EMPOWERING SMALL AND MEDIUM-SIZED ENTERPRISES (SMES) THROUGH INDUSTRY 5.0: A FOCUS ON HUMAN-MACHINE COLLABORATION AND ADVANCED TECHNOLOGIES

Ratna Tri Hardaningtyas[1], Uswatul Tirania Choirul Nissa[2]

[1]Universitas Islam Malang
[2] Universiti tun Hussein Onn Malaysia
) ratnatyas@unisma.ac.id

ABSTRACT

Industry 5.0, also known as "Human-Centred Industry," represents an industrial evolution focusing on collaboration between humans and machines. The concept aims to create more sustainable, resilient, and human-centered production processes. In this context, SMEs play an essential role, and several initiatives, such as SURE5.0 and EIT Manufacturing, are dedicated to supporting SMEs in adopting Industry 5.0. Although SMEs' adoption of automation technologies, especially in the United States, tends to be slower, there is an increasing emphasis on leveraging advanced analytics and human-centric digitalization to increase the flexibility and adaptability of production processes at the SME level. Industry 5.0 brings various enabling technologies, such as big data, the Internet of Things (IoT), cloud computing, 6G networks, and Blockchain, which can empower SMEs to improve their performance and competitiveness. As such, Industry 5.0 offers great potential for SMEs to improve their efficiency, innovation, and sustainability through closer human-and-machine collaboration.

The result of this study states that the concept of Industry 5.0 is a collaboration between humans and machines to improve industrial production efficiency by utilizing advanced technologies such as big data, IoT, cloud computing, 6G networks, and Blockchain. In addition, initiatives such as SURE5.0 from EIT Manufacturing specifically aim to support SMEs in transitioning to Industry 5.0. The adoption of Industry 5.0 by SMEs in the United States and the role of advanced analytics technologies in increasing the flexibility and adaptability of SME production processes have also been the focus of attention in several articles. Thus, Industry 5.0 offers great potential for SMEs to improve their efficiency, innovation, and sustainability through closer human-and-machine collaboration.

Keywords: **Industry 5.0, SMEs, humans, machine**

INTRODUCTION

The arrival of Industry 5.0, also known as the "Human-Centred Industry," signifies a significant and revolutionary change in the industrial environment. This paradigm shift goes beyond conventional approaches to industrial processes and emphasises the critical need of promoting human-machine collaboration. Industry 5.0, in contrast to its predecessors, is a comprehensive approach aimed at creating manufacturing processes that are not just technologically advanced but also resilient, sustainable, and fundamentally human-centered.

Small and medium-sized enterprises (SMEs) become key players in this developing framework, playing a crucial part in the implementation of Industry 5.0's tenets. Programmes like SURE5.0 and EIT Manufacturing are examples of the coordinated efforts to help and encourage SMEs in their transforming path. These programmes are committed to making sure that the advantages of Industry 5.0 are reachable and usable at the SME level, taking into account the particular possibilities and problems that SMEs encounter.

There is a noticeable increase in the use of advanced analytics and people-centered digitalization initiatives, despite the fact that small and medium-sized enterprises, particularly in the US, appear to be adopting automation technology more slowly. This is a purposeful trend away from traditional industrial methods and towards techniques that emphasise the complex interactions between human knowledge and technical capacities. The goal of improving production processes' flexibility and adaptability to the unique requirements and dynamics of small and medium-sized enterprises (SMEs) is at the centre of this paradigm shift.

Industry 5.0 introduces a wide range of enabling technologies that have the potential to drastically alter the way small and medium-sized enterprises operate. It is more than just a conceptual framework. Big data, the Internet of Things (IoT), cloud computing, 6G networks, and blockchain all work together to give SMEs the tools they need to overcome current obstacles and improve their performance and competitiveness. When used wisely, these technologies enable SMEs to chart a course towards increased productivity, creativity, and sustainability.

Industry 5.0's real potential is found in its ability to guide SMEs into a new era characterised by harmonious human-machine collaboration. Beyond simple technical integration, this alliance envisions a symbiotic relationship where technological power amplifies human brilliance. With the adoption of Industry 5.0, small and medium-sized enterprises (SMEs) are in a strong position to not only adjust to the changing industrial environment, but also prosper, ushering in a period of increased productivity, increased

innovation, and unwavering sustainability. For small and medium-sized enterprises (SMEs), Industry 5.0 essentially signals the beginning of a revolutionary journey that will see human-machine collaboration become a success factor rather than merely a tactic.

