



CienciAmérica: Revista de Divulgación Científica de la  
Universidad Tecnológica Indoamérica

ISSN: 1390-9592

ISSN: 1390-681X

[cienciamerica@uti.edu.ec](mailto:cienciamerica@uti.edu.ec)

Universidad Tecnológica Indoamérica  
Ecuador

Morillo-Aguilar, Kleber R.

IMPACT OF TECHNOLOGICAL ENABLERS IN THE INDUSTRY AND MANUFACTURING OF SMEs

CienciAmérica: Revista de Divulgación Científica de la Universidad Tecnológica  
Indoamérica, vol. 11, no. 2, <https://doi.org/10.33210/ca.v11i2.394>, 2022, July-December

Universidad Tecnológica Indoamérica  
Ecuador

- Complete issue
- More information about this article
- Journal's webpage in [redalyc.org](https://redalyc.org)



---

# IMPACT OF TECHNOLOGICAL ENABLERS IN THE INDUSTRY AND MANUFACTURING OF SMEs

*Impacto de los habilitadores tecnológicos en la industria y la  
fabricación de las PyMES*

*Impacto dos capacitadores tecnológicos na indústria e fabricação de  
PMEs*

---

Kleber R. Morillo-Aguilar<sup>1</sup> 

<sup>1</sup> Faculty of Energy, Industries and Non-Renewable Natural Resources. National  
University of Loja. Loja-Ecuador. e-mail: [kleber.morillo@unl.edu.ec](mailto:kleber.morillo@unl.edu.ec)

Reception date: September 10, 2022.

Acceptance date: November 08, 2022.

## ABSTRACT

**INTRODUCTION.** The fourth industrial revolution is a no return path for the entire business sector. In the EU, 99% of SMEs are negatively impacted by the low technological adoption in their operational and production processes. **OBJECTIVE.** This Systematic Literature Review presents the results found in studies where the impact of the adoption of emerging technologies in SMEs is analyzed and their main trends are identified. **METHOD.** Through the systematic search, the selection of studies that include emerging technologies with the exception of DLTs and proposals for management directions for the adoption of DT in companies was made. Studies of DLTs are excluded in the search. **RESULTS.** Using scientific databases such as Elsevier, Springer link, IEEE among others, 41 related articles (Q1 (55%), Q2 (5%), Q3 (3%)) were found. Taking 87% of works as a reference, it was evidenced that there are still scattered empirical studies, and that proposals predominate in addressing the adoption of DT in SMEs. **DISCUSSION AND CONCLUSIONS.** It was identified that, within exploratory studies, the technological trend is connectivity, use of internet services and integration of digital technology. This study provides updated information on the trend to explore and exploit digital transformation in companies.

**Keywords:** Emerging technologies, digital transformation, innovation, SME.



## RESUMEN

**INTRODUCCIÓN.** La cuarta revolución industrial es un camino sin retorno para todo el sector empresarial. En la UE el 99% de las PyMES se ven impactadas negativamente por la escasa adopción tecnológica en sus procesos operativos y productivos. **OBJETIVO.** La presente Revisión Sistemática de Literatura tiene como objetivo presentar los hallazgos encontrados en estudios donde se analiza el impacto de la adopción de tecnologías emergentes en las PyMES y se identifican sus principales tendencias. **MÉTODO.** Mediante la búsqueda sistemática se hizo la selección de estudios que incluyan tecnologías emergentes y propuestas de gestión para la adopción de la TD en PyMES. En la búsqueda se excluyen estudios de DLTs. **RESULTADOS.** Usando BDD científicas como Elsevier, Springer link, IEEE entre otros, se encontró 41 artículos (Q1 (55%), Q2 (5%), Q3 (3%)) relacionados. Tomando el 87% de trabajos como referencia, se evidenció que todavía existen estudios empíricos dispersos, y que predominan las propuestas en el direccionamiento para adopción de la TD en PyMES. **DISCUSIÓN Y CONCLUSIONES.** Se identificó que la tendencia tecnológica es la conectividad, el uso de servicios de internet e Integración de la tecnología digital. Este estudio aporta información actualizada sobre la tendencia para explorar y explotar la TD en las empresas.

**Palabras claves:** Tecnologías emergentes, Transformación digital, Innovación tecnológica, PyMES.

## RESUMO

**INTRODUÇÃO.** A quarta revolução industrial é um caminho sem volta para todo o setor empresarial. Na UE, 99% das PME são impactadas negativamente pela baixa adoção tecnológica em seus processos operacionais e produtivos. **OBJETIVO.** Esta Revisão Sistemática da Literatura tem como objetivo apresentar os achados encontrados em estudos onde se analisa o impacto da adoção de tecnologias emergentes nas PME e se identificam suas principais tendências. **MÉTODO.** Por meio da busca sistemática, foi feita a seleção de estudos que contemplam tecnologias emergentes e propostas de gestão para a adoção de DT em PME. Estudos de DLTs são excluídos da pesquisa. **RESULTADOS.** Utilizando bases de dados científicas como Elsevier, Springer link, IEEE entre outras, foram encontrados 41 artigos relacionados (Q1 (55%), Q2 (5%), Q3 (3%)). Tomando como referência 87% dos trabalhos, evidenciou-se que ainda existem estudos empíricos dispersos, e que predominam propostas para abordar a adoção de TD em PME. **DISCUSSÃO E CONCLUSÕES.** Identificou-se que a tendência tecnológica é a conectividade, o uso de serviços de internet e a integração da tecnologia digital. Este estudo fornece informações atualizadas sobre a tendência de explorar e explorar DT nas empresas.

**Palavras-chave:** Tecnologias emergentes, transformação digital, inovação, PME.

## INTRODUCTION

Developed countries have spent years developing public policies and investing resources for the development of innovation and entrepreneurship, research on the effects on the business sector is abundant in developed countries but scarce in emerging countries [1]. Since the appearance of the COVID 19 pandemic, the adoption of emerging technologies has accelerated and Digital Transformation (DT) has become an imperative for all states, but mainly for emerging countries and even more so for Small

and Medium Enterprises (SMEs). This sector occupies 99% of the business net in the European Union (EU).

