# 10. Computer Programming Activities

## 10.1 Definition of the Sector

The generally accepted definition of IT services, which NASSCOM articulates, and Gartner refers to "the application of business and technical expertise to enable organisations in the creation, management, and optimisation of or access to information and business processes.[1]

The NIC code 6201, "Computer programming activities", was selected based on the selection exercise of choosing sectors. It consists of the following sub-sectors (Table 10.1):[2]

**Table 10.1: Definition of the technology sub-sector used in the analysis**

| *NIC Code* | *Description* |
|---|---|
| 62011 | Writing, modifying, and testing the computer programme to meet the needs of a particular client, excluding web page designing |
| 62012 | Webpage designing |
| 62013 | Providing software support and maintenance to the clients |

*Source*: Central Statistical Organisation, Ministry of Statistics and Programme Implementation. 2008. National Industrial Classification (All Economic Activities). 2008. https://www.ncs.gov.in/Documents/NIC_Sector.pdf.

## 10.2 Background

India's technology sector is rapidly transforming through spatial computing, merging the physical and digital worlds to enhance efficiency. Augmented Reality and Virtual Reality technologies are revolutionising various industries, from virtual banking services to immersive medical training, shaping the future of the industrial landscape. The technology is utilised by significant sectors such as banking, retail, healthcare, manufacturing, automotive, and education. The adoption of spatial computing is rising due to a strong tech ecosystem, widespread smartphone usage, and government backing, with the added boost of increased remote collaboration during the pandemic.

Indian enterprises are fostering innovation and growth by modernising their legacy systems through Information Technology (IT) upgrades and Enterprise Resource Planning (ERP) enhancements in response to a swiftly evolving digital environment. Companies are shifting towards a data-centric strategy, increasing computational requirements. The conventional dependence on hardware progress, like Computer Processing Units (CPUs) and Graphics processing units (GPUs), is approaching its maximum capacity. The next era of computing involves enhancing codes rather than simply upgrading hardware through sheer force. The rise of GenAI introduces complexity, necessitating creative solutions beyond mere processing capabilities. With

[1] Gartner website. https://www.gartner.com/en/information-technology/glossary/it-services.

[2] Alternatively, NASSCOM has divided the IT sectors in the following sub-sectors—IT enabled Services (ITeS), Business Process Management (BPM), Engineering and Research & Development (ER&D), Software Products Development (SPD), Future Skills, etc.[2]

70 per cent of organisations grappling with outdated IT infrastructures, new insights into technical debt and user experience are essential for maximising the advantages of adaptable organisations. Globally, advancements such as GenAI, 5G/6G, Web 3, blockchain, and IT modernisation propel this movement. Key areas for investment include cloud computing, DevOps, data analytics, artificial intelligence, the Internet of Things, and cybersecurity.

Besides Indian technology firms contributing to growth, global capacity centres drive the IT sector. More than 55 per cent of the world's Global Capacity Centres (GCCs) are based in India, with significant centres in Bengaluru, Hyderabad, Mumbai, and Pune. The number of GCCs in India is predicted to expand rapidly, with over 1,900 centres by 2025, contributing to a market size of $60 billion by then.[3]

According to NASSCOM, the Indian IT sector is expected to generate $282.6 billion in revenue in FY25, a 5.1 per cent increase over the previous year. The industry is predicted to exceed $300 billion by FY26, owing to advances in AI, cloud computing, and digital transformation. Export sales are expected to be $224.4 billion, while domestic revenues are projected to increase to $58.2 billion.[4]

## 10.3 Value Chain

The IT sector can be sub-classified into five different subsectors:

- Industry 4.0, also known as intelligent manufacturing, represents the digital evolution of the sector, providing instant decision-making, increased efficiency, adaptability, and responsiveness to transform the manufacturing, enhancement, and distribution processes of businesses.
- Cloud Infrastructure: A cloud infrastructure consists of the software and hardware components of servers housed in data centres, which are set up to deliver cloud computing services to clients. This infrastructure allows companies to lease computing resources as needed via the Internet, utilising a pay-as-you-go model instead of investing in and maintaining their own on-premises data centres, servers, and software.
- Software Products: They can be two types. One is generic software, and the others are bespoke software. While both types of software can be loaded on the user's premises, they are also used through a shared infrastructure on the cloud and are termed Software as a Service.
- IT Integration/System Integration: The integration process involves consolidating various smaller components or data from separate subsystems into one cohesive unit. Integration in IT involves merging different subsystems, even if they are dissimilar, to create a more extensive system that can efficiently share data as required. This typically necessitates organisations to develop a

[3] Times of India. 2024. "India to have 1.9k GCCs with $60billion in market size by 2025". Times of India. https://timesofindia.indiatimes.com/city/bengaluru/india-to-have-19k-gccs-with-60bn-in-market-size-by-2025/articleshow/110576787.cms#:~:text=Bengaluru%3A%20As%20the%20global%20capability,to%20a%20Nasscom%2DKPMG%20report. May 31.

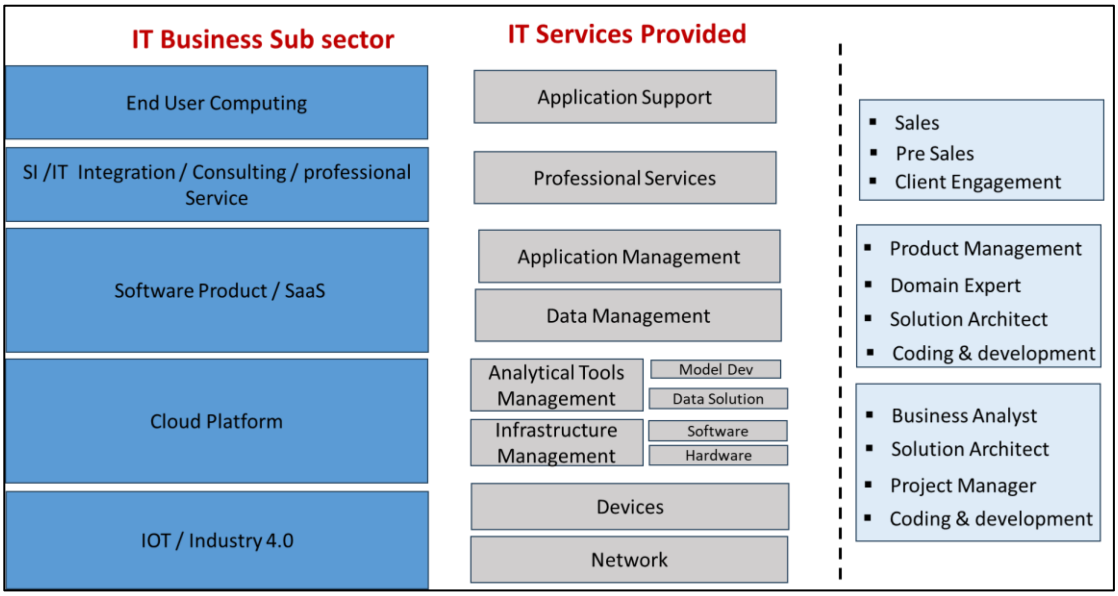
[4] NASSCOM website. https://nasscom.in/knowledge-center/publications/technology-sector-india-strategic-review-2025#.

tailored framework of applications to integrate new or existing hardware, software, and other elements.

- End User Computing: End-user computing (EUC) combines technologies, policies, and processes that give your workforce secure, remote access to applications, desktops, and data they need to get their work done. Modern enterprises use EUC so that their employees can work from wherever they are, across multiple devices, in a safe and scalable way. A well-designed EUC programme gives users immediate access to the digital technologies they need for productivity, both on-premises and remotely in the cloud.
- Each IT sub-sector provides many IT services and requires different skills, as articulated in Figure 10.1.

For each sub-sector, relevant IT services are required, as articulated in Figure 10.1, and the functional roles within each IT service are as follows:

**Figure 10.1: Software value chain and role**




*Source*: NCAER conceptualisation from literature.

