ISSN: 0974-5823 Vol. 7 No. 5 May, 2022

*International Journal of Mechanical Engineering*

# The Fourth Industrial Revolution and the Sustainability of the Asian Steel Sector

**Mahesh Babu Pasupuleti**

*Data Analyst, iMINDS Technology Systems, Inc., 1145 Bower Hill Rd, Pittsburgh, PA 15243, USA*

**Abstract**

This article discusses the background of digitalization as well as some essential themes in the Asian iron and steel sector. It is a case study of steel enterprises that operate across the broader Asian region. Digitalization is a fundamental process that began several decades ago, but which acquired a considerable acceleration by Industry 4.0 and now directly affects all process and industrial industries. This acceleration was made possible by the introduction of the Internet of Things (IoT). It is hoped that this will help Asian businesses to increase both the efficiency of their manufacturing and the sustainability of their operations. Particularly in energy-intensive industries, such as the steel industry, digitalization refers to the application of related technologies to the production processes. This application focuses on two primary, frequently overlapping directions: sophisticated tools for the optimization of the production chain and specific technologies for low-carbon and sustainable production. In addition, the rapid advancement of technology in the steel sector necessitates the ongoing improvement of workers' skill sets in order for the industry to maintain its competitive edge. Along with the projected alterations to the economy, this article examines the impact that digitization will have on the workforce in the steel industry.

**Keywords:** Digital Transformation, Industry 4.0, Steel Sector, Asian Region, Sustainability

## Introduction

In recent decades, the Asian steel sector has changed dramatically. This sector has developed complicated production processes and items due to reorganization and consolidation. The workforce has diminished and changed professionally due to these changes. Digital transformation and Industry 4.0 have reduced time-consuming physical procedures while raising need for qualified people (Dan et al., 2021). Recruitment and job organization have changed. To remain competitive, the steel industry needs a highly qualified, specialized, multi-skilled workforce. Despite skills shortages, recruitment problems, and talent management obstacles, skill gaps must be identified and projected. "Digitalization" refers to transforming communication interactions, business operations, and business models into digital ones (Schumacher et al., 2016). Digitalization uses "digital technology" and digitized and natively digital data to produce income, improve company, replace/transform business processes, and create a digital corporate environment. Companies are embracing digital technologies across all divisions due to "digitalization". "Automation" may refer to "the way through which a process or activity is completed without human help" (Adusumalli, 2016).

Industry 4.0 includes interoperability, decentralization, real-time data collecting, and increased flexibility. First industrial revolution automated previously laborious operations. This habitat was automated by steam and water. During the second industrial revolution, manufacturing used electricity. Simultaneously, the manufacturing sector was formed, transportation technology evolved, and steel industry operations were electrified. IT and computer technologies made the third industrial revolution possible, but human participation was important. The major components are integrating robots into formerly human-only operations, optimizing productivity, and removing industrial bottlenecks. Modern manufacturing is in its fourth industrial revolution, based on integrated process technology. "Industry 4.0" was introduced in 2014 as part of Germany's High Tech 2020 Strategy (Adusumalli, 2018). In "Industry 4.0," machines work autonomously without human interference. Cyber Physical Systems are used to improve automation and connectivity. Cyber Physical Systems are computerized physical systems that can communicate, act, and be independently controlled (CPS). Real-time sensors can communicate data to a local or remote server to exchange information, such as by constructing predictive models. The IIOT can evaluate the data. The ultimate goals include quality control across the entire production chain, early identification and forecasting of anomalous processes, and predicting the remaining lifespan of essential components using sensor-captured data (usually Big Data) (according to the paradigm of Predictive Maintenance).

Effective recruiting and upskilling programs are built, marketed, and training tools for knowledge management, talent development, and recruitment issues are established. The Asian industry is integrating digitization into its manufacturing and organizational processes to become more competitive. Digital technology allows new procedures to be implemented across the entire value chain, from manufacturing to sales to services and everything in between. Digitalization refers to a complete plan that includes all sectors and operations for evaluating a company's value chain and capitalizing on digital possibilities. Digitization is much more than turning "analog" data and documents to digital form. Integrating data interchange and management, creating efficient interfaces, and linking corporate processes are more important (Paruchuri et al., 2021).

