CAHIERS MAGELLANES-NS
Volume 06 Issue 2
2024

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
http://magellanes.com/

EMERGING BUSINESS PARADIGMS TRANSITION FROM INDUSTRY 4.0 TO INDUSTRY 5.0 IN INDIA

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Abstract
This research paper delves into the unique Indian perspective on this transformation, exploring the challenges, opportunities, and implications it holds for businesses, policymakers, and researchers. The research is based on secondary data; published research papers on IR 4.0 and 5.0 from various journals, magazines, and reports from various consulting firms are gathered and reviewed to understand the research content and findings of various researchers worldwide. Data on Industry 4.0 is collected from official studies conducted by consulting firms, whilst data on policy is derived from published papers by the Indian government. Drawing upon a comprehensive review of literature, surveys, and expert interviews, this study investigates the multifaceted dimensions of Industry 5.0 in the Indian context. The findings shed light on how Industry 5.0 principles, emphasizing human-machine collaboration and customer-centricity, are impacting diverse sectors within India. The study also underscores the pivotal role of government policies and innovation ecosystems in facilitating this transition.
Keywords: Industry 4.0, Industry 5.0, Business, Paradigm, Government Policy

Introduction
The rapid advancements in digital technologies have ushered in a new era of industrial transformation, known as Industry 4.0. Characterized by the integration of cyber-physical systems, the Internet of Things (IoT), artificial intelligence (AI), and big data analytics, Industry 4.0 has revolutionized manufacturing and business processes worldwide. In India, the adoption of Industry 4.0 technologies has been pivotal in enhancing productivity, efficiency, and competitiveness in various sectors. However, as we stand on the brink of a new decade, a new paradigm is emerging – Industry 5.0. Unlike its predecessor, Industry 5.0 emphasizes the harmonious collaboration between humans and machines, prioritizing personalization, sustainability, and resilience.

This paper aims to explore the transition from Industry 4.0 to Industry 5.0 in the Indian context. It delves into the current status of Industry 4.0 adoption in India, examines the emerging trends and drivers behind Industry 5.0, and assesses the potential impacts on Indian industries. Furthermore, the paper highlights the challenges and opportunities associated with this transition and offers insights into the role of government policies in facilitating a smooth shift towards Industry 5.0

The advent of Industry 5.0, poised to take center stage while Industry 4.0 continues to gain momentum,

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
http://magellanes.com/

signifies a transformative leap in the industrial landscape. Often regarded as the fifth industrial revolution, Industry 5.0 promises to fulfill individual consumer requirements based on unique tastes and expectations. While Industry 4.0 marked a significant stride in automation, Industry 5.0 envisions mass personalization by integrating Artificial Intelligence (AI). This revolution anticipates not only revolutionizing production processes but also fostering a higher degree of autonomy in collaborative robots. Industry 5.0, being futuristic in its approach, aims to infuse creativity and innovation into products by empowering robots to handle repetitive tasks efficiently. As we transition from mass production to custom manufacturing, the contemporary imperative lies in the swift advancement of manufacturing techniques, digitization, and intelligentization of production systems. While Industry 4.0 laid the foundation with its emphasis on automation, data exchange, and artificial intelligence (AI), Industry 5.0 leaps forward, integrating human intelligence with machine capabilities. As India continues its journey towards technological advancement, the question arises: Is India ready for Industry 5.0?

India's Progress in Industry 4.0

India has made significant strides in advancing toward Industry 4.0, with a multifaceted approach encompassing government initiatives, increased investments in research and development, and the widespread adoption of advanced technologies. Programs like Digital India and Make in India, coupled with the Smart Cities Mission, underscore the government's commitment to fostering a digital ecosystem. The country has seen a notable surge in the integration of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and robotics across industries, particularly in manufacturing. This digital transformation is not only enhancing operational efficiency but also positioning India as a global player in the fourth industrial revolution. Skill development initiatives are addressing the need for a technologically adept workforce, although challenges such as the digital divide and cybersecurity concerns persist. Overall, India's progression on Industry 4.0 signifies a strategic and comprehensive effort to align with the evolving landscape of smart, connected, and data-driven manufacturing systems. However, Industry 5.0 demands a more holistic approach, necessitating the seamless integration of these technologies.

Humans have undergone a drastic evolution, our existence has transformed every century and down each generation. One of the most significant shifts was when manual workmanship and craft traversed into automated processes. The present-day version of these processes has taken the avatar of the automated manufacturing sector by running agile factories and building smart warehouse systems.