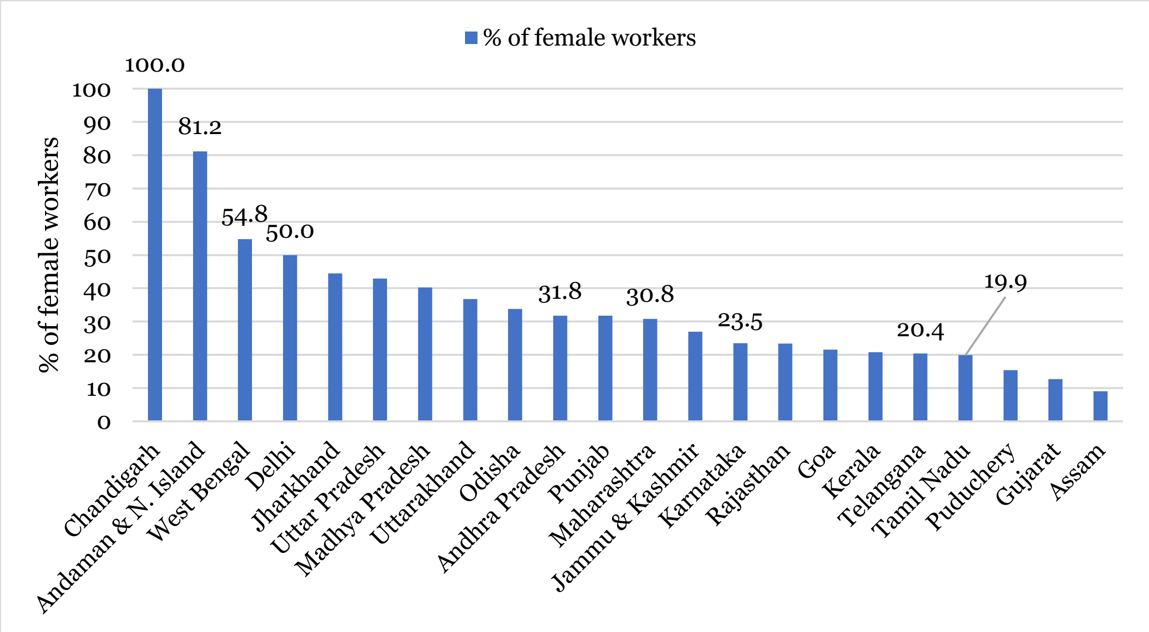
From a domain perspective, the value chain intersects with the following existing domains: finance, health care, commerce, mobility, and aggrotech. Also important are new key emerging domains such as clean tech, climate, ocean–blue water economy, remote sensing, and precision medicine/pharmaceuticals.

## 10.4. Workforce Characteristics

This section of the chapter gives the macro trends for the IT industry regarding labour participation in the IT industry, female workforce, educational attainment, types of skills, etc., based on various renowned secondary data sources.

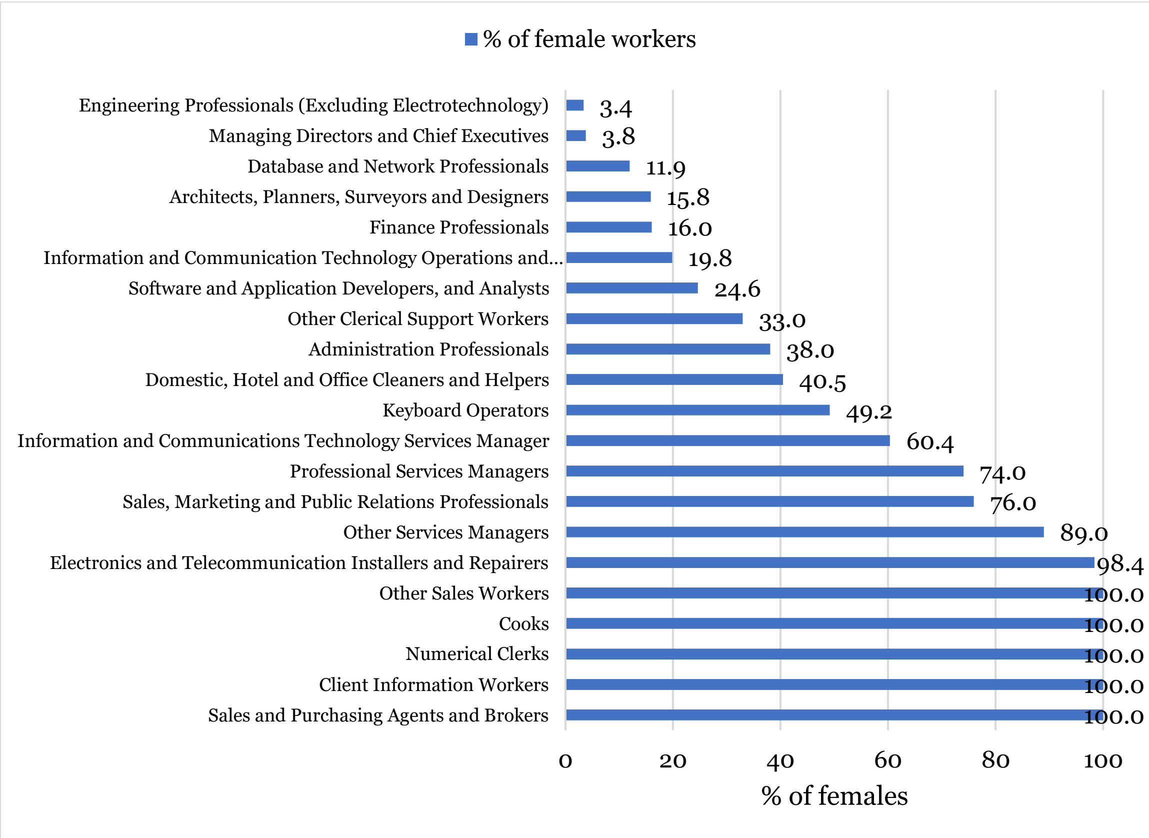
a. ***Share of female workers:*** 26.2 per cent of workers in the IT sector are females. Figure 10.2 shows the share of female IT workers across States/UTs. Figure 10.3 shows the share of female workers across NCO 3-digit job roles.

## Figure 10.2: Percentage of female workers (aged 15+) across States/UTs, 2022–23




*Source*: NCAER Analysis from PLFS 2022–23.

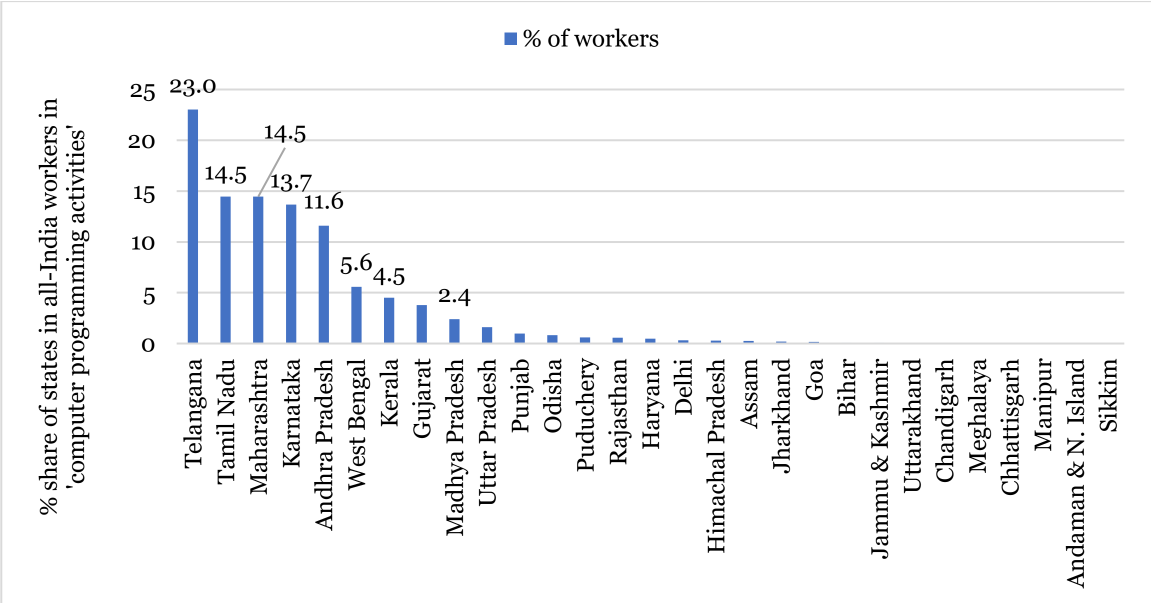
## Figure 10.3: Share of female IT workers in job role, 2022–23




*Source*: NCAER analysis from PLFS 2022–23.

b. ***State***: 77 per cent of workers are located in five States in the IT sector, namely Telangana, Tamil Nadu, Maharashtra, Karnataka, and Andhra Pradesh (Figure 10.4). However, the share of the female workforce in these States is relatively low (Figure 10.2) compared to States like West Bengal and Delhi, where females form either 50 per cent or more of the workforce.