Digital transformation is crucial in the present industrial revolution (Adusumalli, 2016a). New sensors, Big Data, Machine Learning, AI, the Internet of Things, the Internet of Services, Mechatronics and Advanced Robotics, Cloud Computing, Cybersecurity, additive manufacturing, digital twin, and machine-to-machine (M2M) communication are Key Enabling Technologies. Digital technologies can be utilized to build a new plant or retrofit old ones (Ustundag & Cevikcan, 2017). ICT technologies allow Industry 4.0's essential qualities (real-time, interoperability, horizontal and vertical integration of industrial systems) to solve challenges. Flexible production requires flexible work, which can be done through education and lifelong learning programs. Flexibility is key. Industry 4.0 intelligently networks machines, electrical equipment, and IT systems to boost efficiency and optimize processes throughout value creation chains. The company's strategy to usher in a new era of technology based on embedded production system technologies and intelligent manufacturing. Recently, three different Industry 4.0 production methods were outlined (Thomas, 2018).

Smart manufacturing uses current manufacturing technologies and information to optimize the production process. IoT-enabled manufacturing uses smart manufacturing devices in the second environment (Khan et al., 2021). Third, cloud manufacturing. Creating intelligent systems demands interconnected manufacturing systems. Digital technology may boost corporate efficiency and productivity, opening new markets, but numerous significant future qualities have been highlighted. To fulfill industrial needs, workers' skills must adapt. As well as hiring new workers, this includes retraining existing employees in science and technology. This transdisciplinary method includes continuous learning. When that happens, we'll have an adaptive, future workforce that helps businesses compete better and has more labor market "appeal." Redesigning work processes aims to decrease skills mismatches and safeguard workers' future employment (Pasupuleti & Adusumalli, 2021). New digital technology may increase employee safety, energy efficiency, and CO2 usage, resulting to cost savings. More creative and individualized products may be created as a result as well. With digital technology, Asian manufacturers can access new global markets. The Asian manufacturing sector is shifting toward a more flexible, customer-specific framework. Integration, digitization, speed, flexibility, quality, efficiency, and security will help maintain the sector competitive in the global economy.

## Digitalization: An ERA in the Asian Steel Industry

Due to the intricacy of steel manufacture, new technologies may optimize production. The digitalization of steel manufacturing may integrate process automation, IT, and networking. Intelligent integration of plant and lab trials, physical model, and computational model will be key in the digitalization of the steel sector. Recent advancements include modeling steel continuous casting. Many linked phenomena make model verification and validation crucial. To be confidence in modeling studies' projections and improvements, each model element must be validated with known solutions and confirmed using measurements (Adusumalli, 2019). Digitization may increase steel industry quality, flexibility, and efficiency while delivering real-time operational data and information for better and faster decision-making across the value chain. In recent years, the steel sector has embraced digital technology. Decentralized, unmanned autonomous component assembly is difficult and expensive in continuous steel production (Miah et al., 2021).

The steel industry aspires to progress continually in all of these areas by adopting digital technologies in some manufacturing processes, such as Energy Management or Water and Wastewater Management. Digital technology help adapt and integrate new steel manufacturing procedures. A model and forecast of gas usage to reduce erroneously purchased and delivered gas may be provided. This topic was studied using linear regression and genetic programming. Legacy equipment, employment instability, and data protection/safety are the Asian steel sector's biggest issues as it moves to Industry 4.0. Recent research found that organizational impediments are more relevant than technological ones. Industry 4.0 initiatives are driven by corporate management, not technology or manufacturing. Increasing use of digital technology, a lack of relevant educational programs, and delays in training following a technical breakthrough may cause a shortage of qualified individuals. Senior personnel may find it difficult to integrate new technologies and practices. The age gap between current and new hires hinders knowledge transmission. The steelmaking sector doesn't invest enough in training and education and doesn't offer enough in-house training.

## Digitalization in the Asian Steel Sector: Case Studies

The Asian steel industry is currently facing challenges on multiple fronts, including cost pressure, regulatory limits, and quality and service standards. As a direct consequence of this, it has spent the better part of the last few decades actively participating in a variety of legislative initiatives, research and development programs, and patent applications linked to digitalization. Other projects connected to Industry 4.0 include the Smart Factory Working Group on the POSCO Platform. This group recently published the first version of a Roadmap for Asian Steel Manufacturing. This roadmap involves a larger variety of stakeholders, such as plant manufacturers and R&D institutes.

