows a standard, data-driven framework like mapping sub-sectors to NIC codes and aligning job roles with NCO classifications. The approach emphasizes annual vacancy and employer surveys using reliable databases (Economic Census, MCA, GSTN, MoSPI, MoFAHD etc.) along with big data analysis from job portals and platforms (National Career Service, LinkedIn, Naukri.com, and Workindia.in). Special emphasis needs to place on reskilling/upskilling, digital and financial literacy, and recognition of prior learning (RPL). Additionally, stakeholder consultations, Focus Group Discussions (FGDs) are needs to conduct regularly to get insights on hiring challenges, new technologies, and workforce trends. Sectors require bottom-up, district level approach due to regional diversity. In coordination with the MSDE, the Sector Skill Council needs to implement surveys on a regular (at least annual) basis, which captures vacancies of firms. Overall, Labour Market Information System (LMIS) for continuous monitoring, while promoting industry-academia collaboration and curriculum alignment to reduce skill mismatches.

### Annexure 3

#### Discipline wise tables from NIRF data

<b>Table: Placement and salary details of top NIRF ranked Institutions: UG Course 2023-24</b>									
	Discipline	Number placed institution-wise		Placement ratio		Starting median salary range (annual, Rs. Lakh)		Average: Annual Rs. Lakh	
		Max	Min	Max	Min	Max	Min	Weighted	Unweighted
Quartile 1	Agriculture	458	29	0.8	0.2	7.5	4.0	5.4	5.4
Quartile 2		300	35	0.7	0.2	7.1	0.7	4.9	4.6
Quartile 3		608	21	0.7	0.1	13.0	3.0	6.9	6.6
Quartile 4		478	5	0.9	0.1	6.6	1.8	4.8	4.3
Overall		608	5	0.9	0.1	13.0	0.7	5.2	5.2
Quartile 1	Architecture	75	14	0.9	0.5	12.3	4.8	6.7	6.9
Quartile 2		95	15	0.9	0.2	8.2	4.0	5.4	5.5
Quartile 3		117	11	1.0	0.2	8.2	2.5	4.2	4.2
Quartile 4		72	0	0.9	0.0	7.3	0.0	3.7	3.7
Overall		117	0	1.0	0.0	12.3	0.0	5.0	5.1
Quartile 1	Dental	86	19	1.0	0.2	14.8	3.0	5.7	6.3
Quartile 2		85	0	0.8	0.0	14.4	0.0	8.0	8.2
Quartile 3		67	15	0.9	0.4	15.5	3.0	6.1	6.5
Quartile 4		101	20	0.9	0.3	7.8	3.3	6.1	5.5
Overall		101	0	1.0	0.0	15.5	0.0	6.3	6.6
Quartile 1	Engineering	4210	160	1.0	0.7	22.5	6.0	12.3	15.1
Quartile 2		2754	121	0.9	0.4	32.0	4.7	9.2	10.8
Quartile 3		1502	89	1.0	0.5	18.0	5.0	9.8	10.4
Quartile 4		1062	54	1.0	0.2	22.0	3.4	7.5	8.2
Overall		4210	54	1.0	0.2	32.0	3.4	10.2	11.1
Quartile 1	Law	275	15	1.0	0.2	20.0	5.4	15.2	13.9
Quartile 2		312	7	0.9	0.0	14.0	3.0	6.8	7.0
Quartile 3		177	7	0.8	0.1	16.0	5.0	7.2	7.8
Quartile 4		185	18	0.9	0.3	10.0	3.7	6.0	6.3
Overall		312	7	1.0	0.0	20.0	3.0	9.4	8.9
Quartile 1	Medical	217	0	1.0	0.0	18.0	0.0	9.1	8.7
Quartile 2		195	20	1.0	0.1	14.5	1.3	10.7	10.6
Quartile 3		217	0	0.9	0.0	15.2	0.0	8.7	8.2
Quartile 4		203	24	0.9	0.1	14.1	3.6	9.4	8.4
Overall		217	0	1.0	0.0	18.0	0.0	9.6	9.0
Quartile 1	Pharma	146	2	1.0	0.0	13.7	1.8	5.8	5.4
Quartile 2		100	2	0.9	0.1	5.0	2.3	3.6	3.5
Quartile 3		79	3	0.8	0.0	5.2	1.8	4.2	3.8
Quartile 4		87	1	0.9	0.0	6.3	1.7	3.8	3.8
Overall		146	1	1.0	0.0	13.7	1.7	4.4	4.1

