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12. The Next Industrial Revolution Industry 5.0 - The Human Focused Solutions for Sustainable Growth and Development

Thenmozhi

Research Scholar

Department of Management Studies

DR. MGR educational and Research Institute.

Dr. M. Senthil Mathi

Assistant Professor,

DR. MGR educational and Research Institute.

ABSTRACT

Industry 5.0 also known as the fifth Industrial Revolution, is a new and emerging phase of Industrialization tat sees humans working alongside advanced technology and A.I powered robots to enhance workplace processes

while the most companies are still struggling with the digitalization of their business through the integration of artificial intelligence (AI), Internet of Things(IOT), cloud technologies and further developed technology the next step of Industrial Revolution appears in the nearest future.

Industry 5.0 will step into the future daily business due to the velocity of further technological development and changing human process integration. In this context, the paper analyses and evaluate the business impact of the next industrial Revolution, so call industry 5.0. Therefore the actual industry 4.0 business transformation record of accomplishment as well as weakness and threats are analyzed by interviews with experts and business representatives. The first result is the business situation analysis to identify existing gabs with the derivation of opportunities and threats as well as suggestions for the business how to transform best in times of the next Industrial Revolution. Furthermore, the approach of integrate human workers back into the supply chain next to automated processes is debated. This paper underlines the assumption that companies did not recognize, yet the next industrial Revolution because of the lack of entrepreneurship and transformation capacity related to industry 4.0

Industry 5.0 blows the whistle on global industrial transformation. It aims to place humans' well -being at the center of manufacturing systems, thereby achieving social goals beyond prosperity robustly for the sustainable development of all humanity. However, the current exploration of Industry 5.0 is still in its infancy where research findings are relatively scarce and little systematic. This paper first reviews the evolutionary vein of Industry 5.0 and three leading characteristics of industry 5.0: human - centricity, sustainability and res

The Fifth industrial (IR5.0) will see the transformation of the manufacturing sector that can ignite the industrial revolution/ IR 5.0 should ideally be the evolution of the modern manufacturing process in order to allow man and to perform work hand-in-hand

Introduction:

Lignin Priorities for Industry 5.0:

The concepts and principles of Digital Transformation have been explored at length in recent years. Most executives have gained fluency in the capabilities of technology and Digital Business. Building upon these foundational ideas, it's prudent to focus on incorporating the principles of Human Centricity, Resilience, and Sustainability.

Following Are a Few Key Concepts to Focus On:

- **Re-Orienting for Human Centricity:**

There are several dimensions to advancing human-centric business. The first, and top priority, should be attracting and retaining talent. Particularly to technology-centered organizations, human capital is the most strategic asset and businesses will need to accommodate the growing cohort of Gen-Z and Millennials' changing needs. For younger generations of workers, the commitment to environmental and social factors becomes increasingly important in their choice of employer, and this may include a commitment to community initiatives, flex working arrangements, and the cultivation of historically underrepresented minorities in leadership roles.

The human-centric vision also critically involves re-thinking how workers and machines collaborate. Traditionally static manufacturing processes can be updated with new collaborative robotics (co-bots) with line workers empowered to exercise greater flexibility in production. Worker safety and health can also be improved with advanced monitoring capabilities and ergonomic design. A healthy and happy workforce with opportunities for creative personal and professional advancement is likely to create lasting value for the business.

- **Bolstering Resilience:**

Recently, businesses have been forced to cope with increased uncertainties and adapt to cope with change. It's important for organizations to engage in planning exercises that account for potential disruptions across the value chain, from the factory floor to the supplier network, to transportation channels, to regulatory and geopolitical change. Digital technologies and methodologies (simulations and AI-enhanced modeling) can help identify optimal alternative paths in the event of disruption, weighing different factors such as cost, substitution, quality, and logistical concerns into the mix. Start with identifying the greatest points of vulnerability (whether in process or supply chain), isolate the key inputs, and then formulate contingency planning for any disruptions. It's better to have a plan and not need it than be caught unprepared.

- **The Importance of Sustainability:**

With the growing regulatory and investor emphasis on reducing carbon emissions and environmental impact, businesses need to evaluate their resource footprint. This may involve analyzing the source of raw materials, the proportion of waste generated, along with an evaluation of the environmental impact, the energy efficiency of processes, as well as the sources of energy. Many firms have committed to specific reductions of fossil fuels and clean energy generation sources. Additionally, the adoption of new materials and composites (away from petroleum-based for instance) can reduce environmental impact while increasing the practices of recycling and repurposing materials can also help to achieve objectives.