### POSCO

The following are examples of various enabling technologies, as outlined in the use cases developed by POSCO's Smart Group:

The Internet of Things (IoT) is a network that consists of gadgets that are connected to one another. An interconnected environment in which electronic sensors, actuators, and other digital things are networked and linked for the purpose of data collection and exchange is referred to as the Internet of Things (IoT). This is a word that describes a world that is interconnected (Pasupuleti et al., 2019). An online monitoring system that is built on an Internet of Things system architecture should have four layers, as stated by Chisty & Adusumalli (2022). These layers are the sensor, network, service resource, and application layers. On an actual continuous steel casting manufacturing line that was connected to the Team Center platform, a system that is similar to the one that is being proposed has been constructed and tested.

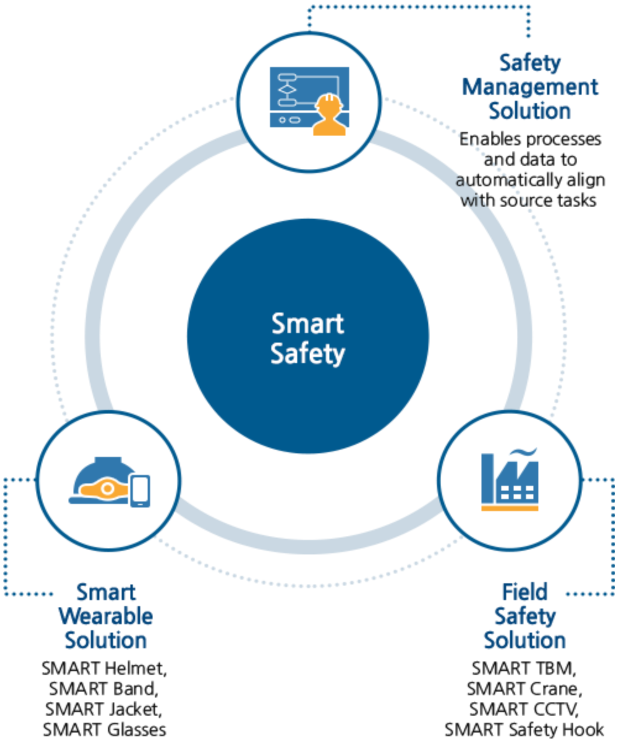


Figure 1: Smart Safety solutions provide corporate applications, tailored services, and AI-Big Data analysis to prevent industrial accidents. (Source: https://www.poscoict.com/)

**Manufacturing with the assistance of robots:** For the purpose of carrying out activities such as assembling and packing, this technology makes use of humanoid robots. Because of the growing demand for improved product quality, faster delivery times, and lower overall costs, automation and the use of robots have become increasingly important in the industrial sector over the course of the last few decades. For instance, the surface quality of steel products may be increased if the current technologies used in the steelmaking plant are modernized with robotics and automation.

**Simulation of manufacturing assembly lines:** Methods for the modeling and optimization of processes have been developed in the steel industry. The development of decision support systems has as its primary objective the exploration of potential alterations to the design and functioning of the system. In addition to that, innovative numerical methodologies have been applied, such as meshless methods in the modeling systems for the steel sector.


Figure 2: The Gwangyang POSCO Smart factory

**Production That Takes Care of Itself:** This method comprises the use of automated coordination of machines, which leads to the most effective use and production of the aforementioned machinery. Decentralized rather than centralized approaches are typically associated with self-organizing industrial systems. Real-time management of production networks is achieved as a result of the incorporation of a new combination of resources, equipment, and people, as well as a rise in the level of automation.

**Big Data and Cloud Analytics:** Traditional database systems may have trouble acquiring, storing, organizing, and analyzing organized and unstructured data in the steel business. Big data analytics analyzes historical data to find quality concerns and reduce product failures. Big-data technologies are used to monitor and improve steel quality. This technology uses unique processing approaches to extract relevant information from diverse data types, understand them, and make discoveries that enable correct decision making. Using live manufacturing line data, surface defects on steel slabs may be accurately predicted, allowing for real-time process modifications and defect reduction. Normal and faulty samples are typically unbalanced. Je-ho (2016) suggested a one-class Support Vector Machine (SVM) classifier to forecast failures in steel slabs using online process data and environmental variables for normal cases. Machine learning-based methods can help extract useful information and expertise from existing data, allowing the building of data-driven models for a number of applications, including material attributes prediction and product fault detection and diagnosis (McKinsey, 2016). Cloud computing offers on-demand services in a dispersed, reliable, scalable environment. This technology handles anything as a service, including SaaS, PaaS, and IaaS. (McKinsey, 2016).