**Figure 10.4: State-wise distribution of workers (aged 15+) in the IT sector (%), 2022–23**

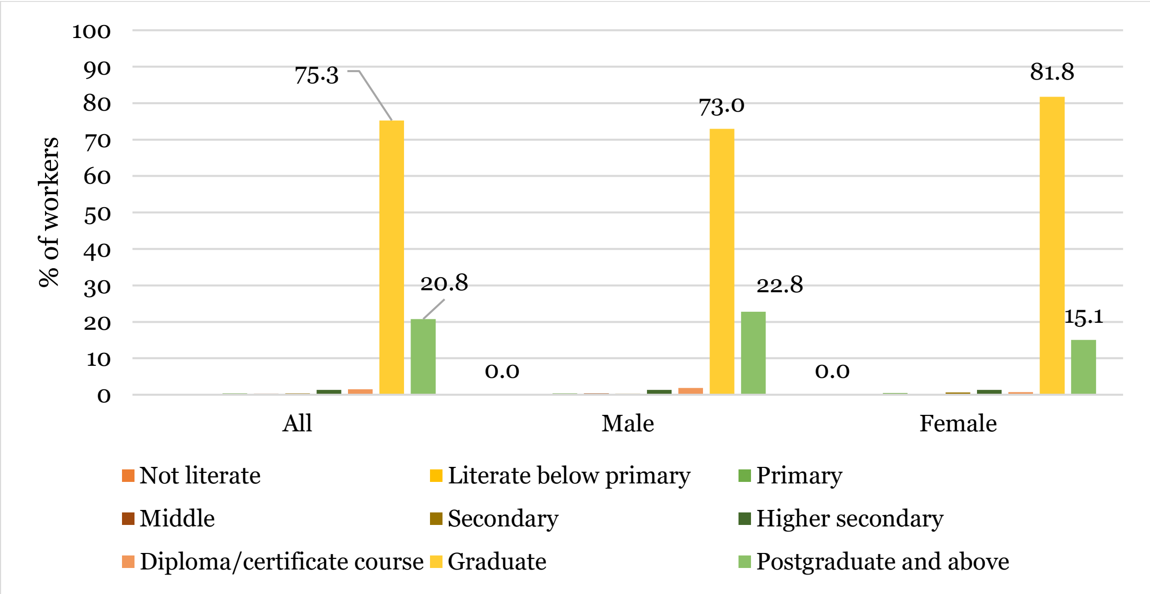



*Source*: NCAER analysis from PLFS 2022–23.

c. ***Education***: In 'general educational attainment', 96 per cent of the workers are graduates and above in the IT sector (Figure 10.5). Marginally, the female educational attainment is higher than males. The majority of the workers in this sector have a technical education. 57.5 per cent of IT workers have a technical degree (Figure 10.6). A higher share of IT female workers (65.9 per cent) have a technical degree. 5.4 per cent of IT have a diploma or certificate (graduate and above level) in engineering/technology. About 27.7 per cent of IT workers do not have technical education.

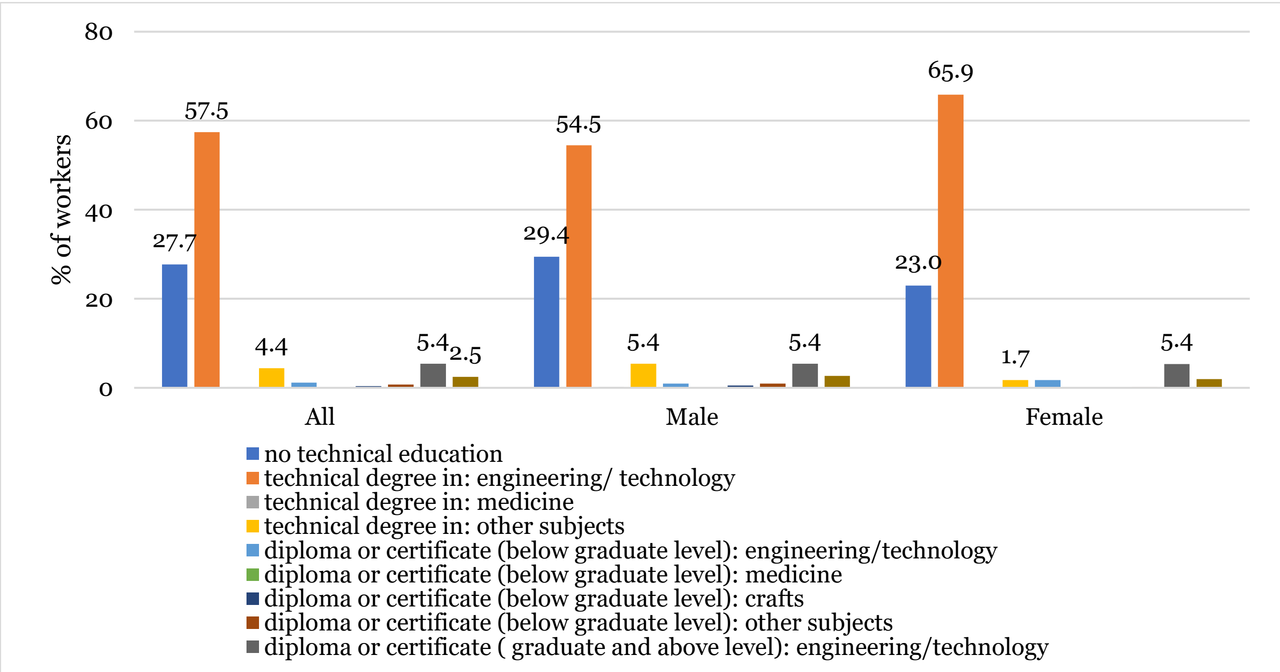
Forty-two per cent of workers have received vocational training (Figure 10.7); 12.9 per cent have received it through formal means and 29 per cent through non-formal means. Twenty per cent of all workers and 25 per cent of all female workers received non-formal vocational training or on-the-job training.

**Figure 10.5: General educational attainment of IT workers, 2022–23**



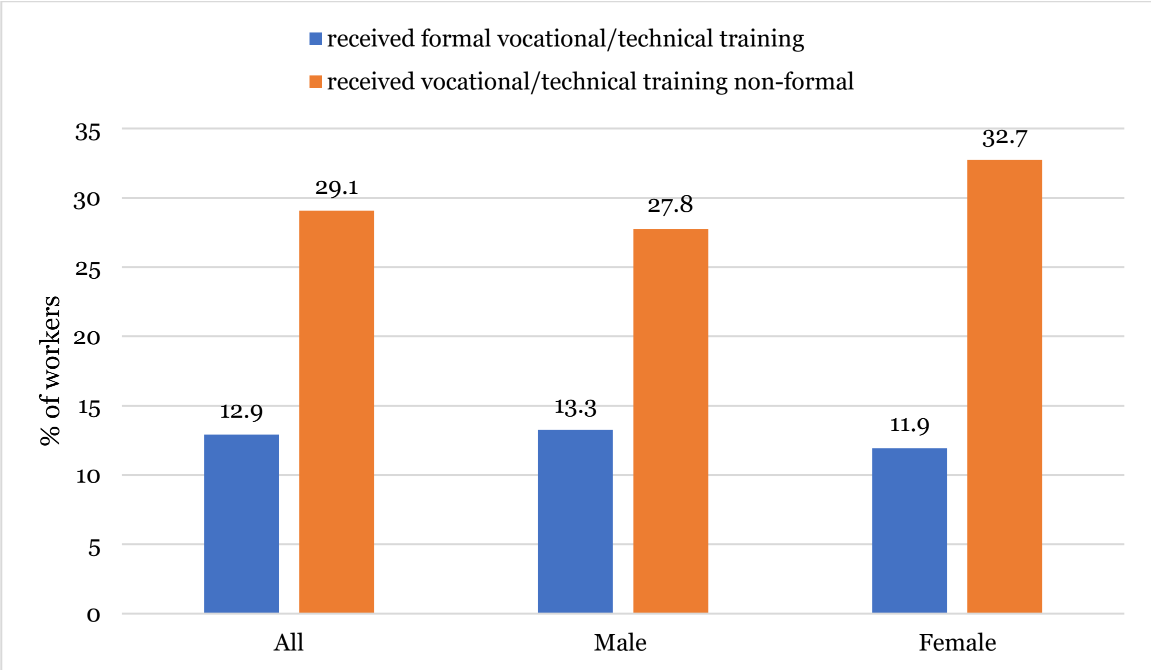

*Source*: NCAER Analysis from PLFS 2022–23.