The EU has established an agenda whose objective is, on one side, to take advantage of data-based innovation and, on the other side, to exploit the current favorable technological and political context to encourage society to empower itself and accelerate the implementation of these new technologies in its internal processes [2]. Countries like Japan are executing a Society 5.0 plan that tries to use the evolution of Science, Technology and Innovation (STI) to lay the foundations for a new ecosystem that serves for the development of a society based on the human being, in the style of market requirement (Market Pull), reducing the risks of implementing this ecosystem [3]. Currently the technology industry is growing faster than the rest of the economy and hence the importance of digital innovation and the adoption of emerging technologies that enable the development of new digital products and services, business processes or business models. However, the implementation of these technologies are both theoretical and practical challenges for companies, even more so in emerging countries and their SMEs [4], [5].

Currently, there is an environment of traditional economy and digital economy that are in the process of integration, interaction and institutional and organizational adaptation, resulting in a new, more complex ecosystem. From this point of view, the CEPAL (2022), maintains that there are dimensions of digital development which are constantly evolving and that affect the level of society, the productive apparatus, and the state. Consequently, the adoption of DT is a highly dynamic and complex process.

DT goes beyond a simple adoption of technology or digitization of processes; it includes changes in all dimensions of an organization from operational processes and products to changes in business models [5]. The DT will allow the migration of the traditional economy to a digital economy that will satisfy the needs of consumers with intelligent products and services and even with a high degree of personalization [6].

Although DT can be used as a differentiating competition strategy for manufacturing companies in SMEs [7], the form of application and direct effect on production processes, operations and business models remains unclear. In addition, entrepreneurs are also unclear about which technologies to implement or the technological trends to which they could opt.

The exploration and exploitation of emerging technologies such as automation, Cyber-Physical Systems (CPS), the Internet of Things (IoT), sensorization, 3D printing, Big Data and cybersecurity, considered mature in Industry 4.0 (I4.0), are elements that impact within the manufacturing production processes of SMEs. With this background, the purpose of this article was to make a Systematic Literature Review of the experiences in different parts of the world to evaluate and deepen through a qualitative analysis the impact of the implementation of emerging technologies in SMEs and to know the current implementation trends of emerging technologies that can truly create added value to the manufacturing processes of SMEs.

The article is made up of an Introduction section where the context of the article is explained and a Systematic Literature Review (SRL) will be made of cases where the use of emerging technologies for the Digital Transformation (DT) of companies is involved. The Materials and methods section details the process followed for the analysis of the articles. In the results section, the main conclusions found in the studies and future work will be highlighted.

### Related jobs

There is recent literature on the impact of the application of emerging technologies in SMEs, however, there has been a pause in the development of these studies due to the appearance of the COVID-19 pandemic. The studies grouped into two large groups are described below.

### Routing strategy

Servitization is based on the level of digitization of suppliers and customers. Thus, the different degrees of integration of products and services, basic, intermediate and advanced level, will depend on the operational needs, required capacities, trends in the industry and value generation opportunities that the companies have [8].

For the integration of digital innovations in organizations, there are studies such as the Wiesböck & Hess (2020) where they indicate that innovations can be circumscribed to 3 concentric rings that are: i) technology-driven development and the different categories of implementation of digital innovations in the center; ii) the facilitators of digital innovations in a second ring and; iii) the governance of digital innovations in a third ring.

From a literature review carried out by Zahra et al., (2022), it follows that industry and administration professionals have been able to introduce changes using two basic activities that are the **exploration** and **exploitation** of **digital technologies**, sometimes using only one strategy and other times combining these two strategies. Considering the facilities for innovation, DT can make three key changes: 1) DT promotes the decoupling of form and function, reducing the importance of assets in dependency-power relationships; 2) DT promotes disintermediation, reducing the power of the intermediary in the value chain and giving greater freedom to suppliers of products and services, and finally; 3) Digitization drives generativity, allowing the integration of geographically dispersed markets and creating new ways of creating value [9].

### Digital Transformation Strategy

In the case of Grandinetti et al. (2020), an analysis of B2B (Business to Business) companies in Italy was made, considering servitization and PSS (Product-service System) based on IoT, where it was found that <<The "industrializing" business models for servitization based on I4.0 reinforce quality of the relationship when suppliers and customers develop new digital services through functional co-creation >>. However, the study is limited to the analysis of one of the many I4.0 technologies and therefore the effect of other emerging technologies was not analyzed.

In the case of the IoT, Pirola et al. (2020) they argue that digitization and servitization go hand in hand and are complementary. Today, they require digital platforms to establish and manage business ecosystems, enabling flexible collaboration and open innovation for new business models. Within this perspective, the implementation of IoT or Digital Twins (DT, Digital Twins), used as technological enablers of intelligent services and data feedback, can help to generate new functionalities and PSS knowledge exchange throughout the product life cycle. However, one of the main problems is the energy required to implement IoT, for this reason it seeks to develop new policies, standards, security, privacy and technical considerations for a Green IoT [12].

In the investigation of [13] the impact of the IoT in companies is evaluated. It proposes how to convert a manufacturing company into a service-oriented product (Servitization) with theoretical and managerial suggestions using the IoT technological enabler. The research indicates that the sales model is a strategic factor for the digital servitization of companies.

## METHODOLOGY

For the present study, a compilation of studies from the last four years was carried out in order to perform a Systematic Literature Review (SLR) but limited to a set of emerging technologies from the I4.0. In order to have rigor, objectivity and transparency in the research process, studies related to the emerging technologies of Automation and Robotics, Internet of Things, Big Data, Data Analytics, Additive or Smart Manufacturing, Cybersecurity and Sensorization have been selected. Likewise, technologies that are not fully developed and that have to do with DLTs, as well as research that is not related to the improvement of manufacturing production in SMEs, are excluded from this review.