Source: NIRF Ranking 2025, Ministry of Education

<b>Table: Placement and salary details of top NIRF ranked Institutions: PG Course 2023-24</b>									
		Number placed institution-wise		Placement ratio		Starting median salary range (annual, Rs. Lakh)		Average: Annual Rs. Lakh	
	Discipline	Max	Min	Max	Min	Max	Min	Weighted	Unweighted
Quartile 1	Agriculture	246	27	0.8	0.1	10.4	4.0	6.7	6.8
Quartile 2		261	21	0.9	0.4	7.7	0.8	6.1	5.6
Quartile 3		103	28	0.8	0.3	19.5	5.7	9.7	9.3
Quartile 4		132	1	1.0	0.0	12.5	4.3	7.3	7.3
Overall		261	1	1.0	0.0	19.5	0.8	7.2	7.2
Quartile 1	Architecture	217	11	0.9	0.4	11.0	6.0	7.8	7.7
Quartile 2		122	3	1.0	0.2	18.4	5.2	9.5	8.2
Quartile 3		138	5	1.0	0.3	8.4	4.8	6.1	6.4
Quartile 4		56	1	1.0	0.8	9.6	4.0	7.3	5.8
Overall		217	1	1.0	0.2	18.4	4.0	7.8	7.1
Quartile 1	Dental	54	10	1.0	0.5	23.0	3.8	10.2	11.9
Quartile 2		37	10	1.0	0.4	17.0	8.2	12.7	12.8
Quartile 3		44	8	1.0	0.9	16.5	6.5	9.4	9.7
Quartile 4		44	15	1.0	0.8	35.0	6.0	12.4	12.8
Overall		54	8	1.0	0.4	35.0	3.8	11.0	11.7
Quartile 1	Engineering	884	46	1.0	0.4	28.0	5.3	12.1	12.0
Quartile 2		356	24	1.0	0.1	23.0	4.0	8.9	8.3
Quartile 3		294	7	1.0	0.2	20.0	6.0	10.6	9.8
Quartile 4		592	3	1.0	0.2	12.4	3.6	8.9	7.8
Overall		884	3	1.0	0.1	28.0	3.6	10.8	9.5
Quartile 1	Law	88	29	1.0	0.6	12.0	6.2	9.4	9.2
Quartile 2		70	0	0.9	0.0	7.2	0.0	6.2	4.8
Quartile 3		134	1	0.9	0.3	8.2	5.4	6.1	6.4
Quartile 4		36	0	1.0	0.0	15.0	0.0	7.7	5.3
Overall		134	0	1.0	0.0	15.0	0.0	7.8	6.5
Quartile 1	Medical	420	12	1.0	0.1	30.5	12.1	19.7	19.3
Quartile 2		476	23	1.0	0.7	28.8	1.5	14.9	16.9
Quartile 3		180	16	1.0	0.2	47.0	1.5	15.8	18.2
Quartile 4		527	15	1.0	0.5	93.7	1.7	25.8	22.6
Overall		527	12	1.0	0.1	93.7	1.5	19.5	19.2
Quartile 1	Pharma	235	16	1.0	0.3	9.0	2.6	6.2	6.2
Quartile 2		92	11	1.0	0.4	33.0	3.3	5.9	5.8
Quartile 3		128	9	1.0	0.6	7.5	3.0	5.0	5.0
Quartile 4		75	10	1.0	0.6	6.7	2.2	4.3	4.3
Overall		235	9	1.0	0.3	33.0	2.2	5.5	5.3

Source: NIRF Ranking 2025, Ministry of Education

Note: Quartile table for two disciplines, Skill and Distance (Open Universities) cannot possible because of very few institutions.

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