**Figure 10.6: Attainment of technical education of IT workers (aged 15+), 2022–23**




*Source*: NCAER Analysis from PLFS 2022–23.

**Figure 10.7: Share of workers (aged 15+) who have received vocational training, 2022–23 (%)**




*Source*: NCAER Analysis from PLFS 2022–23.

d. ***Skill****:* 96 per cent of the workers are high-skilled, and 96.8 per cent of the female IT workers are high-skilled.

e. ***Occupations***: 77.4 per cent of workers are 'Software and Application Developers and Analysts', 5 per cent are 'Information and Communications Technology Services Managers' and 2.1 per cent are 'Managing Directors and Chief Executives'. The corresponding numbers for female workers are 72.3 per cent, 11.4 per cent and 0.3 per cent respectively. Figure 10.3 shows that women are concentrated in a few job roles. Their share is particularly low in leadership positions and mainly focused on support jobs. Significantly, in the most prevalent job role, 'software and application developers', the percentage share of females is 26 per cent.

f. ***Engagement Status****:* 95.6 per cent of workers are regular salaried/wage workers. 3.7 per cent are own-account workers, and 0.7 per cent are employers (Table 10.2). The corresponding numbers for male workers are 94.1 per cent, 5 per cent and 0.8 per cent. The corresponding numbers for female workers are 99.5 per cent, 0.1 per cent and 0.2 per cent.

**Table 10.2: Engagement status of workers (%)**

| | ***All Workers (aged 15+)*** | | | | | |
|---|---|---|---|---|---|---|
| | ***Self-employed*** | | | ***Regular salaried/ wage employee*** | ***Casual Wage Labour*** | ***Total*** |
| | ***Own account worker*** | ***Employer*** | ***Worked as helper in h.h. enterprise (unpaid family worker)*** | | | |
| Computer programming activities | 3.7 | 0.7 | 0.0 | 95.6 | 0.0 | 100.0 |
| All workers 15+ | 35.6 | 3.2 | 18.6 | 21.4 | 21.2 | 100.0 |
| | ***All Male Workers (aged 15+)*** | | | | | |
| Computer programming activities | 5.0 | 0.8 | 0.0 | 94.1 | 0.0 | 100.0 |
| All workers 15+ | 39.6 | 4.5 | 9.5 | 24.0 | 22.3 | 100.0 |
| | ***All Female Workers (aged 15+)*** | | | | | |
| Computer programming activities | 0.1 | 0.2 | 0.2 | 99.5 | 0.0 | 100.0 |
| All workers 15+ | 27.3 | 0.6 | 37.4 | 15.9 | 18.8 | 100.0 |

*Source:* NCAER analysis from PLFS 2022–23.

## 10.5 Identification of Geographical Clusters

There are many ways of identifying geographical clusters. Rao and Balsubramanya (2017) examined the rise of IT Service Clusters in India and its industrial impact.[5] The authors identified seven clusters—Bengaluru, Chennai, Hyderabad, Mumbai, Pune, the National Capital Region of Delhi, and Kolkata. This report aims to develop a methodology to identify clusters to help government officials within their region or sectors identify them. As in the earlier sections, we discussed various ways of defining them. Porter (1990) described an industry cluster as a geographically proximate group of firms and associated institutions in related industries linked by economic and social interdependencies.[6] However, in the IT sector, as recommended by Rao and Balsubramanya (2017), it is more sensible to use the Delgado et al. (2014) definition of clusters for the IT sector, which defined clusters as "geographic concentrations of industries related by knowledge, skills, inputs, demand, and/or other linkages".[7] Using the same framework as agriculture and livestock, there are four pillars—infrastructure, innovation, business environment, and human resources (skills) (Table 10.3). Similar to other sectors, a simple rank was computed for each indicator. Then, a step-wise average was calculated, resulting in a final average of all the rankings from each pillar. The results are shown in Table 10.4. The topmost clusters at State level are Maharashtra, Tamil Nadu, Karnataka, Uttar Pradesh, Gujarat, Telangana, Andhra Pradesh, and West Bengal. The State-level STPI exports are also ranked, and then a

[5] Rao, P. M. and Balasubrahmanya, M.H. 2017. "The Rise of IT Services Clusters in India: A case of growth by replication". *Faculty of Marketing & International Business Publications*. 2. http://digitalcommons.liu.edu/post_mrkibfpub/2

[6] Porter, M. E. 1990. *Competitive advantage of nations*. New York: Free Press.

[7] Delgado, M., Porter, M. E., & Stern, S. 2014. "Defining clusters of related industries". *NBER Working Paper No. w20375*. https://www.nber.org/system/files/working_papers/w20375/w20375.pdf. Boston: MA: National Bureau of Economic Research.

correlation between the geographical cluster rankings and the rankings of the States based on STPI exports is computed. The correlation coefficient is 0.83. By no means is the cluster methodology perfect, but it is a reasonably decent indicator to compute clusters.

**Table 10.3: Geographical clusters framework for the IT sector**

| *Pillar* | *Indicator* | *Source* | *Link* | *State* | *District* |
|---|---|---|---|---|---|
| Infrastructure | Electricity Energy Sale for Commercial Purposes | Central Electricity Authority | https://cea.nic.in/dashboard/?lang=en | √ | X |
| | Teledensity | Telecom Regulatory Authority of India Performance Indicators/Annual Report | (https://www.trai.gov.in/release-publication/reports/performance-indicators-reports) | √ | X |
| | Internet Density | | | √ | X |
| Innovation | No. of start-ups | DPIIT | https://www.startupindia.gov.in/digital-map/maps | √ | √ |
| Business Environment | Number of STPs | STPI Annual Report | https://stpi.in/en/stpi-annual-reports | √ | √ |
| Human Resources/ Skills | No. of colleges specialising in engineering & technology | ASHIE | https://aishe.gov.in/aishe-final-report/ | √ | √ |

*Source*: NCAER conceptualisation from literature.

**Table 10.4: Geographical cluster of the IT sector[8]**

| *State* | *Infrastructure* | *Innovation* | *Human Resources* | *Business* | *Average* |
|---|---|---|---|---|---|
| Maharashtra | 6.7 | 1.0 | 2.0 | 1.0 | 2.7 |
| Tamil Nadu | 6.7 | 5.0 | 1.0 | 3.0 | 3.9 |
| Karnataka | 8.0 | 2.0 | 5.0 | 1.0 | 4.0 |
| Uttar Pradesh | 12.0 | 4.0 | 6.0 | 5.0 | 6.8 |
| Gujarat | 10.3 | 7.0 | 4.0 | 9.0 | 7.6 |
| Telangana | 9.7 | 6.0 | 7.0 | 9.0 | 7.9 |
| Andhra Pradesh | 15.0 | 13.0 | 3.0 | 5.0 | 9.0 |
| West Bengal | 10.0 | 11.0 | 14.0 | 3.0 | 9.5 |
| Delhi | 6.7 | 3.0 | 19.0 | | 9.6 |
| Kerala | 9.0 | 8.0 | 9.0 | 14.0 | 10.0 |
| Rajasthan | 13.0 | 10.0 | 10.0 | 9.0 | 10.5 |