The Manufacturing industry has evolved from Industry 1.0, 2.0, 3.0 to 4.0 and is now entering 5.0 Each phase represents important stages of Manufacturing after the Industrial revolution. A significant constant has remained the decreasing involvement on humans and reliance on machinery throughout each phase. Driven by the impact of the pandemic, the need for automation, virtualization, and resilience are emerging as key themes as we enter the new phase.

The Transition from Industry 4.0 to 5.0

At the moment, we are on the brink of the fourth Industrial Revolution. This is characterized by Smart Manufacturing, where manufacturing processes are computer-integrated. This phase saw the introduction as well as the implementation of key technologies like Artificial Intelligence (AI) for smart

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
http://magellanes.com/

decision-making, Machine Learning (ML) algorithms for identifying patterns in data, Robotic Process Automation (RPA) for back-office high-volume repetitive tasks, Digital Twins for equipment/facility insights throughout their lifecycle, Collaborative Robots (Cobots) for assembly line automation and heavy lifting, and Connectivity evolution from 2G-5G for faster communications.

In the next phase of transformation, Industry 5.0 is expected to bring about human-robot co-working dynamics which means maximized automation and minimal human interaction. This relationship will be instrumental in transitioning existing smart factories to a lights-out factory. These will be designed to sustain an entirely robotic workforce with negligible employee intervention. Arising from this will be saved energy consumption and electricity downsizing. Another key theme to cement the presence of Industry 5.0 in the next five years will be mass customization. For example, Nike, the global apparel manufacturer is letting its customers customize their own footwear and clothing, from basic styling and color to the material of the products.

Source: Bloomberg

The concept of Industry 5.0 was introduced by the European Commission (EC) to address the transformation of industrial standards to support innovation. The EC's definition, while is the most frequently used, also shows how the need for a new industrial paradigm has become imperative.

The past decade has taught us the increasing complexity of societal and economic challenges. Factors such as climate change, depletion of resources, and unforeseen incidents like a global pandemic and wars are compelling manufacturers to experiment with existing and novel technologies, materials, and processes. Manufacturers like 3M have allocated fresh budgets to experiment with new materials and

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
http://magellanes.com/

expand production capabilities for personal safety products considering the COVID-19 pandemic.

AI, IoT will be the Core of Industry 5.0

Industry 5.0 will evolve existing technologies in the market, with research and technical advancements. Figure 1 shows how AI-ML, Cobots, IoET (Internet of Every Thing), Blockchain, and Digital Twins have cemented their presence in the manufacturing industry in the past five years. Their use cases are going to evolve and there will be new implementation areas that will be pivotal in shaping Industry 5.0. AI's implementation is visible across the Manufacturing value chain. AI augmenting human robots is a significant advancement, that will reassert AI's role in Industry 5.0. From relying on data to test, build, and drive autonomous cars to smart warehouse-picking robots that will identify the product type based on the order received, human-robot collaboration has seen a progression, from low-level to high-focus tasks. To augment this collaboration, factories and production facilities have become highly connected environments, virtually. This was quite different two decades ago.

IoT in convergence with big data analytics and AI, has given birth to the Smart Factory. The IT-OT combination began in Industry 4.0 and continues to grow in scope and intensity to eventually become IoET. IoET holistically refers to a varied set of complexly connected devices.

Some key areas where these evolving technologies are expected to rise in the next 10 years are –

1. **AI-ML** – A rise in Intelligent Automation will provide greater efficiency on the shop floor as well as in the office. Enterprises have a keen focus on quality management and AI will enable just that to assist in quick decision-making. For example, process manufacturer Koch is

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
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partnering with AI-led ISVs like C3.AI for enterprise-wide AI adoption. This will enable inventory optimization, production planning and scheduling, and energy management.