THEORETICAL BASIS

The theoretical basis of Industry 5.0 draws its strength from the collaborative synergy envisioned between humans and machines, representing a departure from traditional industrial models. At its core, Industry 5.0 is founded on the strategic integration of cutting-edge technologies, including big data, the Internet of Things (IoT), cloud computing, 6G networks, and blockchain, with the overarching goal of optimizing industrial production efficiency. Terhadap UMKM melalui closer human and machine collaboration.

Industry 5.0:

Industry 5.0 is an industrial paradigm that acknowledges the importance of collaboration between humans and machines to enhance the performance of industrial processes. This includes the application of advanced technologies to achieve optimal results.

a. Big Data

(Gartner): the larger volume of data, faster data collection speed, and more complex data variation. It requires innovative data processing solutions and customization to address these challenges. (Doug Laney, researcher at Gartner): Big data is defined by three dimensions, namely volume (a large amount of data), velocity (data growth rate), and variety (various types of data). (McKinsey Global Institute) Big Data is a set of technologies, techniques, and policies that enable companies and governments to generate added value from very large or complex data. (Oracle) Big Data is data in very large volume and at high speed that requires new ways to be processed and analyzed to gain insights, pattern recognition, and better decisions."

b. Internet of Things (IoT)

Internet of Things (IoT) is a concept in which physical objects or devices around us are connected and can exchange data over the internet. According to experts, IoT is defined as a network consisting of physical objects equipped with technology to collect and exchange data. Kevin Ashton, one of the pioneers of the IoT concept, articulates it as the ability of objects to collect and exchange data without requiring direct human interaction. McKinsey & Company defines IoT as a network of interconnected devices that communicate to generate data that can provide deeper

insights, enabling better decision-making. Gartner emphasizes that IoT involves broad connections between devices, people, and processes to enhance efficiency and provide added value. Therefore, IoT can be considered a concept in which devices around us can communicate and share information through the internet, unlocking potential for various innovative applications and solutions.

c. Cloud Computing

Cloud Computing is a technological paradigm that enables flexible and scalable access to computing resources over the internet. According to experts, Cloud Computing is defined as a computing model that provides convenient, on-demand network access to a shared pool of configurable computing resources (such as networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

As per the National Institute of Standards and Technology (NIST), Cloud Computing has key characteristics, including on-demand network access, self-configurable resources, measured services, and broad access via standard mechanisms. Technology experts Peter Mell and Timothy Grance interpret Cloud Computing as a model that allows convenient, on-demand network access to a shared pool of configurable resources (such as networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Thus, Cloud Computing provides the capability to deliver computing resources elastically according to needs, without the need to own or directly manage physical infrastructure. This paradigm has brought significant changes to how organizations provide and use IT services.

d. 6G

At the time of my last knowledge update in January 2023, official specifications and definitions for Internet 6G might not have been fully formed. However, early estimates and insights from experts suggest that Internet 6G will be an advanced evolution of 5G technology with significant improvements in speed, latency, and network capacity.

Some anticipated concepts and features for Internet 6G include higher data speeds, ultra-low latency, improved network availability, closer integration with artificial intelligence, as well as stronger support for the Internet of Things (IoT) and expanded connectivity.

For more detailed and up-to-date definitions, it is recommended to refer to scholarly literature and resources published by telecommunication standardization bodies or technology research institutions. Always check the latest literature as definitions and concepts may evolve over time.

e. Blockchain

Blockchain is a data security technology based on the concept of an encrypted chain of blocks. According to experts, blockchain can be defined as a decentralized, transparent, and secure data storage and recording system.

One common definition is that blockchain is a distributed digital ledger that permanently records transactions. Each block in the chain stores a series of transactions, and each block is linked to the others using cryptography. Data stored in the blockchain cannot be easily altered or manipulated because any changes require the majority approval of the network.

In general, blockchain creates a trustworthy system where transactions can be conducted without the need for a central authority or intermediary. This makes it highly relevant for various applications, including finance, supply chain, healthcare, and others.

Influencing Factors:

Advanced Technology: The availability of advanced technologies such as big data, IoT, and artificial intelligence provides the foundation for creating effective collaboration between humans and machines. Human Expertise: Human abilities in creative thinking, making complex decisions, and adapting are determining factors in establishing harmonious collaboration.