**CPS:** It is a term used to describe a type of system that combines computing, networking, and physical processes. The monitoring and control of physical processes by embedded computers and networks, which also act as regulators, creates feedback loops in which the physical processes influence the computations and vice versa.

**Intelligent network of supply:** It is possible to make supply decisions that are better informed when the entire supply chain is being monitored. When creating a supply chain for the steel industry, it is necessary to take a wide variety of factors and objectives into consideration. Smart supply networks enhance the manufacturing processes of steelworks by introducing models into the integrated supply chain. This helps improve the manufacturing processes from start to end.

**Vertical/Horizontal Integration:** The process of integrating a resource network and an information network within the framework of a value chain is referred to as horizontal integration. In the intelligent factories of the future, vertical integration will be coupled with networked production systems as well as manufacturing that is customized for individual customers (Je-ho, 2016).

**Work, Maintenance, and Service that Benefit from Augmentation:** The implementation of augmented reality is the focus of the fourth dimension, which prioritizes documentation, remote assistance, and operational counsel. This is one of the most fascinating enabler technologies for organizations, particularly for improving the efficiency of maintenance services. For instance, a service professional who is virtually linked may carry out maintenance over the internet. This results in lower costs associated with travel, time savings, and a quicker response to any issues that may arise.

**Vehicles for the supply chain that drive themselves:** This technology is fully dependent on various forms of automated public transit. Businesses are able to optimize their processes and move them along more quickly when they employ intelligent software to aid with their intralogistics activities. In a steelworks, the supply and disposal of raw materials and intermediate products, the removal of completed goods, and the management of byproducts such as bulk material and slag are all extremely important tasks. Through the utilization of an intelligent transport control system, one is able to organize and manage internal transport orders, which ultimately results in enhanced levels of production and service while simultaneously reducing costs.

**Maintenance that is predicted:** Through remote monitoring, it is possible to replace broken equipment before it completely fails. The predictive maintenance strategies are put into action by combining monitoring of the equipment with sophisticated decision-making procedures. Machine learning and data mining are two techniques that may be used to gain insights from data and accurately predict outcomes. These techniques can help in decision-making, which in turn can help steel companies become more competitive.

**Cybersecurity:** It is important to take into consideration the use of this form of technology, particularly for internet-based applications. The use case of cloud-based production monitoring is used to illustrate a procedural methodology for conducting a cyber-security analysis based on the Industry 4.0 reference architectural model and the VDI/VDE guideline 2182. This methodology shows how to do the analysis.

The administration of knowledge is moving toward a more digital format. The steel sector has acknowledged the need to overcome significant challenges presented by digitization in order to remain competitive in an increasingly cutthroat market. Even though we have already started this process, there is yet room for further development. When it comes to this subject matter, the skills and experience of the technical team serve as the basis for these enhancements. The wide distribution of this knowledge and experience among staff members, human ignorance, and the loss of institutional knowledge as a result of employee turnover are the key challenges to putting this information to use.

**Hyundai Steel Co.**

Smart factory execution includes big data-driven iron scrap management. Iron scrap is used in electric furnaces, one of the first steelmaking processes. Electric furnace operation uses high-temperature arc heat and iron wastes created by electrode current. In the past, different grades of iron scrap were inevitably intermingled. Therefore, it was hard to determine the grade and amount of iron scraps used. The company updated the electric furnace with big data. The company put a lightweight in the raw material storage, separated iron scraps by grade, and displayed them on an electronic map. They also installed a laser sensor on the crane transporting the iron scrap so its location may be displayed in real time. All iron scrap grades and information are immediately recorded into the computerized map and aggregated as data. Big data makes it feasible to estimate and assess the amount of iron scraps needed based on quality. The corporation reduced superfluous iron scrap input in the short term and improved its entire operation process by predicting future product quality.

Since 2017, Hyundai Steel has been working to modernize its smart factory by incorporating artificial intelligence (AI) and large amounts of data into its efforts to enhance the manufacturing process and technology of steel mills. The year 2019 marked the beginning of the company's acceleration of new management practices by arguing for the construction of a more advanced "smart enterprise." Enterprise-Wide-Smartization. The term "smart enterprise" refers to a business model that not only involves the production of goods but also the development of "smart management" across all aspects of the production process, including the systems and the infrastructure. In order to accomplish this, the company set up a separate department that is specifically devoted to smart factory technology. This department reports directly to the R&D and quality headquarters and is in charge of smart management in all of the company's processes, systems, and infrastructure.