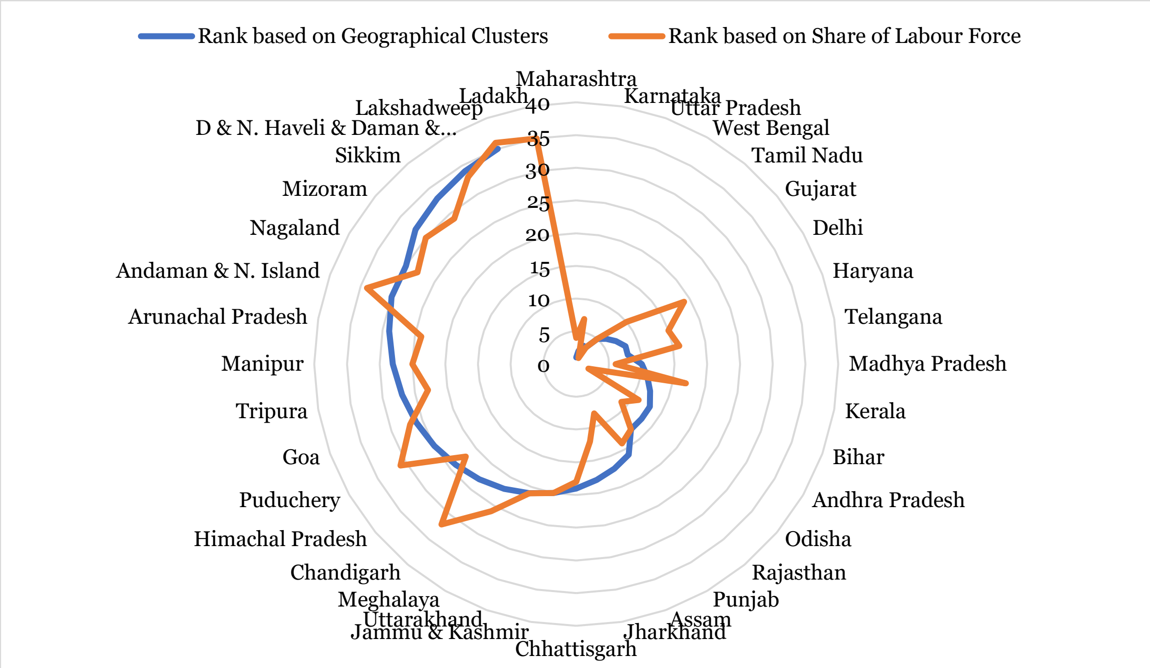
[8] The NASSCOM report used a proprietary database of Draup to compute clusters. However, that database may be compared to PLFS where one is using workers. However, even that cannot be strictly compared because one does not know the sampling strategy behind collecting data of this database. Has this been independently validated or the database compared? It is necessary to undertake research to compare the two databases to have a more complete set of information versus choosing one or the other. Nonetheless, the conceptual idea behind clusters is to see the agglomeration of firms and not just workers. Purely looking at a workers' database whether Draup or PLFS will give an incomplete picture. Therefore, it is recommended to look at both agglomerations in terms of workers and units to get a holistic picture.

| *State* | *Infrastructure* | *Innovation* | *Human Resources* | *Business* | *Average* |
|---|---|---|---|---|---|
| Madhya Pradesh | 18.7 | 12.0 | 8.0 | 7.0 | 11.4 |
| Haryana | 11.0 | 9.0 | 12.0 | 14.0 | 11.5 |
| Odisha | 19.3 | 14.0 | 11.0 | 7.0 | 12.8 |
| Punjab | 12.7 | 16.0 | 12.0 | 14.0 | 13.7 |
| Bihar | 19.3 | 15.0 | 16.0 | 14.0 | 16.1 |
| Uttarakhand | 17.3 | 19.0 | 17.0 | 14.0 | 16.8 |
| Jharkhand $ | 24.7 | 18.0 | 17.0 | 9.0 | 17.2 |
| Chhattisgarh | 23.0 | 17.0 | 15.0 | 14.0 | 17.3 |
| Jammu & Kashmir | 19.0 | 22.0 | 22.0 | 9.0 | 18.0 |
| Himachal Pradesh | 17.0 | 23.0 | 19.0 | 14.0 | 18.3 |
| Ladakh | 18.5 | | | | 18.5 |
| Goa | 16.7 | | 26.0 | 14.0 | 18.9 |
| Assam | 22.0 | 20.0 | 22.0 | 14.0 | 19.5 |
| Puducherry | 28.3 | 24.0 | 21.0 | 14.0 | 21.8 |
| Manipur | 26.7 | 25.0 | 24.0 | 14.0 | 22.4 |
| Tripura | 26.7 | 26.0 | 24.0 | 14.0 | 22.7 |
| Chandigarh | 18.3 | 21.0 | 29.0 | | 22.8 |
| Nagaland | 26.7 | 29.0 | | 14.0 | 23.2 |
| Meghalaya | 25.7 | 27.0 | 30.0 | 14.0 | 24.2 |
| Mizoram | 23.7 | 31.0 | 30.0 | 14.0 | 24.7 |
| Sikkim | 25.3 | 33.0 | 28.0 | 14.0 | 25.1 |
| A & N Islands | 24.0 | 28.0 | 30.0 | | 27.3 |
| Dadar & Nagar Haveli (incl. Daman & Diu) | 31.3 | 30.0 | 27.0 | | 29.4 |
| Arunachal Pradesh | 28.3 | 31.0 | | | 29.7 |
| Lakshadweep | 29.0 | 34.0 | | | 31.5 |

*Sources*: NCAER computations from the following:
1. Telecom Regulatory Authority of India. 2024. The Indian Telecom Services Performance Indicators January–March 2024. https://trai.gov.in/sites/default/files/QPIR_04072024_0.pdf.July.; 2. Central Electricity Authority. Dashboard - Central Electricity Authority (CEA.nic.in).; 3. Department of Higher Education, Ministry of Education, Government of India. All India Survey on Higher Education 2021-22. https://aishe.gov.in/aishe-final-report/.; 4. DPIIT website. https://www.startupindia.gov.in/digital-map/maps; 5. Software Technology Parks of India. 2023. Annual Report 2022–23. https://stpi.in/en/stpi-annual-reports.
*Notes: 1.* For downloading data from the DPIIT website, these terms were used to filter the data: Analytics, AR VR, Computer Vision, Enterprise Software, Finance Technology, Internet of Things, IT Services, Robotics, Telecommunications, and Networking.

The correlation between rankings based on share of labour force and geographical clusters is 0.9 (Figure 10.8).

**Figure 10.8: State-wise rankings based on geographical clusters and share of labour force**




*Sources:* NCAER computations from Figure 10.4 and Table 10.4.

*Note:* Lower ranking means higher concentrations.

## 10.6 Occupational Map

Annexure 10.1 shows the occupational mapping. The key point is that there are new and emerging codes developed by the Sector Skill Council which cannot be mapped to the NCO 2015. Therefore, it is important to update NCO 2015 and NCS database/portal on a regular basis.

## 10.7 Sectoral Findings

### *10.7.1 Stakeholder Interactions*

To get detailed industry insight, various stakeholders were reached in the IT industry, including Industry Associations, Academic Institutions, Global Capacity centres, and Indian software companies, both outsourcing and product. Interviews with these stakeholders were more of a conversation rather than just asking questions from the respondents in the questionnaire. Separate questionnaires were developed for each stakeholder. It helped us understand their perspective more clearly. Questionnaires are available upon request. Successful interactions were held with the 21 stakeholders in the sector, as given in Table 10.5.

**Table 10.5: Distribution of stakeholder interactions in the IT sector**

| ***Sector*** | | ***Computer programming activities*** |
|---|---|---|
| Ministry | | 1 |
| Sector Skill Council | | 1 |
| National-level Industry Association | | 1 |
| No of Firms | Micro/Small | |
| | Medium | |
| | Large | |
| | Total | 17 |
| No. of Placement Cells/TVET Institutions | | 3 |
| Recruitment Agencies | | 1 |
| Other Stakeholders | | 3 |
| Firms plus Other Stakeholders | | 20 |
| Total | | 27 |

*Source:* NCAER.

### *10.7.2. Sectoral Findings*

This section discusses the key findings of the technology sector-based on stakeholder interactions and the literature review. It sheds light on various aspects of technological changes in the industry. It assesses key job roles currently facing a maximum shortage in this sector or scarcity over the next 3 years. The questionnaire for firms in the IT industry (Questionnaire 10) is located at the end of the report.

Skill shortage is an issue in the technology sector and is intensified due to the technologically dynamic nature of the industry. There are specific technologies that drive skills demand, and some of these technologies are sector specific (Table 10.6).