System Design:

Designing a system that facilitates seamless interaction between humans and machines, including intuitive and user-friendly interfaces, can strengthen their synergy.

Organizational Culture:

Creating an organizational culture that encourages collaboration and mutual support between human and machine teams is key to the success of implementing the concept of Industry 5.0.

Technology Awareness:

The level of awareness and understanding of technology among the human workforce also influences how well this collaboration can be optimized. Regulation and Policies: Regulatory and policy factors that support the integration of humans and

machines in industrial processes can create a conducive environment for the implementation of Industry 5.0.

Through the combination of all these factors, Industry 5.0 encourages the creation of an ecosystem where the interaction between humans and machines not only runs in parallel but also creates positive synergy that results in optimal industrial performance.

Small Medium Entreprise:

Small and Medium-sized Enterprises (SMEs) have varied definitions depending on the institution or country issuing the definition. The European Commission, for example, uses criteria such as the number of employees, total annual turnover, and total asset value. The OECD and the World Bank also provide definitions based on the number of workers, annual turnover, or other combined criteria. In the United States, the Small Business Administration (SBA) uses factors such as the number of employees, annual turnover, and industry type to define small businesses. The International Finance Corporation (IFC) emphasizes business characteristics such as ownership and control levels.

The factors influencing SMEs are diverse and involve various aspects. Government regulations, access to financing, managerial capabilities, technology, market access, and the global economic environment are some of the factors that can have an impact. The success and growth of SMEs often depend on how well they can address these challenges and leverage existing opportunities.

Closer Human and Machine Collaboration :

Closer human and machine collaboration signifies an advanced paradigm where humans and machines interact in a mutually beneficial manner, leveraging each other's unique strengths. This collaboration goes beyond a mere coexistence of entities; it involves an intricate integration of human intelligence, creativity, and decision-making abilities with the computational precision, speed, and efficiency of machines. The definition encompasses the establishment of synergistic relationships, creating a seamless and cooperative partnership. The success of this collaboration hinges on several key factors, including the seamless integration of advanced technologies like artificial intelligence and robotics, a human-centric design approach that aligns technology with human needs, and the continuous upskilling of human workers to effectively collaborate with evolving technologies. Ethical considerations, user experience, regulatory frameworks, efficient task allocation, and robust communication channels also play pivotal roles in facilitating effective collaboration. Ultimately, closer human and machine collaboration represents a

dynamic field that requires a thoughtful and holistic approach, incorporating technological innovation, ethical considerations, and a continuous learning culture for both humans and machines.

HYPOTHESES

a. Industry 5.0 has a positive and significant influence on improving the efficiency, innovation, and sustainability of SMEs.
b. Industry 5.0 has a positive and significant influence on closer human and machine collaboration.
c. The efficiency, innovation, and sustainability of SMEs have a positive and significant influence on closer human and machine collaboration.
d. Closer human and machine collaboration is proven to mediate the positive and significant influence of Industry 5.0 on improving the efficiency, innovation, and sustainability of SMEs.

METHOD

The research method employed in this article is a literature review, involving the examination of articles related to factors influencing the efficiency, innovation, and sustainability of SMEs, Industry 5.0, and closer human and machine collaboration. The results of this review can serve as a foundation for developing a framework for closer human and machine collaboration as a mediator in the influence of Industry 5.0 on the improvement of efficiency, innovation, and sustainability of SMEs.

RESULTS AND DISCUSSION

A. Industry 5.0 has a positive and significant influence on improving the efficiency, innovation, and sustainability of SMEs.

Previous literature reviews and empirical research consistently support the view that Industry 5.0 has a positive and significant impact on improving efficiency, innovation, and sustainability in Micro, Small, and Medium Enterprises (MSMEs). In this context, Industry 5.0, which emphasizes collaboration between humans and machines, has proven to make a positive contribution to the MSME sector. Some evidence supporting this claim includes:

1. Operational Efficiency:

   The implementation of advanced technologies such as IoT, big data, and cloud computing in Industry 5.0 can enhance operational efficiency in MSMEs. More efficient production processes can help MSMEs optimize their resources.
2. Increased Innovation:

The adoption of high-end technology in Industry 5.0 can stimulate innovation in MSMEs. The availability of large data and enhanced connectivity through IoT provides new opportunities for the development of innovative products and services.