The sources of information used for this study range from scientific databases, magazines related to the subject, congresses, books, opinion articles, reports, etc. Finally, the last date of consultations made in the various data sources was made in June 2022.

### Research Question

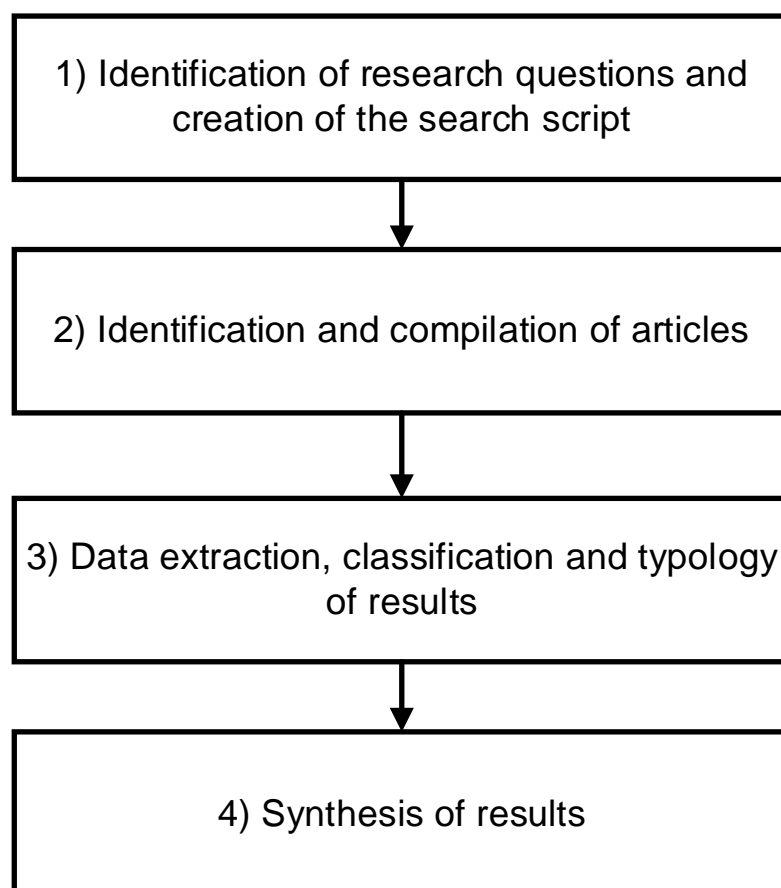
The main objective of this RSL is to cover two research questions: ¿What are the impacts of the emerging technologies of I4.0 on the productive efficiency of companies? What is the current technological trend to evolve traditional companies to the fourth industrial revolution?

To achieve our goal, we searched the main repositories such as: Scopus, Elsevier, Springer link, IEEE, WOS. Journal articles, conference articles, reports, books, scientific articles, research and generic articles were selected using a search string with Boolean operators AND and OR with the following script:

(Digitalization OR Digital) AND (“Innovation” OR Modernization OR cutting edge)  
AND (Renewal OR transformational OR radical change) AND (Manufacturing OR  
Produce OR fabrication) AND (ecosystem\* OR environ\*) AND Servitization

Emerging technologies were included in this research, which are: Internet of Things (IoT); Industrial Internet of Things (IIoT); Smart manufacturing; Additive manufacturing; Sensorization and communication protocols; Automation and industrial robotics; Artificial Intelligence (AI); Big Data and Analysis and; Industrial cybersecurity. Technologies that are not fully mature, such as DLT (Distributed Ledger Technology) and any organizational directive that is not within the scope of the productive and operational performance of companies, were excluded from this review.

This study is structured in four stages: 1) Identification of research questions and creation of the search script; 2) Identification and compilation of articles; 3) Data extraction, classification and typology of results and; 4) Synthesis of results, as can be seen in Figure 1.