**Table 10.6: Technology changes**

| ***Digital Technologies – Across sector*** | ***Sector-Specific technology*** |
|---|---|
| • Python – AI/ML<br>• Full stack developer<br>• Image and signal processing<br>• Natural Language Processing<br>• Large Language Model Building<br>• Small Language Model Building<br>• Deep Neural Networks<br>• Cyber Cloud Security<br>• Cybersecurity:<br>• Cloud Computing<br>• Data Protection<br>• Econometric Modeling<br>• Blockchain and 5G Technology | For Agritech, commerce and EV<br>• Remote Sensing<br>• Drip Technology<br>For Manufacturing -<br>• Robotics<br>• Embedded Computing<br>• Digital Twin<br>Pharmaceutical and Medical<br>• 3D Modeling<br>• 3D Printing:<br>Robotics: Virtual and Augmented Reality (VR/AR)<br>• Nanotechnology<br>• Digital Twin<br>• CRISPR<br>• Bio printing |

*Source*: NCAER stakeholders' survey

The drivers of changing job roles in the technology sector in India are shaped by rapid advancements in technology, evolving business needs, and global trends. Here are the key factors:

- Emerging Technologies: The rise of AI, machine learning, blockchain, and cloud computing has created a demand for specialised roles like AI engineers, data scientists, and cloud architects.
- Digital Transformation: Businesses are adopting digital tools and platforms, leading to roles in DevOps, cybersecurity, and digital marketing.
- Globalisation and Outsourcing (Establishment of GCC): India remains a hub for IT outsourcing, requiring professionals skilled in project management, software development, and client relations.
- 5G and IoT: The rollout of 5G and the growth of Internet of Things (IoT) have spurred demand for roles in network engineering and IoT development.
- Remote Work and Gig Economy: The shift to remote work has increased the need for roles in IT support, collaboration tools development, and freelance tech consulting.
- Focus on Sustainability: Green technologies and sustainable practices are driving roles in energy-efficient IT solutions and environmental data analysis.

We can see the impact of Moore's law in action. **Moore's Law** is the observation made by Gordon Moore, co-founder of Intel, in 1965, which states that the number of transistors on a microchip doubles approximately every two years while the cost of computing power decreases. This trend has driven exponential growth in computing capabilities and has been a guiding principle for advancements in the semiconductor industry.

Typically, job roles are clustered by various titles, depending on the company's domain and whether it is a global multinational corporation versus Indian corporate versus start-up. For instance, the exact role can be Data Engineer, Data Consultant, or Developer. It may have full stack or front-end developers, depending on the technology and area the individual works in. For the report, the titles have been clustered in the following functional areas (each will have multiple areas):

- Developer / Engineer / Data Engineer
- Technical Consultant / Analyst
- Functional Consultant / Analyst
- Security Engineers – which includes various types of security

The point is that finding people is perceived to be somewhat 'difficult' for each job role. There were several reasons behind this, both from the side of the skilling ecosystem (supply-side) and the industry (demand-side).

*Key Challenges identified*

- The PLFS data on occupational characteristics indicates that the technology industry has a relatively high demand for formal education and training. Lack of topic expertise, people management abilities, and keeping up with the most recent technological advancements are some of the leading causes of the hiring gap.
- A key reason for 'difficulty' in filling job roles was that the candidates lacked the "skills to do the job". While they may have theoretical understanding, a lack of practical knowledge of working with the latest machines renders them unemployable, and even if employed, they cannot do the job at hand.
- Technology Skills: The demand for specialised tech skills (AI, blockchain, cloud computing) often exceeds the supply, making it challenging to find the right talent. Engineering colleges provide theoretical knowledge but not necessarily proper domain knowledge to complement the technology skills. For example,

knowledge of heat power engineering or EV engines and information technology experience is essential for manufacturing companies. Information technology and data science can only provide analytical results but not necessarily interpretation of results.

- Absence of non-cognitive skills: Soft skills are also necessary for successful performance in the workplace. Teamwork, conscientiousness, self-control, emotional stability, psychomotor skills, safety awareness, cultural and gender sensitivity, and practical communication are a few of these. The emergence of global capacity centres makes these criteria much more crucial.
- It was also mentioned that recruiters look for coding skills, logical ability, and reasoning skills. Technology skills are missing from coding, application and theoretical framework knowledge. Similarly, it is not just statistical skills but also mathematical skills. We try to map the cognitive and socio-emotional/non-cognitive in Table 10.7.

**Table 10.7: Cognitive and non-cognitive skills**

| ***Cognitive*** | ***Socio-emotional/ Non Cognitive*** |
|---|---|
| • Critical thinking<br>• Problem-solving<br>• Resource/time management<br>• Design Thinking<br>• Man-management and Leadership<br>• Entrepreneurship<br>• Algorithmic Thinking | • Open to experience<br>• Patience<br>• Emotional stability<br>• Cross-country cultural sensitivity, especially for global capacity centres<br>• Communication and articulation<br>• English language articulation/ regional biases<br>• Cultural conscientiousness<br>• Empathy and sensitivity<br>• Non-transactional attitude<br>• Risk-taking ability |

*Source*: NCAER stakeholders' survey.

Due to a lack of domain expertise and a skilling environment, technology companies must provide on-the-job practical and soft-skill training to all new employees, which they believe should have been provided through the education and training system. All engineering and diploma graduates are frequently hired as Graduate Engineer Trainees, which adds to the firm's costs. The impact is significant if there is a hiring to be done with 5–7 years of experience. It is challenging to identify the right hire who has technical skills, domain skills, and non-cognitive abilities.

Table 10.8 shows the key in-demand job roles. A short description of the four roles are given below:

- Data Engineering:[9] It is the practice of designing and building systems for the aggregation, storage and analysis of data at scale. Data engineers empower organisations to get insights in real time from large datasets.
- Technical Business Analyst:[10] Technical Business Analysts analyse science, engineering, business, and other data processing problems to develop and implement solutions to complex applications problems, system administration

[9] IBM website. https://www.ibm.com/think/topics/data-engineering

[10] Franklin University website. https://www.franklin.edu/career-guide/computer-systems-analysts/what-do-technical-business-analysts-do.

issues, or network concerns. Perform systems management and integration functions, improve existing computer systems, and review computer system capabilities, workflow, and schedule limitations. May analyse or recommend commercially available software.

- Data Security:[11] Data security is the practice of protecting digital information from unauthorised access, corruption or theft throughout its entire lifecycle.
- Functional/Domain Analyst:[12] A Functional/Domain Analyst bridges the gap between business needs and technical solutions, focusing on understanding specific business processes and ensuring that software and technology solutions effectively address those needs.

**Table 10.1: Assessment of current and future skills shortage (findings from stakeholder consultations) in computer programming activities Demand shortage is there in four job roles**

| | **Data Engineering*** | **Business Analyst—Technical** | **Data Security** | **Functional/ Domain Analyst** |
|---|---|---|---|---|
| NCO 3/8–digit code | 252 | 251 | 252 | Not available |
| NCO 8-digit /QP code | HCLT/N0003/IT/2024 v1: Data Engineering with Analytics and Visualization IT-ITeS SSC NASSCOM/N0002/IT/2024: Data Engineering – IBM | | | |
| Match from Job Projections (251, 133, 112, 216, 413) @ | | | | |
| No. of stakeholders which mentioned this | 15 | 10 | 17 | 17 |
| Indicative computation of the extent of current needs & vacancy rate (NCAER computations from Big Data Analysis)* | 200,000–225,000 | 50,000–60,000 | 40,000–50,000 | 70,000–80,000 |

[11] IBM website. https://www.ibm.com/think/topics/data-security.