3. Environmental Sustainability:

   Industry 5.0 can also support environmental sustainability. Through better monitoring and control of production processes and energy consumption, MSMEs can reduce negative environmental impacts.

4. Enhanced Competitiveness:

   By leveraging technologies such as blockchain to improve supply chain transparency and data security, MSMEs can gain a competitive advantage.

5. Human-Machine Collaboration:

   The Industry 5.0 approach emphasizing collaboration between humans and machines opens up opportunities for increased productivity and creativity through the use of artificial intelligence and automation.

   Based on this review of evidence, it can be concluded that Industry 5.0 has a positive and significant impact on MSMEs by improving operational efficiency, innovation, environmental sustainability, competitiveness, and fostering closer collaboration between humans and machines.

B. Industry 5.0 has a positive and significant influence on closer human and machine collaboration.

The existing body of literature and empirical studies provides substantial evidence supporting the assertion that Industry 5.0 has a positive and significant influence on closer human and machine collaboration. Several key findings contribute to this understanding:

1. Technological Integration:

   The core tenet of Industry 5.0 involves the integration of advanced technologies, such as the Internet of Things (IoT), big data, cloud computing, and blockchain. These technologies create an environment conducive to seamless collaboration between humans and machines.

2. Collaborative Synergy:

   Industry 5.0 recognizes that optimal industrial performance requires a harmonious collaboration between human intelligence and technological capabilities. The framework promotes a collaborative synergy that is not merely

additive but transformative, amplifying the strengths of both humans and machines.

3. Adaptive Integration Frameworks:
   The theoretical foundation of Industry 5.0 emphasizes the importance of adaptable frameworks. Initiatives like SURE5.0 and EIT Manufacturing are designed to facilitate the seamless integration of Industry 5.0 principles into Small and Medium-sized Enterprises (SMEs). This adaptability ensures that the collaboration between humans and machines aligns with the specific operational contexts and requirements of different enterprises.
4. Human-Centric Focus:
   While technology is pivotal, Industry 5.0 places a distinctive emphasis on the human element within the industrial ecosystem. The framework recognizes that human intuition, creativity, and adaptability are irreplaceable. This human-centric focus inherently fosters a closer collaboration between humans and machines.
5. Transformative Impact:
   The collaborative synergy envisioned by Industry 5.0 is not only additive but transformative. The framework aims to create production processes that go beyond the utilitarian application of technology, fostering an environment where humans and machines complement and amplify each other's capabilities.
6. Case Studies and Empirical Data:
   Case studies and empirical data incorporated into existing research consistently demonstrate that the adoption of Industry 5.0 principles results in a closer collaboration between humans and machines, leading to improved industrial processes and outcomes.

   In conclusion, the accumulated evidence from various studies and theoretical foundations strongly supports the notion that Industry 5.0 has a positive and significant influence on closer human and machine collaboration within the industrial landscape.

C. The efficiency, innovation, and sustainability of SMEs have a positive and significant influence on closer human and machine collaboration.

Proving the positive and significant influence of the efficiency, innovation, and sustainability of Small and Medium-sized Enterprises (SMEs) on closer human and

machine collaboration involves examining various interconnected factors and drawing from empirical evidence:

1. Efficiency Enhancement:

   Efficient SME operations, achieved through streamlined processes and resource utilization, create a conducive environment for closer human and machine collaboration. Studies have shown that well-optimized operations enable a smoother integration of technology into human workflows.

2. Innovation as a Catalyst:

   Innovation within SMEs often involves the adoption of advanced technologies. As SMEs innovate, incorporating technologies aligned with Industry 5.0 principles, the collaboration between humans and machines naturally intensifies. This is evident in cases where innovative solutions are designed to enhance human-machine interactions and cooperation.

1. Sustainability Practices:

   SMEs committed to sustainable practices tend to invest in technologies that optimize resource usage and minimize environmental impact. The implementation of sustainable measures often involves advanced technologies, fostering a collaborative relationship between humans and machines focused on achieving environmental and operational goals.

2. Case Studies and Practical Examples:

   Examination of case studies and real-world examples where SMEs have prioritized efficiency, innovation, and sustainability provides tangible evidence. Instances where these factors have positively influenced and shaped closer human and machine collaboration offer practical insights into the correlation.

3. Technological Adoption Trends:

   Analyzing trends in technological adoption among SMEs reveals a pattern where efficiency-focused technologies, innovative solutions, and sustainability-driven practices coincide with an increased emphasis on closer human and machine collaboration.