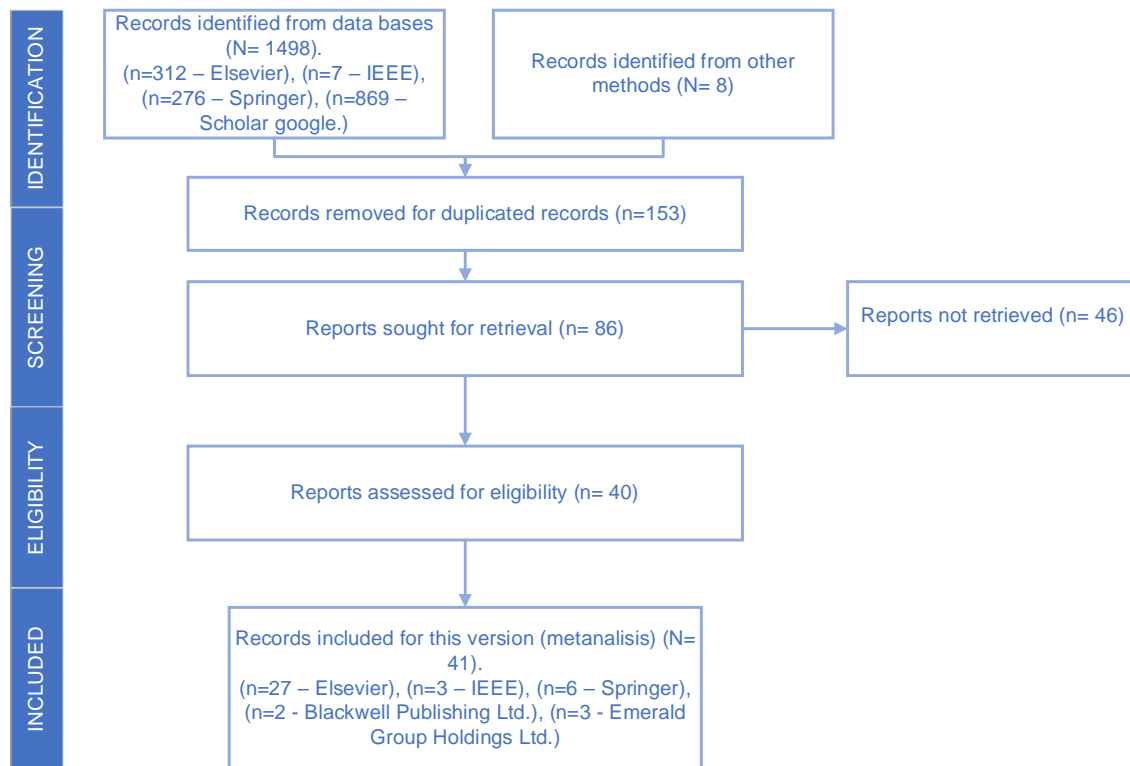
**Figure 1.** Research stages

To carry out the analysis, data extraction and synthesis process, each of the technologies used in each study was identified and classified according to the categorization of the Digital Economy and Society Index (DESI). This avoids the risk of bias in the included studies.



## RESULTS

As a result of the search and selection processes, 41 studies were found that served as the basis for this systematic review. The process can be seen in the flow diagram of Figure 2.



**Figure 2.** Flow diagram

From the result of the review, the following results could be obtained. Table 1 shows the documents that supported the present study. In Table 2 you can see a classification of the different articles selected from the different sources.





**Table 1.** Articles reviewed

Research Institutions	Title	Autor (s)	Year	DOI	Journal type
Tampere University, Finland.	A Survey on Wearable Technology: History, State-of-the-Art and Current Challenges	Aleksandr Ometov	mar-21	<a href="https://doi.org/10.1016/j.comnet.2021.108074">https://doi.org/10.1016/j.comnet.2021.108074</a>	Computer Networks
Business School, Imperial College, London, UK. Antai College of Economics and Management, Shanghai Jiao Tong University, Shanghai, China.	A systematic literature review of entrepreneurial ecosystems in advanced and emerging economies	Zhe Cao & Xianwei Shi	feb-20	<a href="https://doi.org/10.1007/s11187-020-00326-y">https://doi.org/10.1007/s11187-020-00326-y</a>	Small Business Economics
Institut Mines-Télécom, France Azad University, North Tehran Branch, Tehran, Iran. University of Technology Sydney, Sydney, Australia.	Application of Internet of Things and artificial intelligence for smart fitness: A survey	Alireza Farrokhi, Reza Farahbakhsh, Javad Rezazadeh, Roberto Minerva	ene-21	<a href="https://doi.org/10.1016/j.comnet.2021.107859">https://doi.org/10.1016/j.comnet.2021.107859</a>	Computer Networks
Department of Entrepreneurship and Management Systems, Faculty of Management, University of Warsaw, Poland.	Automation-driven innovation management? Toward Innovation-Automation-Strategy cycle	Piotr Tomasz Makowski, Yuya Kajijawa	mar-21	<a href="https://doi.org/10.1016/j.techfore.2021.120723">https://doi.org/10.1016/j.techfore.2021.120723</a>	Technological Forecasting and Social Change
Department of Business Development and Technology Aarhus University Herning, Denmark.	Barriers and Enablers for Digitizing Shop Floor Management Boards	Clausen, P., Mathiasen, J. B., & Nielsen, J. S.	ago-19	<a href="https://doi.org/10.1109/GWS.2018.8686591">https://doi.org/10.1109/GWS.2018.8686591</a>	2018 Global Wireless Summit (GWS)
University of Salento, Italy	Digital entrepreneurship ecosystem: How digital technologies and collective intelligence are reshaping the entrepreneurial process	Gianluca Elia, Alessandro Margherita, Giuseppina Passiante	oct-19	<a href="https://doi.org/10.1016/j.techfore.2019.119791">https://doi.org/10.1016/j.techfore.2019.119791</a>	Technological Forecasting and Social Change
Institute for Information Systems and New Media, LMU Munich	Digital innovations: Embedding in organizations	Florian Wiesböck, Thomas Hess	ago-19	<a href="https://doi.org/10.1007/s12525-019-00364-9">https://doi.org/10.1007/s12525-019-00364-9</a>	Electronic Markets
University of Bergamo, Department of Management, Information and Production Engineering	Digital technologies in product-service systems: a literature review and a research agenda	Fabiana Pirola, Xavier Boucher, Stefan Wiesner, Giuditta Pezzotta	jul-20		Computers in Industry