Beyond Better, Cheaper and Faster:

Preparing for Industry 5.0 is not inconsequential, but there are multiple forces arraying to compel businesses to adopt the core principles of human-centricity, resilience, and sustainability. It’s far better to take the opportunity to prepare ahead of time, rather than react to an unanticipated shock to the system. Beyond better, cheaper, and faster, the technology-enhanced mantra **Industry 5.0 promises to lead the next generation into a balance of decisions that support smarter, cleaner, and more resilient industries.**

- **Industry 5.0 Sustainability:**

Industry 5.0 seeks to create a manufacturing environment that is both sustainable and resilient, while also being human-centric. With the growing regulatory and investor emphasis on reducing carbon emissions and environmental impact, businesses need to evaluate their resource footprint that supports their manufacturing process. This may involve analysing the source of raw materials, the proportion of waste generated, along with an evaluation of the environmental impact, the energy efficiency of processes, as well as the sources of energy. Many firms have committed to specific reductions of fossil fuels and clean energy generation sources. Additionally, the adoption of new materials and composites (away from petroleum-based for instance) can reduce environmental impact while increasing smart manufacturing practices, such as recycling and repurposing materials, to achieve objectives for socio-ecological sustainability.

- **Industry 5.0 Resilience:**

In the Industry 4.0 paradigm, businesses have been forced to cope with increased uncertainties and adapt to cope with change. That’s why Industry 5.0 bolsters resilience for companies looking to balance man and machine. It’s important for organizations to engage in planning exercises that account for potential disruptions across the value chain, from the factory floor to the supplier network, to transportation channels, to regulatory and geopolitical changes that can promote the achievement of societal goals. Digital technologies and methodologies (simulations and AI-enhanced modelling) can help identify optimal alternative paths in the event of disruption, weighing different factors such as cost, substitution, quality, and logistical concerns into the mix. Start with identifying the greatest points of vulnerability (whether in process or supply chain), isolate the key inputs, and then formulate contingency planning for any disruptions. It's better to have a plan and not need it than be caught unprepared.

- **Industry 5.0 Strategy:**

The essential Industry 5.0 strategy is designed to ensure a framework for industry that combines competitiveness and sustainability, allowing industry to realize its potential as one of the pillars of transformation. It is a strategy focused on emphasizing the impact of alternative modes of (technology) governance for sustainability and resilience. An effective Industry 5.0 strategy empowers workers using digital devices, endorsing a human-centric approach to technology; builds transition pathways towards environmentally sustainable uses of technology; expands the remit of corporation's responsibility to their whole value chains; and, finally, introduces indicators that show, for each industrial ecosystem, the progress achieved on the path to well-being, resilience, and overall sustainability.

How to Prepare for Industry 5.0:

As we have discussed previously, the vision for **Industry 5.0 builds upon the technological and business principles of Industry 4.0 with a focus on three ESG-like tenets: Human Centricity, Resilience, and Sustainability.** With many businesses completely committed to adopting technology-enhanced processes and systems, **it's an ideal time to look ahead to the next generation of innovation.** Industry 5.0 can be rightly seen as an evolution, incorporating foundational elements of Industry 4.0 into a more broadly encompassing vision that delivers a wider range of benefits to a broader set of stakeholders. **In this final section of our Industry 5.0 series, we examine the future of Industry 5.0 and how organizations should prepare.**

Multiple Forces Are Driving Change:

It’s become axiomatic that change is a constant for firms across industries, and businesses need to plan how to ensure their value chains can weather disruptions and ensure that there is an ample, appropriately trained workforce sufficient to meet production, sales, and support demands. The “great resignation” wave, in which employees are leaving their jobs at record rates, along with difficulties in filling open roles underscores the value of talent management and particularly the need to attract and retain highly skilled workers. Increased trade protectionism, overwhelmed cargo chains along with shortages of key components and materials highlight the role of resilience. Greater focus on Environmental, Social, and Governance (ESG) factors from the investment community, regulatory emphasis on clean energy, and rising societal prioritization, are compelling organizations to articulate sustainable strategies. In short, multiple drivers are forcing forward-thinking firms to incorporate Industry 5.0 principles into their planning.

Positioning for the Future of Manufacturing:

The World Manufacturing Forum has identified 10 critical skills that will be needed in future manufacturing, and what's important is that the mix of skills includes both digital and technology as well as cross-functional skills that relate to creativity, flexibility, and open-minded thinking.

Key Enabling Technologies for Industry 5.0:

While Industry 4.0 relays on a broad set of mainly ICT technologies, Industry 5.0 will mainly depend on the "cognitive revolution" of such systems that will have to evolve from current narrow domain knowledge capabilities to much broader and context aware cognition. The automation pyramid (Figure 1) defined by ISA-95 [16] describes a model based on incremental complexity and abstraction from field level to business level. In general terms, Artificial Intelligence is being applied in activities where the goal can be clearly specified, and training data can be obtained.

For example: Level 0 Predictive maintenance [17]

Level 1 Soft sensors [18], computer vision for quality assessment [19], basic control loops overcoming PIDs limitations [20], etc.