Recognizing that human resource development is vital for digital transformation, the corporation wants to expand IT training to all departments and train AI experts in advanced statistics and machine learning. This strategy includes the "Digital Transform Academy." Digitalization's economic impact: Worldwide demand stagnation, oversupply, rising country technological development, and domestic and global environmental rules threaten steel sector competitiveness. The World Steel Association predicts 1% annual growth in global steel demand. China and India have grown high-tech facilities competitively, causing global oversupply.

Since the 2008-2009 global financial crisis, the steel industry, the backbone of the European economy, has lost tens of millions of tons of demand. This reduced demand from 188 million tons (average 2004-2008) to 155 million tons (average between 2011 and 2019). COVID-19's structure has deteriorated after 2020. In 2020, the steel margin touched a record low of 180 euros during the COVID-19 outbreak. The margin reached 380 euros from 2020 to 2021 as supply and demand imbalanced. In 2020, European steel industry utilization declined to 63%. In three years, the utilization rate should reach 70-75%. Experts foresee continued volatility and uncertainty in the steel business. This is owing to China's enormous steel market, changing demand from operating rate adjustments, raw material price volatility, and currency volatility.

Korea has expanded around exports by creating a super-large blast furnace-centered steel manufacturing system, but blast furnaces release enormous volumes of carbon dioxide, raising worries over sustainability in the era of carbon neutrality. Digital transformation is a core of competitiveness and a breakthrough in the steel industry's challenge, which includes climate change and a skilled worker shortage. Korea's Ministry of Trade, Sector, and Energy outlined the digital transformation of the steel industry. First, optimal efficiency is achieved by shifting the manufacturing process from operator-sensitive to data-driven. Second, digital transformation can strengthen the steel ecosystem's raw material and lower process sectors. Small and medium-sized businesses that improve efficiency, quality, and added value will grow. Digital transformation can improve steel industry safety and the environment. Digital technology monitors and cautions workers' risks in real time, and steel manufacturing emissions may be reliably measured and controlled.

## What lies ahead for the stainless steel industry in terms of digitalization?

Digital data acquisition, processing, and analysis can help forecast process behavior and make decisions. IoT and increased data collection and storage form a network of interconnected devices. Modern analytical tools can pre-process data more rapidly and fully with access to more data sources. Real-time data allows monitoring of the steelmaking process and completed product. Using sensors allows for easy tracing and eradication of errors and faults during manufacturing. This may improve production efficiency. Data accessibility and machine learning (ML) can improve equipment maintenance by predicting and completing work before problems arise.

Self-operating systems are created by combining traditional technologies with AI and ML. Automation applications will reduce error rates, improve speed, and save operational costs (Adusumalli et al., 2022). Automations. Steel production and use should be more mechanized. Interconnecting systems overcomes lack of transparency, improving process efficiency. Machine-to-machine (M2M) connections enhance industrial plant use by integrating manufacturing systems. Improved connectivity and data exchange can help steelmaking processes with remote sites and extended supply networks. Market changes and harmful working conditions may be rectified.

Digital customer access allows organizations direct mobile internet connection to their customers, providing transparency and innovative offerings. Digital data availability, automation of production processes, connectedness of value chains, and development of digital consumer interfaces allow industry restructures and business model changes. Steelmakers may be better able to engage with suppliers and consumers.

### *Digitalization's workforce effects*

Industrial 4.0's adjustments to industrial structures include strategic workforce planning, proper organization structure, alliance building, and technology standardization. From human labor-centered production to fully automated employment and monotonous, physically exhausting activities to creative ones (Thomas, 2018). Positive advances are feasible, but so are negative ones, including greater unemployment and de-skilling.