University of International Business and Economics, Beijing, China.	Digital transformation by SME entrepreneurs: A capability perspective	Liang Li, Fang Su, Wei Zhang, Ji-Ye Mao	abr-17	<a href="https://10.1111/isi.12153">https://10.1111/isi.12153</a>	Information Systems Journal
Research Center of the Central China for Economic and Social Development, Nanchang University, China	Digitalization, competition strategy and corporate innovation: Evidence from Chinese manufacturing listed companies	Huwei Wen, Qiming Zhong, Chien-Chiang Lee	abr-22	<a href="https://doi.org/10.1016/j.rfa.2022.102166">https://doi.org/10.1016/j.rfa.2022.102166</a>	International Review of Financial Analysis
Entrepreneurship and Innovation, Luleå University of Technology, Luleå, Sweden.	Ecosystem transformation for digital servitization: A systematic review, integrative framework, and future research agenda	Milad Kolagar, Vinit Parida, David Sjödin	mar-22	<a href="https://doi.org/10.1016/j.busres.2022.03.067">https://doi.org/10.1016/j.busres.2022.03.067</a>	Journal of Business Research
School of Strategy and Leadership, Faculty of Business and Law, Coventry University, Coventry, West Midlands, UK.	Exploring the impact of digital transformation on technology entrepreneurship and technological market expansion: The role of technology readiness, exploration and exploitation	Vahid Jafari-Sadeghi, Alexeis Garcia-Perez, Elena Candelo, Jerome Couturier	nov-20	<a href="https://doi.org/10.1016/j.busres.2020.11.020">https://doi.org/10.1016/j.busres.2020.11.020</a>	Journal of Business Research
Conference on Information Communications Technology and Society (ICTAS).	Exploring the role of digital innovation hubs in socioeconomic development	T. Vakirayi and J. V. Belle	jun-20	<a href="https://10.1109/ICTAS47918.2020.233992">https://10.1109/ICTAS47918.2020.233992</a>	2020 Conference on Information Communications Technology and Society, ICTAS 2020 - Proceedings
The European Commission (DG Connect and DG RTD)	Financing the digitalization of small and medium-sized enterprises. The enabling role of digital innovation hubs Executive summary	Innovation Finance Advisory, European Investment Bank	ene-19		European Investment Bank
IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC).	Five Management Pillars for Digital Transformation Integrating the Lean Thinking Philosophy	David Romero, Myrna Flores, Martin Herrera, Homero Resendez	ago-19	<a href="https://10.1109/ICE.2019.8792650">https://10.1109/ICE.2019.8792650</a>	2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)





Universita LUM Jean Monnet, Casamassima, Italy. University of Salento, Lecce, Italy.	Fostering digital transformation of SMEs: a four levels approach	Antonello Garzoni and Ivano De Tur, Giustina Secundo and Pasquale Del Vecchio	dic-19	<a href="https://10.1108/MD-07-2019-0939">https://10.1108/MD-07-2019-0939</a>	Management Decision
University of Padova, Padova, Italy. University of Salerno, Fisciano, Italy. University of Naples–Parthenope, Napoli, Italy department of Strategy and Management, Paris School of Business, Paris, France	Fourth industrial revolution, digital servitization and relationship quality in Italian B2B manufacturing firms. An exploratory study	Roberto Grandinetti, Maria Vincenza Ciasullo, Marco Paiola, Francesco Schiavone	jun-20	<a href="https://doi.org/10.1108/TQM-01-2020-0006">https://doi.org/10.1108/TQM-01-2020-0006</a>	TQM Journal
Department of Computer and Information Sciences, Northumbria University, Newcastle Upon Tyne, UK.	From serendipity to sustainable green IoT: Technical, industrial and political perspective	Mehmet Fatih Tuysuz, Ramona Trestian	ago-20	<a href="https://doi.org/10.1016/j.comnet.2020.107469">https://doi.org/10.1016/j.comnet.2020.107469</a>	Computer Networks
European Commission, Joint Research Centre (JRC), Ispra, Italy	From spatial data infrastructures to data spaces—A technological perspective on the evolution of European SDIs	Alexander Kotsev, Marco Minghini, Robert Tomas, Vlado Cetl and Michael Lutz	mar-20	<a href="https://doi.org/10.3390/ijgi9030176">https://doi.org/10.3390/ijgi9030176</a>	ISPRS International Journal of Geo- Information
Strategic Management & Entrepreneurship Department, Carlson School of Management, University of Minnesota, Minneapolis, MN, USA.	How digital technology promotes entrepreneurship in ecosystems	Shaker A. Zahra, Wan Liu, Steven Si	ene-22	<a href="https://doi.org/10.1016/j.technovation.2022.102457">https://doi.org/10.1016/j.technovation.2022.102457</a>	Technovation
Technical University of Madrid, Spain.	Innovation ecosystems theory revisited: The case of artificial intelligence in China	Alberto Arenal	mar-20	<a href="https://doi.org/10.1016/j.elpol.2020.101960">https://doi.org/10.1016/j.elpol.2020.101960</a>	Telecommunications Policy
Ionian Department of Law, Economics and Environment, University of Bari Aldo Moro, Taranto, Italy.	Internet of Things and Big Data as enablers for business digitalization strategies	Andrea Sestino, Maria Irene Prete, Luigi Piper, Gianluigi Guido	jul-20	<a href="https://doi.org/10.1016/j.technovation.2020.102173">https://doi.org/10.1016/j.technovation.2020.102173</a>	Technovation
Department of Economics and Management, University of Padua, Italy	Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms	Marco Paiola, Heiko Gebauer	mar-20	<a href="https://doi.org/10.1016/j.indmarman.2020.03.009">https://doi.org/10.1016/j.indmarman.2020.03.009</a>	Industrial Marketing Management