Level 2 Multivariate controls, Model Predictive Control (MPC) systems [21] that command multiple Level 1 subsystems, optimizers.

Level 3 Work Order schedulers [22] and planning optimizers [23]

Level 4 Machine Learning based optimizers for logistics and supply chain management [24]. Financial risk estimation [25].

Next Cognitive Level:

According to Confucius' words: "By three methods we may learn wisdom: First, by reflection, which is the noblest; Second, by imitation, which is the easiest; and third by experience, which is the bitterest" [34]. Current state-of-the-art shows that while so ware based systems can be extremely powerful on learning from the third way (trial and error), human reflection capabilities are far from what machines will be able to do in a near future. The effective combination of these two capabilities, even if hard to achieve, is the most promising way to overcome the current limitations of Artificial Intelligence. Artificial Intelligence, fueled by Big-data availability and High Processing power (e.g., GPUs for Deep Learning) has experienced a dramatic success in many activities, outperforming humans' capabilities in specific tasks. However, this kind of success stories are always limited to narrow scope activities where the implicit information contained in data samples can be used for further inference [35]. Broader ways of thinking are still beyond the capabilities of machines, from both technological and methodological perspectives [36]. 3.2.

Augmented Intelligence:

It can be understood as the "synergistic technology of humans and computers" [37]. As stated in the IEEE Digital Reality whitepaper [38], "It's goal is to enhance human intelligence rather than operate independently of or outright replace it. It's designed to do so by improving human decision-making and, by extension, actions taken in response to improved decisions". However, even if the functional foundations of Augmented Intelligence are clearly defined, technical implementations are far from becoming a reality. Jain et al. [39] identify four basic problems that current Artificial Intelligence systems will have to solve to reach Augmented Intelligence capabilities: intuitive reasoning, causal modelling, memory and knowledge evolution. However, physical word aspects (crucial for robotics) are not considered by these authors. We propose a model where functional capabilities and technological requirements are combined to lead the technology towards the Augmented Intelligent concept that includes both virtual and physical aspects

Co-Working with Robots:

As humans have never effectively collaborated with robots, many questions arise in aspects such as ethical, psychological, societal, economical, regulatory, etc. [26]. From a technological perspective, the co-working with robots is still in its early stages. Hangout et al. [40] define three human-robot interaction (HRI) categories: • Human-Robot Coexistence: Capability of sharing the dynamic workspace between humans and robots without a common task. • Human-Robot Cooperation: Humans and robots are working on the same purpose and fulfill the requirements of time and space simultaneously. • Human-Robot Collaboration: Complex tasks with direct human interaction, either with explicit contact or human communication. The Human-Robot Collaboration level, will require very advanced aspects of natural language processing, cognitive perception, logical inference, human behavior interpretability, etc. Safety and efficiency will require a robust and detailed understanding of the surrounding environment (as in the case of Autonomous Driving). In general terms, the concept of robot can be extended to an Autonomous Agent. Autonomous Agents might be endowed with a body (robots, Cyber-Physical Systems–CPS) or might be virtual. In both cases, they will have to fluently interact with humans, sharing information and contributing to decisions

Sustainability:

The environmental impact of industrial activities is mainly regulated by laws created from global perspectives. Companies incorporate the regulation aspects and introduce them as constraints in their processes. The European Commission foresees that within the "context of climate crisis and planetary emergency" a new paradigm beyond Industry 4.0 is needed [12]. Vaio et al. [42] perform a systematic review of Artificial Intelligence business models in the sustainable development goals perspective, concluding that "To achieve high sustainability standards, it is necessary to improve the technical scientific quality of the production systems" through the implementation of Knowledge Management Systems (KMS) that share internal and external knowledge. This view, points at the need of a holistic

Augmented Intelligence that is able to provide the perspective of a global benefit and the most suitable trade-off between individual companies' objectives and general interests in terms of sustainability and environmental impact.

The development of such suprasystem will require a cultural drift together with regulatory adjustments that support the inclusion of general interest metrics in individual business KPIs. Not less important, the effective management of all the Big-data and associated multiple industrial activities will require a cognitive level that is not available in the current state of the art.

Conclusions:

Whether Industry 5.0 will solve or mitigate big societal and environmental problems will be conditioned by two main factors: 1) a change in the socio-cultural and business mindset and 2) a big step forward in the cognitive capabilities of decision-making processes. We have addressed this second condition to conclude that the next cognitive revolution will not rely exclusively on artificial intelligence. Instead, the synergy between humans and machines will be the key to deal with the challenges that big data based broad reasoning will present. While humans will have to learn to collaborate in such way, the big scientific and technological gap between artificial and augmented intelligence is due to the weakness of current AI systems in perception, natural language communication, mathematical & conceptual reasoning, and data interpretability (Figure 3). A roadmap towards Industry 5.0 should look for the excellence in these aspects.

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