[12] Generative AI from Indeed website. https://www.indeed.com/career-advice/resumes-cover-letters/functional-analyst-skills#:~:text=What%20is%20a%20functional%20analyst,productivity%20of%20a%20business%20domain.

| | Data Engineering* | Business Analyst—Technical | Data Security | Functional/ Domain Analyst |
|---|---|---|---|---|
| Location of firms | Bangalore, NCR, Kochi, Hyderabad, Mumbai | Bangalore, NCR, Kochi, Hyderabad, Mumbai | Bangalore, NCR, Kochi, Hyderabad, Mumbai | Bangalore, NCR, Kochi, Hyderabad, Mumbai |
| Average monthly income (₹) for 3– 5 Years | 1,25,000–1,70,000 | 1,25,000–1,70,000 | 3,00,000–4,00,000 | ~ 1,50,000–3,50,000 |
| Note | Senior-level experience varies widely depending on experience, domain, location. | | | |
| Educational Qualifications | B. Tech /M. Tech Engineering, M. Tech/PhD. Engineering + AI/ML programs | B. Tech /M. Tech Engineering+ AI/ML programs | B. Tech /M. Tech Engineering (AI and Data Science; or Computer Science/IT + Cybersecurity Certificate) | Domain Experience with any Graduation. Preference is Post Graduation |
| Skills required at the competency level (3 or more) | **Cognitive Skills**:<br>• Critical thinking,<br>• Problem-solving,<br>• Resource/time mgmt.<br>• Algorithmic Thinking<br>**Socio-emotional skills:**<br>• Active Listening,<br>• Patience<br>• Cross-country cultural sensitivity-especially for Global capacity centres<br>**TVET:**<br>• Python – AI/ML<br>• Full stack developer<br>• image and signal processing<br>• Natural Language Processing<br>• Large Language Model Building<br>• Small Language Model Building<br>• Deep Neural Networks | **Cognitive Skills:**<br>• Critical thinking,<br>• Problem-solving,<br>• Communication skills<br>• Resource/time mgmt.<br>• Design Thinking<br>• Algorithmic Thinking<br>**Socio-emotional skills:**<br>• Active Listening,<br>• Man management and Leadership<br>• Entrepreneurship<br>• Open to experience,<br>• Patience<br>• Emotional stability<br>• Cross-country cultural sensitivity-especially for Global capacity centres<br>  • Cultural conscientiousness,<br>  • Empathy and sensitivity | ***Cognitive Skills:***<br>• Critical thinking,<br>• Problem-solving,<br>• Algorithmic Thinking<br>**Socio-emotional skills:**<br>• Active Listening,<br>• Patience<br>• Emotional stability<br>• Cross-country cultural sensitivity-especially for Global capacity centres<br>**TVET**:<br>• Specialised skills in security in terms of – Data security, infrastru | **Cognitive Skills:**<br>• Critical thinking,<br>• Problem-solving,<br>• Communication skills<br>• Resource/time mgmt.<br>• Design Thinking<br>• Algorithmic Thinking<br>**Socio-emotional skills:**<br>• Active Listening,<br>• Man management and Leadership<br>• Entrepreneurship<br>• Open to experience,<br>• Patience<br>• Emotional stability<br>• Cross-country cultural sensitivity-especially for Global capacity centres<br>  • Cultural conscientiousness, |

| | Data Engineering* | Business Analyst—Technical | Data Security | Functional/ Domain Analyst |
|---|---|---|---|---|
| | | • Non-transactional attitude<br>**TVET:**<br>• Technical coding skills as well as technical design skills. Typically has worked as Data engineer or a full stack developer | cture security and access security.<br>• Specialised certification preferred | • Empathy and sensitivity<br>• Non-transactional attitude<br>**TVET:**<br>• In-depth domain knowledge – e.g. Health care, BFSI, engineering. Experience preferred |
| Skills Shortage | No | Yes | Yes | No |
| Skills Gap | Yes | Yes | Yes | Yes |
| Relevance of TVET System | Yes | Yes | NA | No |
| Gender (Challenges) | No challenge in 1-3 years however as years of experience increases, female candidature reduces | No challenge: Women preferred | Rare skill and gender-based hiring is even rare | Functional domain in financial services and core engineering such as Heat power or High voltage |
| | ▪ Remote working enabled the return to labour force participation(LFP)<br>▪ Focused program to enrol women back in the workforce<br>▪ Diversity norms by level and function have helped increase LFP | | | |
| Challenges Faced by Industries in Meeting Skill Requirements * | • Tier II town - Job options and opportunities are limited, thereby hampering talent identification by corporates<br>• Talent gap at mid- and senior- level higher | • Tier II town - Job options and opportunities are limited, thereby hampering talent identification<br>• Talent gap at mid and senior level higher | • No formal course in engineering for data security | • Talent focused on coding rather than domain experience resulting in gap<br>• Tier II town - Job options and opportunities are limited, thereby hampering talent identification. |
| Industry-specific interventions that facilitate skill and capacity development (best practices) | • Capacity-building sessions on non-cognitive skills<br>• Partnership with institutes for skills<br>• Hackathon<br>• Cultural sensitivity initiative<br>• Structured diversity and women in tech program | | | |
| Policy Recommendations: | **Skill Training Programme:**<br>• Partner with Industries to structure course curriculum<br>• Establish Centres of Excellence with Industry specific leaders<br>• Encourage collaboration between educational institutions and research bodies to promote practical learning. | | | |

| | Data Engineering* | Business Analyst—Technical | Data Security | Functional/ Domain Analyst |
|---|---|---|---|---|

**Curriculum Development:**

- Focus on domain building and not just data analytics
- Engage industry experts to co-develop training content and modules
- Focus on non-cognitive skills
- Communication Skills development focus

**Gender:**

- Focused program to enrol women back in the workforce
- Diversity norms by level as well as function have helped increase LFP.
- Ensure no pay gap is observed for women in tech

**Skill Initiatives:**

- Make internship compulsory, as in medical science
- Collaborate with the industry for internship
- Establish mentorship programs with experienced industry as a part of final-year project coursework
- Organise intensive boot camps and hackathons

**Others/Macro Policy:**

- Emerging centres are driving demand, such as Indore, Bhubaneswar, Kochi, Chandigarh, Kolkata, Goa, Ahmednagar, Vadodara, Jaipur, Thiruvananthapuram, and Pune—primarily non-metros and emerging metros.
- Digital communication has reduced 'Virtual Distance' in information but not necessarily 'connectivity distance' impacting talent availability
- Ensure appropriate
  - Air connectivity
  - Health care
  - State government 'perceived openness and ease of doing business'
  - Education infrastructure

It should be noted that core technical, non-cognitive, and cognitive skills differ for different experience levels. Based on our interview table, 10.9 attempts to summarise the findings.

**Table 10.9: Skills gap summary: based on years of experience and type of skills**

| | *Years of Experience* | | |
|---|---|---|---|
| | *< 3 yrs* | *3-7 Yrs* | *7-10 Yrs* |
| **Core Skills** | | | |
| Technical Acumen | High | High | Medium |
| Problem Solving— | Medium | high | Low |
| Analytical | Medium | High | High |
| Project / Program Management | Low | Medium | High |
| **Non-Cognitive Skills** | | | |
| Business Acumen | Low | Low | High |
| Leadership | Low | Medium | High |
| Continuous Learning | High | High | High |
| Design thinking | Medium | High | High |
| Strategic Thinking | Low | Low | High |
| **Soft Skills** | | | |
| Cross-Functional Collaboration | Low | Medium | High |
| Interpersonal Communication | Medium | High | High |
| Ethics and Legal Awareness | Medium | High | High |
| Cultural Sensitivity | Medium | High | High |

*Source*: NCAER stakeholders' survey.

*Location*

It is not just skills but the availability of skills at the location where the opportunity lies. Apart from Mumbai, NCR, Bangalore, Chennai, and Hyderabad, the new emerging centres are driving demand, such as Indore, Bhubaneswar, Kochi, Chandigarh, Kolkata, Goa, Ahmednagar, Vadodara, Jaipur, Thiruvananthapuram, and Pune. While the key driving factor is the availability of talent, including the presence of good universities and technology institutes, companies also prefer locations with lower rental costs, air connectivity, health care, and perceived openness and ease of doing business.

However, relatively fewer people want to join the workforce in those cities as the perception is that jobs in tier II towns are 'not cool enough' and working in tier II towns may hamper job mobility and exposure. Only people who want to move back to their home town are attracted by these new technology centres in tier II cities. While digital communication has reduced 'virtual distance' in information, not necessarily 'connectivity distance' plays a key role in impacting mobility to tier II towns.