Department Electrical and Computer Engineering American University of Beirut, Lebanon.	IoT Survey: An SDN and Fog Computing Perspective	Ola Salman	jul-18	<a href="http://10.1016/j.comnet.2018.07.020">http://10.1016/j.comnet.2018.07.020</a>	Computer Networks
CESE, INESC TEC, Campus da FEUP, Portugal	Providing industry 4.0 technologies: The case of a production technology cluster	Gustavo Dalmarco, Filipa R. Ramalho, Ana C. Barros, Antonio L. Soares.	nov-19	-	The Journal of High Technology Management Research
Nord University Business School, Division of Innovation and Entrepreneurship, Norway.	Scale quickly or fail fast: An inductive study of acceleration	Raj K. Shankar, Tommy H. Clausen	jul-20	<a href="https://doi.org/10.1016/j.technovation.2020.102174">https://doi.org/10.1016/j.technovation.2020.102174</a>	Technovation
Department of Industrial-Academic Collaboration, Japan Science and Technology Agency K's Gobancho, Japan	Science, technology and innovation ecosystem transformation toward society 5.0	Kayano Fukuda	jul-19	<a href="https://doi.org/10.1016/j.jpe.2019.07.033">https://doi.org/10.1016/j.jpe.2019.07.033</a>	International Journal of Production Economics
Department of Industrial Engineering, Universidade Federal do Rio Grande do Sul, Brazil.	Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective	Alejandro G. Frank, Glaucio H.S. Mendes, Néstor F. Ayala, Antonio Ghezzi	ene-19	<a href="https://doi.org/10.1016/j.techfore.2019.01.014">https://doi.org/10.1016/j.techfore.2019.01.014</a>	Technological Forecasting and Social Change
University of Applied Sciences and Arts Northwestern Switzerland	Strategic action fields of digital transformation: An exploration of the strategic action fields of Swiss SMEs and large enterprises	Marc K. Peter, Corin Kraft and Johan Lindeque	dic-19	<a href="https://10.1108/JSMA-05-2019-0070">https://10.1108/JSMA-05-2019-0070</a>	Journal of Strategy and Management
International Journal of Advanced Engineering Research and Science (IJAERS)	Systematic Literature Review (SLR) Development of the IoT Industry in the South America Region	Izualber Muniz, Douglas Castro da Silva, Bryan Alexander Saravia	jun-22	<a href="https://dx.doi.org/10.22161/ijaers.96.39">https://dx.doi.org/10.22161/ijaers.96.39</a>	International Journal of Advanced Engineering
Eindhoven University of Technology, Department of Industrial Engineering & Innovation Sciences, Eindhoven. The Netherlands School for Environment and Sustainability. University of Michigan.	Technology Forgiveness: Why emerging technologies differ in their resilience to institutional instability	Bonning Roca, Jaime et. Al	ene-21	<a href="https://doi.org/10.1016/j.techfore.2021.120599">https://doi.org/10.1016/j.techfore.2021.120599</a>	Technological Forecasting and Social Change





Technovation.	Technology, entrepreneurship, innovation and social change in digital economics	Steven Si, Jeremy Hall, Roy Suddaby, David Ahlstrom, Jiang Wei.	ene-22	<a href="https://doi.org/10.1016/j.technovation.2022.102484">https://doi.org/10.1016/j.technovation.2022.102484</a>	Technovation
Departamento de Organización de Empresas, Universitat Politècnica de Valencia, Spain.	The effect of digitalization on business performance: An applied study of KIBS	Samuel Ribeiro-Navarrete, Maria Orero-Blat	dic-20	<a href="https://doi.org/10.1016/j.busres.2020.12.065">https://doi.org/10.1016/j.busres.2020.12.065</a>	Journal of Business Research
Newcastle University Business School	The Examination of the Corporate Organization and Implementation of Industry 4.0 in a High Value	Julian Rueb	nov-20	978-1-7281-7037-4	2020 IEEE International Conference on Engineering,
Department of Economics and Management "Marco Fanno", University of Padova, Padova, Italy.	The process of business model innovation driven by IoT: Exploring the case of incumbent SMEs	Paiola M., Agostini, L., Grandinetti, R., Nosella, A.	mar-22	<a href="https://doi.org/10.1016/j.ndmarman.2022.03.006">https://doi.org/10.1016/j.ndmarman.2022.03.006</a>	Industrial Marketing Management
Center for Entrepreneurship, College of Business and Economics, Qatar University, Doha, Qatar	The Shenzhen ecosystem: What it means for the western world	Mokter Hossain	ene-22	<a href="https://doi.org/10.1016/j.techsoc.2022.101919">https://doi.org/10.1016/j.techsoc.2022.101919</a>	Technology in Society
School of Business and Economics, Loughborough University, UK.	The strategic impacts of Intelligent Automation for knowledge and service work: An interdisciplinary review	Crispin Coombs, Donald Hislop, Stanimira K. Taneva, Sarah Barnard	feb-20	<a href="https://doi.org/10.1016/j.sis.2020.101600">https://doi.org/10.1016/j.sis.2020.101600</a>	Journal of Strategic Information Systems
Inland Norway University of Applied Sciences.	Transformational shifts through digital servitization	Bård Tronvoll et al.	feb-20	<a href="https://doi.org/10.1016/j.ndmarman.2020.02.005">https://doi.org/10.1016/j.ndmarman.2020.02.005</a>	Industrial Marketing Management
Entrepreneurship and Innovation Group, Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, Sweden. School of Management, University of Vaasa, Vaasa, Finland.	Transforming provider-customer relationships in digital servitization: A relational view on digitalization	Anmar Kamalaldina, Lina Linde, David Sjödin, Vinit Parida	ago-20	<a href="https://doi.org/10.1016/j.ndmarman.2020.02.004">https://doi.org/10.1016/j.ndmarman.2020.02.004</a>	Industrial Marketing Management
Entrepreneurship and Innovation, Luleå University of Technology, Luleå, Sweden.	Value Creation and Value Capture Alignment in Business Model Innovation: A Process	David Sjödi, Vinit Parida, Marin	jul-20	<a href="https://doi.org/10.1111/jpim.12516">10.1111/jpim.12516</a>	Journal of Product Innovation Management





View on Outcome-Based  
Business Models

Jovanovic, Ivanka  
Visnjic

**Table 2.** Data sources.

Publisher	Journal name	SJR	Article number	Percentage	Representation
Blackwell Publishing Ltd.	Information Systems Journal	Q1	1	2%	
	Journal of Product Innovation Management	Q1	1	2%	
CEPADE-Polytechnic University of Madrid	Management and Organization	Q3	1	2%	
CELAC	Economic Commission for Latin America and the Caribbean (CELAC)		1	2%	
Complutense Editions	Social Mediations		1	2%	
Elsevier	International Journal of Production Research	Q1	1	2%	
	International Review of Financial Analysis	Q1	1	2%	
	Journal of Business Research	Q1	1	2%	
	The Journal of High Technology Management Research	Q1	1	2%	
Elsevier B.V.	Computer Networks	Q1	5	9%	
	Computers in Industry	Q1	1	2%	