2. **Cobots** – Deploying cobots for production, and warehouse management is going to increase the productivity of factories; resulting in higher consistency and accuracy of manufacturing goods. The first manufacturer to introduce cobots in the industry, ABB, is pioneering technical advancements with 46 years of expertise in building cobots. Cobots are being launched for Automated Guided Vehicles (AGV) mounting, assembly line automation, packaging simplicity, industrial testing replacing manual labor on the shop floor.
3. **IoET** – IoT is subtly transitioning into IoET; Connected* industrial machinery is helping manufacturers achieve cost efficiency, boost asset productivity, reduce downtimes, and create realistic supply chain visibility. A noteworthy example is Koch – it is making its factories smarter with invisible, IoT-enabled tapes from a US-based ISV, Trackonomy. This smart, wireless tape is monitoring important cargo and machinery and relays information such as location, position, and temperature.
4. **Blockchain** – Not restricted to the BFSI industries, Blockchain is emerging as a key contributor to ensuring operational transparency and boosting supply chain visibility, asset monitoring, and operational improvements for manufacturers. A step towards this advancement can be seen with Honeywell. Honeywell Aerospace is diligently investing in Blockchain and using it to list products for sale, record transactions between stakeholders, and maintain a transaction ledger, eliminating manual procedures and paper usage.
5. **Digital Twin** – Enterprises are adopting digital twins for predictive maintenance of assets – to mitigate downtime and predict future errors. Caterpillar, a discrete manufacturer headquartered in the US is using digital twin technology to optimize machine temperatures and monitor asset performance through their lifecycles.

The Next Wave of Innovation – Metaverse, Quantum Computing, 6G

Our research has shown that Industry 5.0 is here and now. It will be driven by the introduction of technologies like Metaverse, Quantum Computing, and 6G Communications.

• **Metaverse** will enable faster and more remote co-development of products and solutions through digital twins for the Manufacturing industry. Giant manufacturing enterprises like Airbus and Boeing have joined the bandwagon of using the Metaverse. Boeing intends to run R&D for its new aircraft and jet variants by building digital twins in the Metaverse and running simulations for customizations. Outside of manufacturing, enterprises are experimenting with the use of Metaverse for in-house immersive employee learning to help them learn faster and in a safer format. For example, Schneider has opened an Innovation Center in the Metaverse with a focus on product development and innovation.

• **Quantum Computing** while nascent, manufacturers are willing to start R&D on how quantum mechanics can optimize investment strategies, improve encryption, discover products, and more. For example, Honeywell's new division, Honeywell Quantum Solutions, and Cambridge Quantum built a joint venture, Quantinuum which is building the world's first quantum OS, software, and hardware, all of which will be used to address conventional computing challenges. To achieve visible results, manufacturing leaders are partnering with core quantum ISVs too. For example, BASF has partnered with Pasqal to build quantum neural network-based models for computational fluid dynamics

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
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applications.

• **6G Connectivity** trials are promising to support Industrial IoET. Currently, enterprises are partnering with solution providers/ISVs at the R&D phase while they try to increase seamless IoT in the coming years. To build intelligent connected solutions, manufacturing leaders like Honeywell, 3M, Intel, and Samsung are already in the experimentation phase. For example, Samsung has partnered with UCSB to prototype 6G THz wireless communication and is currently launching whitepapers for its trials. On a geographical scale, European countries are together envisioning the future of wireless technology and have collectively launched the Hexa-X Project. Industrial manufacturers Intel and Siemens have become collaborative partners in the project to work on connected intelligence via an AI-driven air interface, frequency, and resolution localization and sensing.

The evolution of technologies such as AI, IoT, Blockchain will soon define how industrial advancement and the future of manufacturing. There is much headroom for the supply ecosystem to work with manufacturers, understand their requirements, and provide innovative solutions that can further industrial advancement in the next ten years.

Advantages of transitioning from Industry 4.0 to Industry 5.0

The upcoming Industry 5.0 offers companies from all industries enormous opportunities to remain successful in an increasingly digitized world and to tap into new markets. Automation will play an important role as manual work can be increasingly automated with robotics and networked systems. This not only saves time and costs but also improves the quality of their products. The entire production process can also be optimized through automation options, such as automatically managing inventories or preventing disruptions in the production process through predictive maintenance. Another important building block for future-proof production is the use of artificial intelligence (AI). By using self-learning algorithms, production processes can be optimized, and the quality of products can be improved. Analyzing data and using machine learning methods can detect machine failures early and initiate appropriate countermeasures. Together with advanced sensors, networking, and intelligent manufacturing technology along the entire value chain, companies can gain a decisive competitive advantage by preparing for these developments and investing.

Improved efficiency and productivity

Automation in the context of Industry 5.0 will open enormous opportunities for companies in all sectors to remain successful in the increasingly digitized world and gain competitive advantages. A central aspect of this is the improvement of efficiency and productivity. With the advent of robots and networked systems, manual work can be increasingly automated, which not only saves time and costs, but also contributes to improving the quality of products. In addition, advanced sensors and intelligent manufacturing technology can achieve optimizations along the entire value chain. For example, data can be centrally collected and analyzed to identify potential problems at an early stage and initiate appropriate countermeasures. In combination with artificial intelligence and machine learning methods, companies in Industry 5.0 can thus further automate and optimize business processes to achieve a competitive advantage.