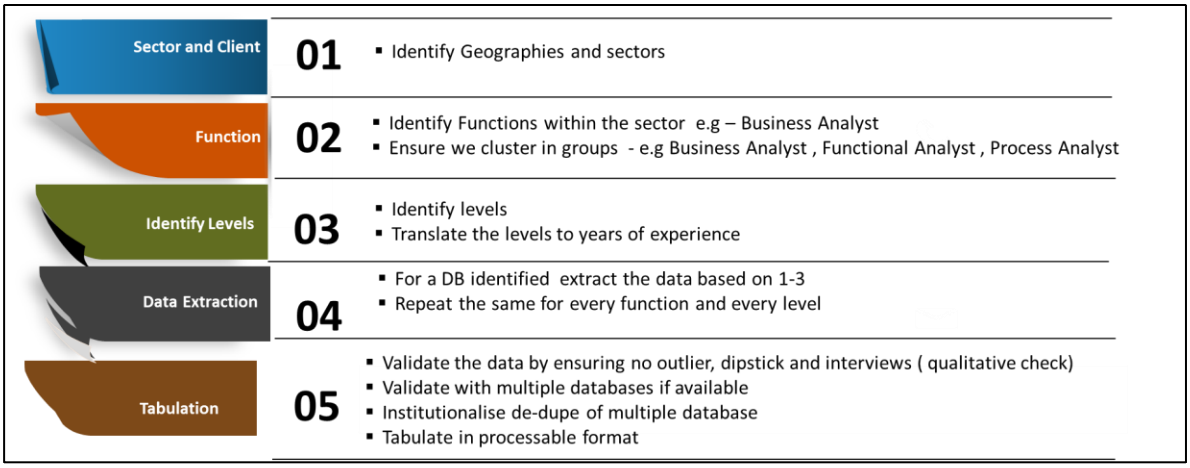
*Women in Workforce in Technology*

While there were no apparent biases for or against any gender, the preferred functions for women in technology were—Business analyst, quality control, and program management. The qualitative interviews revealed that the above roles require patience, perseverance, flexibility, and communication skills, which are key to the above roles. The socio-emotional skills of women employees make them preferred candidates for project execution and delivery, including quality control. However, there were gaps at the senior level, and a pay gap was observed. Women in tech are often paid less than their male counterparts. Additionally, work-life balance was an issue. The tech industry usually demands long hours and high levels of commitment, which can be challenging for women balancing work with family responsibilities. Another issue highlighted was mobility, as women could not relocate for growth. Lastly, fewer leadership roles resulted in a lack of role models, collectively subduing aspirations for women in technology.

## 10.8 Web Scraping / Big Data Methodology

Data scraping helps evaluate job demand by extracting information from job listings. The approach starts with defining specific goals, such as identifying crucial information like job titles, skills, locations, or sectors. Using technologies like Python libraries (e.g., BeautifulSoup, Scrapy, Selenium) or no-code solutions (e.g., Octoparse, ParseHub), scripts can be configured to navigate job boards and retrieve pertinent data (Figure 10.9). Following scraping, the raw data is cleaned to assure accuracy by removing duplicates and extraneous information. The organised data is then saved in forms such as CSV or databases for analysis. Analysing trends with tools like Pandas or Tableau can provide insights, allowing for the depiction of employment demand patterns. It is crucial to follow ethical procedures throughout the process, including honouring website terms of service and avoiding anti-scraping methods such as CAPTCHAs. It is also essential to determine if multiple databases are used, and if yes, they need to be deduped. This approach can deliver actionable insights into changing job demands in specific industries.

**Figure 10.9: Analytics using web data**




*Source*: Author's conceptualisation.

## 10.9 Policy Recommendations

Based on the industry insights as discussed in the above section, the following policy recommendations are suggested for the IT sector for addressing skills shortages:

a. *Curriculum Development:* To structure the course curriculum, Curricula must be developed in partnership with partners from industries. It entails engaging with industry experts to co-develop training content and modules and establishing centres of excellence with industry-specific leaders. The curriculum needs to focus on domain building and not just data analytics
b. *Skill Initiatives:* Encourage academia-industry collaboration, guest faculties from industries, make internship compulsory, such as in medical science, and collaborate with the industry for internship. Encourage collaboration between educational institutions and research bodies to promote practical learning. There have to be structured mentorship programs with the experienced sector as a part of final-year project coursework, including intensive boot camps and hackathons
c. *Non-Technical Skills:* Attention to be paid to non-cognitive skills, especially cultural sensitivity and communication skills.
d. *Job Sites:* Require to improve spatial matching of industry and workers.
e. *Diversity and Inclusion:* To encourage women in technology, it is necessary to have remote working, which enables women to return to the labour force. There needs to be a focused program to enrol women back in the workforce. Diversity norms by level and function have helped increase Labour Force Participation(LFP).

## 10.10 Recommended Methodology

Based on the above, the recommended methodology to assess skills shortages and skill gaps for this sector is the following:

1. Map the sub-segments of the sector to the NIC codes and specify them clearly. The sectoral sub-sectors have to be mapped to the NIC codes to ensure a multi-disciplinary approach and ensure that all experts can talk to each other in a holistic fashion. Further, this enables the policymaker to track the data at any desired terminology or aggregation.

2. Update mapping of NCO 2015 job roles with job roles identified by the Sector Skill Councils. This should be an annual exercise. Considering the rapid pace of technology in this sector, the job codes have to be regularly updated. It has to be ensured the that Skill Digital Hub of MSDE and National Career Services portal are linked to each other and changes in one reflect changes in both.
3. In coordination with the Ministry of Skill Development and Entrepreneurship, the Sector Skill Council needs to implement surveys on a regular (at least annual) basis, which captures vacancies of firms. The job roles should be mapped/matched with the ones previously identified. Ideally the Economic Census forms the frame for any survey. Given the lack of data, the Ministry of Corporate Affairs' database or Goods and Services Tax Network are the other sources of universal data, from where data may be used to derive the universe. That universe needs to be divided into the sub-sectors as previously identified. Then proper sampling strategy needs to be adopted to understand the validity of the results. Biases needs to be addressed. Response rates should also be collected.
4. Big Data analysis is highly recommended for SSCs using various job sites. They should also use/assess data from National Career Services and various employment exchanges around the country. The job roles should be mapped/matched with previously identified job roles.
5. Other databases as desired also may be used to complement existing databases. Any gaps in two different databases needs to be recognised and reconciled to understand sectoral trends in the market.
6. The questionnaires asked respondents of the mediums used for hiring employees. While direct recruitment through job fairs at ITI and campus recruitments from engineering colleges were common, several firms also advertised positions on websites such as LinkedIn, Naukri.com, and Workindia.in and National Career Services. The job details from advertised positions on these portals can help create a good database to understand the kind of job roles which are in demand by the industry along with the corresponding educational qualifications, skill-sets, and salaries. Constant tracking of such data can also help keep the job-roles and skills database dynamic.
7. Stakeholder interactions needs to be carried out as an annual exercise based on templates designed by the MSDE. It will capture jobs which are difficult to fill but also get a holistic view of the sector in terms of emerging technological trends, emerging jobs, detailed qualitative needs for qualifications and skills, hiring practices, best practices of firms, migration trends, practices to encourage female labour force participation, etc. This can be complemented by market intelligence reports, etc. that is available.
8. Last but not the least, the MSDE, Ministry of Labour and Employment and Ministry of Statistics and Programme Implementation should design an occupation-wage-employment survey. It is absolutely important to identify the occupation codes as identified previously. Ideally the Economic Census should form the frame for any survey.

This chapter describes the approach and instrument that can be used to collect insights about skill shortages in the technology sector. The chapter seeks to give actual solutions to the issues encountered while testing the technique. Given the unique nature of the practice, in-person interviews are encouraged from the outset. However, once the Labour Market Information System (LMIS) is operational and the data-gathering method has been standardised, MSDE may consider allowing firms to submit details directly. This direct submission could include sending an electronic questionnaire to the MSDE website, where enterprises can submit their responses.

Furthermore, it is critical to investigate leveraging big data/web data to analyse abilities and requirements. The job specifics from posted opportunities on these portals can assist in building a substantial database to understand the types of job roles in demand in the business and the matching educational qualifications, skill sets, and remuneration. Constantly tracking such data can also assist in maintaining the job roles and skills database current. Separating the definition by domain inside the technology sector would be a good idea—a junction of abilities and domains.

Big data is also a possible source to investigate and use to support qualitative firm-level interviews. Respondents were questioned about the recruiting processes in the questionnaires. In addition to hiring directly through ITI job fairs and engineering college campuses, several companies also posted job openings on websites like LinkedIn, Naukri.com, and Workindia.

Even though the respondents agreed that a labour market information system is helpful, the workforce won't meet skill demands unless the education and skilling ecosystem can keep up with curriculum design. In light of this, industrial associations and the sector skill council should attempt to improve industry-academia cooperation. Another stakeholder emphasised the necessity of "empowering companies" and giving them the support they need to train their employees. Engineering institutions must consider these collaborative opportunities to prepare a workforce for the industry.