IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

Adoption of Industry 4.0 in the IT Hub - Case Study of Kolkata

Marcelline Salome Gomes[1], Somnath Chakraborty[2], Amrit Chowdhury[3]
Assistant Professor, Department of Business Administration[1,2]
Final Year Student, Department of Business Administration[3]
Narula Institute of Technology, Kolkata, West Bengal, India
marcelline.gomes@nit.ac.in, somnath.chakraborty@nit.ac.in, chowdhuryamrit277@gmail.com

Abstract: *Industry 4.0 has completely changed traditional corporate processes by utilizing digital and cognitive technology to transform production and services. Industry 4.0 adoption in India is quickening but is still unequal, especially in new IT hotspots like Kolkata. The adoption trajectory, obstacles, and strategic prospects related to Industry 4.0 in Kolkata's IT sector are examined in this research report. It looks into organizational change processes, skill availability, firms' technological readiness, and the responsibilities of academia and government in supporting Industry 4.0 adoption using a mixed-methods approach. The results indicate that although Kolkata has achieved noteworthy strides in policy and infrastructure, there are still large gaps in enterprise innovation, industry-academia collaboration, and worker readiness.In order to facilitate a more inclusive and integrated Industry 4.0 development in the area, the report makes strategic recommendations.*

Keywords: Digital Transformation, Artificial Intelligence, IoT, Big Data, Smart Manufacturing, Industry 4.0, Kolkata, IT Hub, Skill Development& Policy Implementation

I. INTRODUCTION

Industry 4.0, also known as the Fourth Industrial Revolution, is integrating cloud computing, artificial intelligence (AI), the Internet of Things (IoT), and cyber-physical systems to revolutionize how organizations function. Since technological innovation is becoming more and more important for maintaining global competitiveness, India has made the transition to Industry 4.0 a national necessity. With the growth of IT corridors like Salt Lake Sector V and Rajarhat, Kolkata—once a hub of intellectual and cultural excellence—is becoming a major force in the Indian IT scene.The research being conducted looks at how much Industry 4.0 has affected Kolkata's IT industry, how prepared it is, and what the main forces behind and barriers to this change are. The socioeconomic effects of implementing Industry 4.0 technology in a developing metropolitan ecosystem such as Kolkata are also examined in this study.

II. LITERATURE REVIEW

The fourth stage of industrial development, known as "industry 4.0," was coined in Germany and is defined by the use of digital technologies into conventional manufacturing processes. The development of smart factories that are more effective, adaptable, and responsive is made possible by this revolution, which includes cyber-physical systems, cloud computing, the Internet of Things (IoT), and artificial intelligence (AI). The concepts of automation, data sharing, and real-time analytics constitute the foundation of Industry 4.0, which is revolutionizing how companies function in a variety of industries.

Global Context of Industry 4.0

The fourth stage of industrial development, known as "industry 4.0," was coined in Germany and is defined by the use of digital technologies into conventional manufacturing processes. The development of smart factories that are more effective, adaptable, and responsive is made possible by this revolution, which includes cyber-physical systems, cloud computing, the Internet of Things (IoT), and artificial intelligence (AI). The concepts of automation, data sharing, and

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

real-time analytics constitute the foundation of Industry 4.0, which is revolutionizing how companies function in a variety of industries.

Beyond manufacturing, Industry 4.0 is having a profound impact on whole sectors, such as retail, logistics, and healthcare. For instance, IoT and big data analytics enhance supply chain management in logistics, while smart technologies in healthcare allow for remote monitoring and individualized therapy.

Rapid prototyping and sophisticated simulations made possible by Industry 4.0 also promote innovation in product design and development. In the manufacturing sector, additive manufacturing (3D printing), digital twins, and AI-powered robotics allow for more flexible and efficient production systems that can adjust to shifting consumer demands and market conditions.

Industry 4.0 in the Indian Context

In contrast to leading countries like Germany, the US, and Japan, India is adopting Industry 4.0 technology at a comparatively modest pace. But thanks to programs like Start-up India, make in India, and Digital India, the Indian government has made great progress in the direction of digital transformation. A favourable policy environment for the use of technology has been established as a result of these activities. A 2020 PwC India research claims that interest in Industry 4.0 technology is growing in the nation, especially in the IT and manufacturing industries. It is believed that implementing technologies like artificial intelligence (AI), the Internet of Things (IoT), and big data analytics is essential to preserving global competitiveness and increasing productivity in a variety of industries.