The digital economy requires reskilling current workers and training new personnel to meet future expectations. Employers may benefit from training programs centered on digital and business issues. Lifelong learning in digital skills can help businesses succeed through continuous training. Talents mismatches occur when supply doesn't meet demand for a particular set of skills, halting economic progress and reducing job and income opportunities (Pasupuleti & Adusumalli, 2018). Companies, like those in the steel sector, want versatile individuals with a variety of talents rather than highly specialized ones. Businesses need individuals with transferable skills who can be flexible and work across divisions. Businesses need employees who can switch tasks and intervene in numerous areas. Due to job insecurity, employees may benefit from cross-functional skills. Digitalization can offer new adaptable skills and people who can quickly grasp new digital technologies in industry, notwithstanding the loss of 40,000 jobs due to restructuring in recent years. Cognitive sciences combine awareness, knowledge, and cutting-edge control algorithms to help (Je-ho, 2016). Industry 4.0 will prioritize ICT over fundamental competencies. Hybrid OS personnel need soft skills including teamwork, communication, and autonomy. Employees should adapt to transdisciplinary learning perspectives. New engineering standards require students to collaborate across disciplines and obtain business-relevant knowledge and skills. Integrated engineering curriculum may bridge the gap between academics and industry. Mechatronic engineering, industrial engineering, and computer science rely extensively on transdisciplinary teams, tasks, and thinking for Industry 4.0.

### *Digitalization's economic impact*

Digital economy may provide steel firms new opportunities. To develop and build new business models, you must understand how digitalization is changing competition. Slowing global economic momentum and decreasing net trade contribution caused the EU economy's fall in 2018, which is anticipated to continue into the first half of 2019. Creating a digital economy demands EU-wide coordination and cooperation. In this sense, establishing agreed European standards and exchanging ideas, information, and experiences are key. A connected economy demands robust infrastructure to link plant and equipment extensively and securely. The Asian manufacturing sector's digital shift must be accomplished quickly to boost competitiveness and restrict new competitor activities. Raw material costs are more important than transformation costs. Manufacturing applications include real-time supply chain optimization, human-robot cooperation, smart energy utilization, digital performance management, and predictive maintenance. Digital technologies and machine learning may help reduce costly unplanned shutdowns in the metals business.

## Conclusion

Even if steel production is partially automated, it may be optimized. The steel industry will be more prepared for Industry 4.0. Digitizing processes through online adjustment and optimization increases process flexibility and reliability, production, product quality, and maintenance practices. They also boost energy efficiency while monitoring and adjusting environmental performance. This review paper's findings reveal that the key challenge of digitalization is integrating all systems and production units along three dimensions: vertically (from the sensor to the ERP system), horizontally (across the entire production chain), and life-cycle-integration (across the entire plant's lifecycle from construction to decommissioning) (based on the decisions taken during the steel production chain, taking into account technological, economic, and environmental aspects). Digitalization requires multidisciplinary teams, tasks, and thinking to deliver interdisciplinary skills. New IT, automation, and optimization technologies may help. Predictive Maintenance can be implemented through equipment monitoring and smart decision making. ML-based data mining algorithms can be used to forecast and schedule maintenance. Knowledge Management is important for digitalization advancement. Individual manufacturing unit optimization and chain-wide interactions are steel's digitalization goals (and beyond). This improves quality, flexibility, and productivity. Future digitalization applications will include those below. Adaptive online control includes continuous improvement, data synchronization, zero-defect production, traceability, and intelligent and integrated manufacturing.

The steel sector will face several hurdles in the next years to successfully integrate digitalization, such as standardizing systems and protocols, better managing the workplace, employing more trained personnel, and investing in research to develop acceptable frameworks. Digitization should boost industry and economic output. New technology may cause job losses in the industrial industry but also help workers get higher qualifications. Many factors will induce medium-term changes. The industrial workforce will be affected. For long-term viability, the steel sector must operate within legal boundaries. Rising energy consumption and the need to implement low-carbon energy systems push the steel sector to use digital technology to deal with environmental regulations. In a few years, metals and mining should remove all waste and pollution while using half as many resources. Digital technology may improve sustainability performance, create processes to account for industrial sustainability needs and potential, and test new business models. Adopting high-performance components, machines, and robotics will optimize materials and energy utilization and lead to a circular economy. Non-technical elements such as European, national, and regional framework conditions, market and customers, human resources, skills, and the labor market must to be considered for digital transformation to succeed. These are in the revised SPIRE Roadmap 2050. Human resources and fresh skills are key to unlocking innovative ideas in firms.