	International Journal of Production Economics	Q1	1	2%	
	Journal of Strategic Information Systems	Q1	2	4%	
Elsevier B.V.	Business horizons	Q1	1	2%	
Elsevier Inc.	Industrial Marketing Management	Q1	4	7%	
	Journal of Business Research	Q1	2	4%	
	Technological Forecasting and Social Change	Q1	5	9%	
Elsevier Ltd	Technology in Society	Q1	1	2%	
	Technovation	Q1	4	7%	
	Telecommunications Policy	Q1	1	2%	
Emerald Group Holdings Ltd.	Journal of Strategy and Management	Q2	1	2%	
	Management Decision	Q1	1	2%	
	TQM Journal	Q2	1	2%	
European Investment Bank	European Investment Bank		1	2%	
IEEE	2018 Global Wireless Summit (GWS)		1	2%	
	2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)		1	2%	







	2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)		1	2%	
	2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC)		1	2%	
	IEEE		4	7%	
Institute of Electrical and Electronics Engineers Inc.	2020 Conference on Information Communications Technology and Society, ICTAS 2020 - Proceedings		1	2%	
MDPI AG	ISPRS International Journal of Geo-Information	Q1	1	2%	
Others	International Journal of Advanced Engineering	Q1	1	2%	
Springer	Electronic Markets	Q1	1	2%	
	Small Business Economics	Q1	1	2%	
Springer International Publishing	Springer International Publishing		1	2%	
Springer Nature Singapore	Springer Nature Singapore		1	2%	
Springer Science and Business Media Deutschland GmbH	Review of managerial Science	Q1	1	2%	
	Service Business	Q1	1	2%	

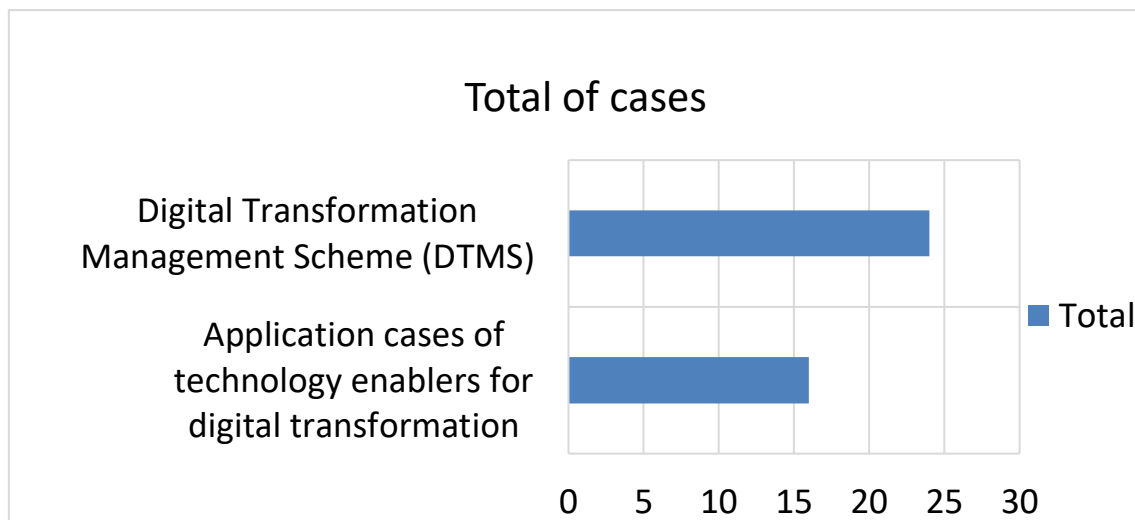


While in Table 3 you can see the type of documents reviewed according to the research questions.

**Table 3.** Type of document

Document type	Article number	Percentage	Representation
Journal article	36	52%	
Report	11	16%	
Book	8	12%	
Generic	8	12%	
Conference procedures	5	7%	
magazine article	1	1%	

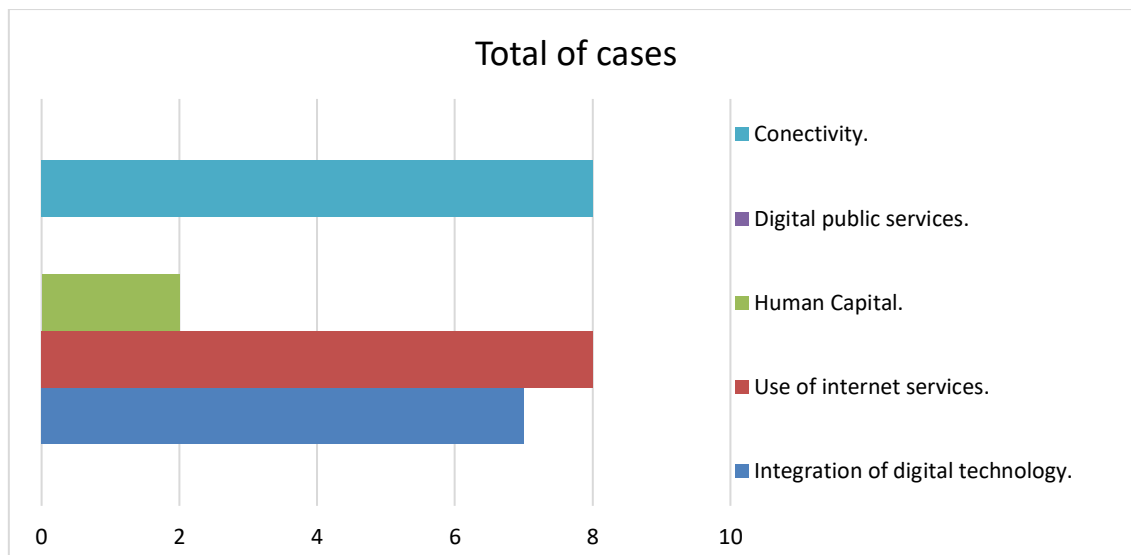
The analysis of the present investigation was made by the classification of the articles investigated in two parts. On one hand, the documents that propose innovative strategies to explore and exploit emerging technologies in such a way as to increase the performance of their production processes that we will call Digital Transformation Management Scheme (DTMS); and on the other hand, the studies that illustrate various results showing the impacts of adopting emerging technologies that we will call Application cases of technology enablers for digital transformation, as can be seen in Figure 3.