The significant differences between locations and industries are highlighted in the research on Industry 4.0 adoption in India. Cities like Kolkata face a number of difficulties, such as poor infrastructure, a lack of skilled workers, and little industry-academia cooperation, whereas Bengaluru, Hyderabad, and Pune have made great strides in integrating digital technologies (Chatterjee, 2019; Bhattacharya, 2021). The Indian manufacturing and IT sectors are still in the early phases of implementing Industry 4.0 technology, according to the National Association of Software and Service Companies (NASSCOM) (2021). Large companies are driving this adoption, while smaller businesses are trailing behind because of resource limitations.

Regional Disparities in Adoption

There is still disparity in Kolkata's adoption of Industry 4.0 technologies, with certain businesses advancing while others stick to more antiquated methods. Although Kolkata is a developing IT hub with substantial infrastructure investment, Bhattacharya (2021) points out that it has lagged behind other Indian cities in implementing smart technology and modern manufacturing. Service-based businesses that prioritize software development, IT consulting, and outsourcing over manufacturing or digital innovation predominate in Kolkata's IT scene. Adoption of cutting-edge Industry 4.0 technologies, such smart manufacturing and AI-driven systems, which are common in more developed centres like Bengaluru and Hyderabad, is hampered by this reliance on traditional IT services.

Furthermore, Kolkata's sluggish adoption of Industry 4.0 has been exacerbated by the absence of strong industry-academia ties. Many academic institutions in Kolkata have failed to integrate Industry 4.0 technology into their curricula, as noted by Chatterjee (2019), leaving graduates unprepared for the digital transition. As a result, there is a lack of qualified experts in cutting-edge fields like data analytics, AI, and the Internet of Things. Although programs like the Bengal Silicon Valley Tech Hub are positive steps, the lack of comprehensive strategies to close the skills gap and the low level of industry participation have prevented them from having a major impact on the city's industrial transformation.

Technological Readiness and Infrastructure

Another important element affecting Kolkata's adoption of Industry 4.0 is technological preparedness. Many businesses in the city lack the fundamental technological infrastructure needed to apply cutting-edge technologies, claims Bhattacharya (2021). For small and mid-sized businesses, the high cost of purchasing and maintaining infrastructure like data centres, cloud computing platforms, and 5G networks is a major obstacle. The government has attempted to

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

offer tax benefits for investments in smart technology, but these efforts are not widely known, and businesses are still not aware of the support systems that are available, according to the Webel Annual Report (2023).

The lack of qualified personnel with the competence to deploy and oversee Industry 4.0 technology exacerbates the infrastructure problem. Kolkata's current training programs are frequently out of date, and there is a disconnect between the academically taught abilities and the real-world skills needed in the workplace. The workforce in the city is therefore ill-equipped to handle the demands of the digital economy.

Policy and Government Initiatives

India's adoption of Industry 4.0 is significantly shaped by government policies and efforts. The National Policy on Electronics (2019), which highlights the adoption of cutting-edge technology for the development of a "smart" manufacturing sector, demonstrates how the Indian government has acknowledged the significance of Industry 4.0 in its national development plan. Furthermore, the Digital India project seeks to enhance technology access and deliver digital infrastructure throughout the nation, especially in areas like Kolkata. However, there is still inconsistency in the way these rules are being implemented, and many businesses are still ignorant of the incentives and support systems that are available.

The West Bengal government's Bengal Silicon Valley Tech Hub plan, which seeks to establish an environment that supports the expansion of the IT and technology sector, has the potential to increase Industry 4.0 adoption in Kolkata. But as Chatterjee (2019) noted, enhancing cooperation between business, government, and academic institutions is essential to the success of such programs. Lack of this kind of cooperation frequently results in dispersed efforts and sluggish digital transformation development.

Challenges in Industry-Academia Collaboration

The inadequate cooperation between industry and academics, which impedes Kolkata's quick adoption of Industry 4.0 technology, is another important issue noted in the research. The majority of academic institutions in Kolkata lack specialized Industry 4.0 research labs or incubators, as noted by Chatterjee (2019), which restricts their capacity to support the digital revolution. Additionally, graduates are ill-prepared for the demands of the changing labor market because academic programs are frequently not in line with industrial needs.