## References


1. Adusumalli, H. P. (2016). Digitization in Production: A Timely Opportunity. *Engineering International*, *4*(2), 73-78. https://doi.org/10.18034/ei.v4i2.595
2. Adusumalli, H. P. (2016a). How Big Data is Driving Digital Transformation?. *ABC Journal of Advanced Research*, *5*(2), 131-138. https://doi.org/10.18034/abcjar.v5i2.616
3. Adusumalli, H. P. (2018). Digitization in Agriculture: A Timely Challenge for Ecological Perspectives. *Asia Pacific Journal of Energy and Environment*, *5*(2), 97-102. https://doi.org/10.18034/apjee.v5i2.619
4. Adusumalli, H. P. (2019). Expansion of Machine Learning Employment in Engineering Learning: A Review of Selected Literature. *International Journal of Reciprocal Symmetry and Physical Sciences*, *6*, 15–19. Retrieved from https://upright.pub/index.php/ijrsps/article/view/65
5. Adusumalli, H.P., Ali Chisty, N.M., Rahman, M., Hossain, S., & Pasupuleti, M.B. (2022). Bio-innovation and technological digitization of mushroom cultivation and marketing for rural development. *Academy of Marketing Studies Journal*, *26*(S3), 1-7.
6. Chisty, N. M. A., & Adusumalli, H. P. (2022). Applications of Artificial Intelligence in Quality Assurance and Assurance of Productivity. *ABC Journal of Advanced Research*, *11*(1), 23-32. https://doi.org/10.18034/abcjar.v11i1.625
7. Dan, Y., Ahmed, A.A.A., Chupradit, S., Chupradit, P.W., Nassani, A.A. and Haffar, M. (2021). The Nexus between the Big Five Personality Traits Model of the Digital Economy and Blockchain Technology Influencing Organization Psychology. Frontiers in Psychology, 12(780527), 1-12. https://doi.org/10.3389/fpsyg.2021.780527
8. Je-ho, C. (2016). The fourth industrial revolution: The winds of change are blowing in the steel industry. *Asian Steel Watch*, 2, 6–15.
9. Khan, W., Ahmed, A. A. A., Vadlamudi, S., Paruchuri, H., Ganapathy, A. (2021). Machine Moderators in Content Management System Details: Essentials for IoT Entrepreneurs. Academy of Entrepreneurship Journa, 27(3), 1-11. https://doi.org/10.5281/zenodo.4972587
10. McKinsey. (2016). Industry 4.0 after the Initial Hype: Where Manufacturers are Finding Value and How They Can Best Capture It.
11. Miah, M. S., Pasupuleti, M. B., & Adusumalli, H. P. (2021). The Nexus between the Machine Learning Techniques and Software Project Estimation. *Global Disclosure of Economics and Business*, *10*(1), 37-44. https://doi.org/10.18034/gdeb.v10i1.627
12. Paruchuri, H.; Vadlamudi, S.; Ahmed, A. A. A.; Eid, W.; Donepudi, P. K. (2021). Product Reviews Sentiment Analysis using Machine Learning: A Systematic Literature Review. Turkish Journal of Physiotherapy and Rehabilitation, 23(2), 2362-2368. https://doi.org/10.5281/zenodo.5534344
13. Pasupuleti, M. B., & Adusumalli, H. P. (2018). Digital Transformation of the High-Technology Manufacturing: An Overview of Main Blockades. *American Journal of Trade and Policy*, *5*(3), 139-142. https://doi.org/10.18034/ajtp.v5i3.599
14. Pasupuleti, M. B., & Adusumalli, H. P. (2021). The Reputation of Machine Learning in Wireless Sensor Networks and Vehicular Ad Hoc Networks. *Asian Business Review*, *11*(3), 119-124. https://doi.org/10.18034/abr.v11i3.603
15. Pasupuleti, M. B., Miah, M. S., & Adusumalli, H. P. (2019). IoT for Future Technology Augmentation: A Radical Approach. *Engineering International*, *7*(2), 105-116. https://doi.org/10.18034/ei.v7i2.601
16. Schumacher, A.; Sihn, W.; Erol, S. (2016). In Automation, Digitization and Digitalization and Their Implications for Manufacturing Processes. In Proceedings of the International Scientific Conference on Innovation and Sustainability, Bucharest, Romania, 28–29 October 2016; pp. 1–6.
17. Thomas, B. G. (2018). Review on modeling and simulation of continuous casting. *Steel Res. Int.*, 89, 1700312.
18. Ustundag, A.; Cevikcan, E. (2017). Industry 4.0: Managing the Digital Transformation. *Springer*: Berlin, Germany.