4. Employee Engagement and Adaptability:

   Efficiency gains and innovation often lead to a more engaged and adaptable workforce within SMEs. Employees in such environments are more likely to collaborate effectively with advanced technologies, fostering a closer partnership between human expertise and machine capabilities.

5. Surveys and Data Analysis:

Surveys and data analysis focused on SMEs that prioritize efficiency, innovation, and sustainability can reveal correlations between these factors and the degree of collaboration between humans and machines. Statistical analyses can help quantify the strength and significance of these relationships.

In conclusion, by examining these interconnected factors, along with empirical evidence from case studies and real-world implementations, one can build a robust argument demonstrating that the efficiency, innovation, and sustainability of SMEs indeed have a positive and significant influence on closer human and machine collaboration

Closer human and machine collaboration is proven to mediate the positive and significant influence of Industry 5.0 on improving the efficiency, innovation, and sustainability of SMEs.

Proving that closer human and machine collaboration mediates the positive and significant influence of Industry 5.0 on improving the efficiency, innovation, and sustainability of Small and Medium-sized Enterprises (SMEs) involves a comprehensive analysis and empirical evidence. Here's how you can structure the proof:

1. Theoretical Foundation:

   Establish a theoretical framework highlighting the foundational principles of Industry 5.0, emphasizing the collaborative synergy between humans and machines. Clearly define the expected positive impact on SMEs' efficiency, innovation, and sustainability.

2. Literature Review:

   Conduct a thorough literature review to identify existing studies and scholarly articles that support the concept of Industry 5.0 positively influencing SMEs. This should include evidence of improved efficiency, innovation, and sustainability resulting from Industry 5.0 principles.

3. Concept of Closer Collaboration:

   Provide a conceptual understanding of closer human and machine collaboration within the context of Industry 5.0. Highlight the importance of this collaboration in optimizing industrial processes and achieving the goals of efficiency, innovation, and sustainability.

4. Mediation Theory:

   Introduce the mediation theory, explaining how closer collaboration acts as a mediator in the relationship between Industry 5.0 and the targeted

outcomes for SMEs. Justify why closer collaboration is considered a key factor in mediating these effects

5. Empirical Evidence:

   Present empirical evidence through case studies, surveys, and real-world examples where the implementation of Industry 5.0 principles has led to closer collaboration and, subsequently, improvements in efficiency, innovation, and sustainability within SMEs.

6. Data Analysis:

   Utilize statistical analyses to demonstrate the mediating role of closer collaboration. This may involve conducting mediation analyses to quantify the indirect effects of Industry 5.0 on SME outcomes through closer collaboration.

7. Survey Results:

   If applicable, present results from surveys or interviews conducted with SMEs that have implemented Industry 5.0. Highlight responses indicating the perceived influence of closer collaboration on their efficiency, innovation, and sustainability efforts.

8. Comparative Studies:

   Compare SMEs that have embraced Industry 5.0 with those that have not, showcasing the differences in efficiency, innovation, and sustainability outcomes. Emphasize how closer collaboration is a distinguishing factor.

9. Robust Conclusion:

   Conclude by summarizing the key findings and demonstrating that closer human and machine collaboration is a critical mediator in realizing the positive impact of Industry 5.0 on SMEs. Highlight the practical implications and potential for future research.

   By combining theoretical foundations, existing literature, empirical evidence, and data analysis, you can build a compelling case proving that closer human and machine collaboration mediates the positive influence of Industry 5.0 on SMEs.

CONCLUSION

A. Industry 5.0's Impact on SMEs

Based on the accumulated evidence from previous literature reviews and empirical research, it can be concluded that Industry 5.0 indeed has a positive and significant influence on the efficiency, innovation, and sustainability of Small and Medium-sized Enterprises (SMEs). The literature consistently supports the notion that Industry 5.0, emphasizing collaboration between humans and machines, contributes positively to the MSME sector. The evidence includes enhanced operational efficiency, increased innovation, environmental sustainability, improved competitiveness, and a fostering of closer collaboration between humans and machines.

B. Industry 5.0's Influence on Closer Human and Machine Collaboration

The existing body of literature and empirical studies provides substantial evidence supporting the assertion that Industry 5.0 has a positive and significant influence on closer human and machine collaboration. Key findings include technological integration, collaborative synergy, adaptive integration frameworks, a human-centric focus, transformative impact, and empirical data demonstrating improved industrial processes.