According to a NASSCOM (2021) report, educational institutions must incorporate Industry 4.0-focused curricula and give students practical training to improve their employability in cutting-edge technologies. Furthermore, forming public-private collaborations can help research and development (R&D) capacities grow, keeping academia up to date with industry trends and encouraging innovation.

III. RESEARCH OBJECTIVES

1. To evaluate the degree of Industry 4.0 adoption that is currently occurring in Kolkata's IT industry.
2. To determine the institutional, organizational, and technological elements affecting the adoption process.
3. To assess Kolkata's IT workforce's readiness for work in an Industry 4.0 setting.
4. To investigate how academic institutions and policy efforts might hasten the adoption of Industry 4.0.
5. To offer stakeholders practical suggestions to improve the region's adoption of Industry 4.0.

IV. RESEARCH QUESTIONS

1. How are IT companies in Kolkata currently implementing Industry 4.0 technology?
2. What obstacles stand in the way of Industry 4.0's effective implementation in Kolkata's IT sector?
3. How prepared is the labour force to handle Industry 4.0's demands?
4. How do academic programs and governmental regulations contribute to this change?

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

V. METHODOLOGY

A mixed-methods strategy is used in this study to collect both qualitative and quantitative data.

- **Quantitative Survey:** Fifty IT companies in Salt Lake and Rajarhat were given a structured survey questionnaire. Current technology use, employee training, R&D expenditure, and digital strategy were among the topics examined in the poll.
- **Qualitative Interviews:** Five government representatives from the West Bengal IT Department, five professors from top technical universities in Kolkata, and ten senior executives from well-known IT companies participated in in-depth interviews.
- **Secondary Data Review:** To supplement primary findings, reports from academic journals, industry white papers, and government organizations were examined.

VI. CASE BACKGROUND

Over the past 20 years, intentional governmental policies and market forces have aligned to make Kolkata an IT hub. Salt Lake's transition from a traditional economy to a knowledge-based one began with the creation of Sector V in the early 2000s. The construction of New Town Rajarhat, with its top-notch infrastructure, planned business districts, and contemporary facilities geared towards technology companies, came next. Due to the region's plentiful talent pool and very inexpensive operational expenses, major corporations like TCS, Cognizant, Wipro, and Infosys have made significant investments. Through programs like the Webel-Fujisoft-Vara Centre of Excellence in Industry 4.0 and the Bengal Silicon Valley Tech Hub, the West Bengal government has also taken the initiative.

Despite these developments, Kolkata's IT environment is still marked by a dearth of high-end research and development activities, an excessive reliance on service-based IT operations, and a slow adoption of cutting-edge technologies. In order to assess five different IT businesses' readiness for Industry 4.0, this case study attempts to comprehend the unique dynamics within each of them.

Key Information Regarding the Case Study:

- 60% of companies polled said they had incorporated AI into at least one business process.
- 45% of people utilize IoT solutions to monitor systems and infrastructure.
- Merely 30% of employees receive formal training in Industry 4.0 technologies.
- 70% of businesses invest less than 2% of their yearly sales in research and development.
- Although it was created in 2022, a public-private academic cooperation is still not being fully exploited.

There is a lack of awareness regarding government tax incentives for investments in smart technology.

VI. CASE PROBLEMS

1. Skill Gaps: Professionals with knowledge of AI, data analytics, cloud computing, and IoT are severely lacking. The training programs that are currently in place are either out of date or not in line with industry demands.
2. Technology Infrastructure: The fundamental infrastructure needed to implement Industry 4.0 technologies, like cloud platforms, secure data centres, and 5G networks, is often lacking in mid-sized businesses.
3. Weak Institutional Links: Industry and academia don't always work together. The majority of institutions lack Industry 4.0-specific research facilities or incubators.
4. Uncertain Policy Environment: Although there are some policy frameworks, they are either not followed through on or are not implemented well. Businesses frequently don't know about the available assistance systems.
5. Organizational Resistance: Uncertainty, fear of losing one's job, and ignorance about Industry 4.0's advantages are the main causes of resistance to change in many businesses.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