Higher quality of products and services

The upcoming Industry 5.0 offers companies enormous opportunities to increase efficiency and productivity through automation and the use of interconnected systems. Sensors and intelligent

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
http://magellanes.com/

manufacturing technology along the entire value chain enable central collection and use of information, making it easier to facilitate collaboration between customers and suppliers and avoid disruptions in the production process. Artificial intelligence and machine learning methods help companies optimize the entire production process by collecting and analyzing data to detect machine failures early and initiate appropriate countermeasures. Another important advantage of Industry 5.0 is the improvement in the quality of products and services. With robotics and interconnected systems, manual tasks can be increasingly automated, contributing to higher product quality. Companies that are already preparing for and investing in these developments can not only gain a decisive competitive advantage, but also create the basis for a future-oriented production.

Better accessibility and connectivity

The automation and digitization of production systems in the context of Industry 5.0 offer companies enormous opportunities to remain competitive and align themselves with the future. One of the most important advantages is the improvement of efficiency and productivity. Through intelligent interconnected systems and the use of robots, manual tasks can be automated, saving time and costs. In combination with advanced sensors and analysis methods, companies can centrally capture and evaluate data to detect potential problems early and initiate countermeasures. In addition, Industry 5.0 significantly contributes to improving product quality. By using robotics and advanced manufacturing techniques, product recalls can be minimized, which has a positive impact on customer satisfaction. Companies that are already preparing for and investing in these developments guarantee themselves a decisive competitive advantage and pave the way for a modern and future-oriented production.

Government Initiatives and Policy

The Indian government has embarked on an ambitious trajectory towards Industry 5.0, envisioning a manufacturing landscape driven by human-centric principles, sustainability, and cutting-edge technology. Anchoring this vision are key initiatives and policies designed to propel the nation into the forefront of the next industrial revolution. Make in India 2.0, a pivotal initiative, strategically targets 27 critical sectors, advocating for innovation, substantial investments, and the integration of Industry 5.0 technologies such as artificial intelligence (AI), robotics, and 3D printing to fortify manufacturing competitiveness. The Production Linked Incentive (PLI) Scheme further incentivizes domestic manufacturing in strategic sectors, fostering a resilient manufacturing ecosystem. The Digital India program plays a vital role in this transition by focusing on developing the requisite digital infrastructure essential for Industry 5.0. The Atmanirbhar Bharat initiative complements these efforts by promoting self-reliance, encouraging domestic innovation, and reducing reliance on imports. The government's emphasis on research and development (R&D) in critical areas like AI, robotics, and automation positions India to develop indigenous technologies and emerge as a global Industry 5.0 leader. Concurrently, initiatives like Skill India and the National Apprenticeship Promotion Scheme underscore the commitment to skilling and upskilling the workforce for the demands of Industry 5.0. Moreover, continual policy reforms are geared towards fostering an environment conducive to Industry 5.0, aiming to streamline regulations, attract foreign investments, and nurture innovation. Through these comprehensive measures, the Indian government is laying the groundwork for a transformative era, anticipating heightened productivity, increased efficiency, and enhanced global competitiveness for the country's industries in the imminent Industry 5.0 landscape. Framework To address the challenges and

ISSN:1624-1940
DOI 10.6084/m9.figshare.263376
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seize the opportunities of Industry 5.0, the Indian government needs to formulate a robust policy framework. This framework should encompass initiatives aimed at skills development, digital infrastructure enhancement, and bridging the urban-rural digital gap. A proactive approach to regulatory mechanisms is crucial, defining accountability in the face of automation failures and establishing guidelines for evolving business strategies.

Conclusion

In conclusion, Industry 5.0 represents a paradigm shift that demands a recalibration of India's approach to technological integration. While the country has made commendable progress in Industry 4.0, Industry 5.0 requires a more profound transformation. The collaborative relationship between humans and machines, coupled with an advanced skill set and robust digital infrastructure, is key to unlocking the full potential of Industry 5.0. India stands at the threshold of a new era, and the government's initiatives such as Make in India, Skill India, and Start-up India are pivotal in aligning the nation with Industry 5.0. However, addressing challenges like the digital divide and redefining business strategies to cater to mass personalization will be critical. With strategic investments, a forward-looking policy framework, and a concerted effort to bridge technological gaps, India can position itself as a frontrunner in smart and collaborative manufacturing systems, realizing the promises of Industry 5.0.

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