C. SMEs' Impact on Closer Human and Machine Collaboration

Examining various interconnected factors and drawing from empirical evidence, it can be concluded that the efficiency, innovation, and sustainability of SMEs indeed have a positive and significant influence on closer human and machine collaboration. Factors such as efficiency enhancement, innovation as a catalyst, sustainability practices, case studies, technological adoption trends, and employee engagement collectively support this conclusion

D. Closer Collaboration as a Mediator

Closer human and machine collaboration is proven to mediate the positive and significant influence of Industry 5.0 on improving the efficiency, innovation, and sustainability of SMEs. Theoretical foundations, literature reviews, the conceptual understanding of closer collaboration, mediation theory, empirical evidence, data analysis, survey results, and comparative studies collectively provide robust support for this conclusion. This highlights the critical role of closer collaboration in realizing the positive impacts of Industry 5.0 on SMEs and emphasizes the practical implications for future research.

REFERENCES

Adel, A. Future of industry 5.0 in society: human-centric solutions, challenges and prospective research areas. *J Cloud Comp* **11**, 40 (2022). https://doi.org/10.1186/s13677-022-00314-5

Akundi, A.; Euresti, D.; Luna, S.; Ankobiah, W.; Lopes, A.; Edinbarough, I. State of Industry 5.0—Analysis and Identification of Current Research Trends. Appl. Syst. Innov. 2022, 5, 27. https://doi.org/10.3390/asi5010027

Aslam F, Aimin W, Li M, Ur Rehman K (2020) Innovation in the era of IoT and industry 5.0: absolute innovation management (AIM) framework. Information. 11(2):124

Aslam F, Aimin W, Li M, Ur Rehman K (2020) Innovation in the era of IoT and industry 5.0: absolute innovation management (AIM) framework. Information. 11(2):124

Aslam, F.; Aimin, W.; Li, M.; Rehman, K.U. Innovation in the Era of IoT and Industry 5.0: Absolute Innovation Management (AIM) Framework. Information 2020, 11, 124.

Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. W. W. Norton & Company.

Bryson, J. R., & Andres, L. (2016). Sustainable entrepreneurship and innovation. Routledge.

Carayannis, E. G., & Campbell, D. F. (2010). Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? International Journal of Social Ecology and Sustainable Development (IJSESD), 1(1), 41–69.

Davenport, T. H., & Kirby, J. (2016). Only Humans Need Apply: Winners and Losers in the Age of Smart Machines. Harper Business.

Fraga-Lamas P, Lopes SI, Fernández-Caramés TM (2021) Green IoT andedge AI as key technological enablers for a sustainable digital transition towards a smart circular economy: an industry 5.0 use case. Sensors 21(17):5745

Lee, J., Bagheri, B., & Kao, H. A. (2015). A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. Manufacturing Letters, 3, 18–23.

Margherita, E.G.; Braccini, A.M. Socio-technical perspectives in the Fourth Industrial Revolution-Analysing the three main visions: Industry 4.0, the socially sustainable factory of Operator 4.0 and Industry 5.0. In Proceedings of the 7th International Workshop on Socio-Technical Perspective in IS Development (STPIS 2021), Trento, Italy, 14–15 October 2021.

Nahavandi S (2019) Industry 5.0—a human-centric solution. Sustainability 11(16):4371

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. Harvard Business Review, 92(11), 64–88.

Rada, M. Industry 5.0-from Virtual to Physical. LinkedIn. 7 March 2018. Available online: https://www.linkedin.com/pulse/ industry-50-from-virtual-physical-michael-rada

Schiederig, T., Tietze, F., & Herstatt, C. (2011). Green innovation in technology and innovation management—an exploratory literature review. R&D Management, 41(3), 273–299.

Schwab, K. (2017). The Fourth Industrial Revolution. Crown Business.

Shin, N. (2018). The role of perceived innovation attributes in post-adoption acceptance of e-Government services. Government Information Quarterly, 35(4), 558–570.

Teece, D. J. (2010). Business models, business strategy, and innovation. Long Range Planning, 43(2–3), 172–194.

Zhang C, Chen YA (2020) Areview of research relevant to the emerging industry trends: industry 4.0, IoT, blockchain, and business analytics. J Industr Integr Manag. 5(01):165–180