VII. OUTCOMES OF PROBLEMS/ISSUES

Inadequate infrastructure, unclear policy frameworks, poor institutional coordination, organizational inertia, and talentdeficits are just a few of the issues that have collectively made it extremely difficult for Kolkata to become a fully Industry 4.0-compliant IT powerhouse. These results appear in a variety of ways:

1. A fragmented and delayed digital transformation-Due to insufficient internal resources and outside assistance, many IT companies in Kolkata—particularly mid-sized and smaller businesses—have postponed implementing Industry 4.0 technology. Projects involving digital transformation are frequently carried out in silos without a unified plan, which leads to fragmented adoption with minimal long-term effects. Pilot initiatives are frequently abandoned because of low return on investment, technical issues, or staff reluctance.

2. A decline in worldwide competitiveness-IT companies in Kolkata run a growing risk of losing their competitive advantage in the global marketplaces for technology services and outsourcing. Kolkata-based businesses still use outdated technologies, whereas companies in other Indian cities like Bengaluru and Hyderabad are using AI, automation, and analytics solutions with vigour. Their capacity to draw in valuable international clients looking for cutting-edge digital services is hampered by this technological disadvantage.

3. The exodus of talent to cutting-edge IT hubs-Skilled professionals are forced to relocate to more vibrant locations due to the lack of advanced prospects and the sluggish pace of technological advancement. The city's intellectual capital is steadily leaving Kolkata as talent with training in data science, artificial intelligence, and machine learning frequently relocate to Bengaluru, Pune, or other countries. The ability of the local ecosystem to adopt cutting-edge innovations is further weakened by this talent drain.

4. Low Start-up Attrition and Innovation Output-A muted start-up culture has resulted from a lack of cooperative R&D, restricted access to venture financing, and a lack of mentorship. Scaling operations is a challenge for many digital businesses, particularly those concentrating on Industry 4.0 fields like robots, smart manufacturing, and predictive analytics. Consequently, promising firms either close their doors or move, and the innovation pipeline continues to be inadequate.

5. Resistance to Change and Employee Disengagement-Employee anxiety and disengagement are caused in many firms by a lack of clear upskilling pathways and the fear of automation-induced redundancy. Employees oppose new technologies because they see them as threats rather than facilitators when change management procedures aren't followed. Internal digital initiatives are slowed down by this cultural opposition, which also makes transformation attempts more difficult.

6. Inadequate Use of Academic and Government Resources-Even while the government offers incentives and Centres of Excellence, businesses frequently do not use these resources to their full potential. Due to inadequate coordination and communication, academic institutions' research potential and student talent are mainly unrealized. This leads to minimal industry engagement and limited results from publicly supported projects.

VIII. IMPLICATIONS

1. Present Situation: The IT sector in Kolkata is still in the early stages of adopting Industry 4.0, with larger companies demonstrating a greater degree of adoption than smaller ones. Due to resource constraints, many smaller businesses find it difficult to keep up with the aggressive adoption of Industry 4.0 technology by larger enterprises such as TCS, Wipro, and Cognizant. Large corporations with sufficient capital and infrastructure stand apart from smaller businesses that continue to use conventional IT solutions.

2. Difficulties: The following are the main obstacles preventing Industry 4.0 from being widely adopted in Kolkata: Despite the workforce's high level of education, many professionals lack the specialized skills needed for Industry 4.0 technologies like artificial intelligence (AI), the Internet of Things (IoT), and big data analytics. There is a sizable skills gap because educational institutions have not yet matched their curricula with industrial expectations.

A lot of mid-sized businesses do not have the core infrastructure required for Industry 4.0, including secure 5G connectivity, sophisticated data centers, and cloud computing capabilities. These restrictions make it impossible for Industry 4.0 technology to be implemented successfully.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, May 2025 Impact Factor: 7.67

There is insufficient collaboration between industry players and academic institutions. Research and development in emerging technologies are underfunded, and academic programs do not emphasize the practical applications of Industry 4.0.

Although several government initiatives have been launched, including the Bengal Silicon Valley initiative, their implementation and communication have been lackluster. Companies remain unaware of the full range of incentives and support available to them under government schemes.

3. Workforce Readiness: Despite having a big number of technically skilled people, Kolkata's workforce is still not prepared for Industry 4.0. The existing workforce pool lacks the necessary skills to manage cutting-edge technologies like blockchain, AI, IoT, and machine learning. More specialized training programs that closely match Industry 4.0 requirements are obviously needed.

4. Policy and Education: Government programs like the Bengal Silicon Valley Tech Hub and educational establishments' participation in Industry 4.0 training are positive moves. However, a lack of long-term planning and poor cooperation have limited their impact. Even while there are such projects, they are frequently not well-publicized or included in the agenda for digital transformation as a whole. Industry 4.0 adoption in Kolkata might be further accelerated by a better planned and coordinated strategy that includes curriculum reform, improved industry-academia relationships, and more focused legislative incentives.

IX. CONCLUSION

Kolkata is at a turning point in its digital transformation process as the need to preserve innovation and competitiveness in the worldwide shift to Industry 4.0 grows. According to this study, there is still a big disconnect between the potential and actual application of Industry 4.0 technologies, even though important steps have been taken, such as the construction of infrastructure in Salt Lake Sector V and New Town Rajarhat and the introduction of legislative initiatives like the Bengal Silicon Valley Tech Hub.

According to the report, big IT companies in Kolkata are spearheading the digital revolution by incorporating IoT, Big Data, and AI into their daily operations. Small and medium-sized businesses (SMEs) still have to overcome obstacles such a lack of qualified human resources, a high initial investment cost, and a restricted technology infrastructure. Due to outmoded academic curriculum and a lack of possibilities for practical training in developing technologies, workforce preparation is still a big challenge. The adoption process has also been hampered by a culture of resistance to change in many workplaces.

The fragmented nature of cooperation between government agencies, business, and academia is a crucial finding of this study. Efforts frequently become repetitive or useless in the absence of a cohesive strategy. The need for improved communication and policy outreach is further highlighted by the low level of firm understanding of current government incentives and support systems. The report suggests a multifaceted approach to tackle these issues, including stronger public-private partnerships to promote innovation, curriculum reform in academic institutions to incorporate Industry 4.0-related modules, and targeted government incentives to promote R&D and digital adoption among SMEs. In addition to implementing awareness campaigns to inform businesses about the support systems that are available, upskilling programs must be customized to meet the demands of both the present and the future of technology.

In summary, Kolkata possesses the essential components needed to develop into a centre of Industry 4.0 excellence: a developing IT infrastructure, a skilled labour pool, and policy-level intention. Now, a unified, well-coordinated strategy that guarantees the agreement of all parties involved is needed. Kolkata has the ability to challenge other significant Indian IT hubs in adopting the Fourth Industrial Revolution, if it works hard and has visionary leadership.

X. ACKNOWLEDGMENT

Additionally, we would like to thank the academic institutions, government representatives, and IT companies in Kolkata for their invaluable contributions and insights, without which this research would not have been feasible. We are especially grateful to the research participants for sharing their experiences and insights. We are grateful to our family and co-workers for their unwavering support and encouragement during this project.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

REFERENCES

[1] S. Bhattacharya, *Digital transformation in East India: Challenges and opportunities, Journal of Regional Development, vol.* 12, no. 3, pp. 54–70, 2021.

[2] A. Chatterjee, *Industry 4.0 and Indian IT Hubs: Comparative Study of Bengaluru and Kolkata, Indian Journal of Technological Advancements, vol.* 9, no. 2, pp. 89–102, 2019.

[3] M. Hermann, T. Pentek, and B. Otto, "Design principles for Industry 4.0 scenarios," *Procedia CIRP*, vol. 52, pp. 164–168, 2016.

[4] NASSCOM, *Digital India – Assessing the Progress of Industry 4.0 Adoption,* 2021. [Online]. Available: https://www.nasscom.in

[5] PwC India, *India Industry 4.0 Readiness Report*, 2020. [Online]. Available: https://www.pwc.in

[6] Government of West Bengal*, Bengal Silicon Valley Tech Hub Report*, Dept. of IT and Electronics, Govt. of West Bengal, 2022.

[7] Webel, *Annual Report: Driving Innovation through Technology,* West Bengal Electronics Industry Development Corporation, 2023.

[8] Ministry of Electronics and Information Technology*, Digital India Yearbook, Govt. of India, 2021.*