**Figure 3.** Classification of studies

Within the studies where technological enablers were applied for the exploration and exploitation of digital transformation, the Digital Economy and Society Index (DESI)

categorization was used where the five subcategories were used to characterize the studies and identify the trends of the studies, according to Figure 4.



**Figure 4.** Categorization of studies according to DESI

Furthermore, it was found that after making a systematic review of qualitative empirical evidence that identifies comprehensive information on the implementation of DT in manufacturing companies, the studies carried out in a high-value manufacturing company in Germany allowed us to identify three key factors: 1) The creation of a central department for the DT; 2) the election of a CDO (*Chief Digital Officer*) and; 3) corporate openness for cooperation as cultural change. Lean Management has been discovered as a major enabler for I4.0 adoption [14].

In a study carried out in Portugal, it can be seen that instructional instability negatively influences the adoption of emerging technologies for the manufacturing sector. A theory was even developed about an organization's resistance to early adoption of a new technology due to institutional instability and also due to technology immaturity [15].

In another study carried out in Sweden by Sjödin et al. (2020), an analysis and study were made of two successful and four unsuccessful cases of implementing new business models when moving from selling products to selling services, guaranteeing performance results of products and services. According to Sjödin et al. (2020), he maintains that « This form of business model innovation requires a profound, although little known, change in the way of creating, delivering and capturing value ».

In a study of a shipping company to evaluate the digitalization process that it has carried out in more than 11 years, it was possible to demonstrate the steps that the company took to migrate and update services to digital services. In order for manufacturing companies to direct and evolve their businesses towards servitization, it requires not only the implementation of technological enablers, but also three interconnected changes: (1) from planning to discovery, (2) from scarcity to abundance,

and (3) from hierarchy to association. First, top management must develop and promote a clear, shared, and compelling vision for both the company and the entire network. Second, digital servitization requires radically different knowledge and skills. Third, replicated and (re)distributed at marginal cost, new datasets enable novel services and ultimately enhance competitive advantage. These strategic changes are necessary to ensure the success of digital servitization [17].

In a study carried out by Sestino et al., (2020), it is clearly indicated that the adoption of IoT and Big Data generates an amount of disorganized knowledge and that therefore companies should always analyze and evaluate the impact of these technologies. The same must be applied considering a strategic framework because otherwise it can be counterproductive for the company.

In another study carried out in Germany in 199 companies, it shows the benefits of digitization in the innovation process with the incorporation and support of an Innovation Management Software (IMS – *Innovation Management Software*), which improves efficiency in New Product Development (NPD - New Product Development). However, in the same study it is concluded that the consulting services complementary to the implementation of IMS have a negative influence due to an issue of decision-making capacity in the Innovation Management [19]. Endres (2022), argue in their study of German companies that « Innovation managers prefer less sophisticated and easy-to-use digital solutions without the need for more sophisticated services such as consulting, training and customer support or customization».

In a study carried out in companies in the community of Valencia-Spain, it was analyzed how information systems affect business performance in the services sector, factors such as the age and gender of the manager and the size of the company. It was intended to know how the digitization of *Knowledge-Intensive Business Services (KIBS)* contributes to performance. It is concluded from the study that the use and updating of social networks for corporate purposes, as well as a high level of training in digital tools, regardless of the gender and age of the manager, can obtain good results for the company [20].

In this study, an analysis was carried out in different companies in Portugal, a cluster of 10 companies, where the adoption of technologies from I4.0 was evaluated. In them, it was found that the opportunities for improvement are in efficiency, flexibility, productivity, cybersecurity, quality of products and services, and decision processes based on data analysis [21].

In a study carried out in a cluster of Chinese A-Share companies, it is evident that there is an indirect relationship between the digitization of the manufacturing industry and investment in corporate innovation. Manufacturing companies can implement DT as a differentiating competition strategy while, at the same time, the possibility of generating a cost-competitive strategy is inhibited. Thus, companies with greater viability have a greater incentive to innovate, regardless of the scale of operation, ownership or productivity [7].

Finally, according to Jafari-Sadeghi et al., (2021), a study carried out in companies from 28 EU countries during the period from 2009 to 2015 shows how DT was applied and three basic elements of this application were identified: 1) Technological preparation; 2) Technological exploration and; 3) Technological exploitation.

## DISCUSSION AND CONCLUSIONS

Of the studies reviewed for the present investigation, it was found that most of them propose a DTMS, while few studies with explicit results of improved processes in companies are still evident, as can be seen in Figure 3. The investigation shows that most of the companies that have adopted technological enablers are characterized by having connectivity, use of internet services and Integration of digital technology, but they do not specify in what areas and in what way they have adopted it.

It can also be observed that most companies are interested in adopting IoT and IIoT as the main technology enablers. In studies such as: [2], [10], [18], [23], [24], it is identified that companies are taking into account Big Data and Data Analysis data collection and processing systems as tools to improve production systems and also migrate or evolve business models, leading them to a servitization process, which is the current business trend. However, the studies show new technologies in a general way, but they do not show which is the most effective or popular.

Of the studies reviewed, the positive effects of the adoption of technology are evident, however, they are limited to showing the effects qualitatively and with conclusions that are more business-oriented. Evidence of the impacts of DT on production processes in a diffuse way generates uncertainty for other companies about how to explore and exploit new technologies, according to what was reviewed in the studies.

It is concluded from the research that the studies in companies that have adopted emerging technologies, the results of said adoptions are qualitative; and that the impacts are positive in the improvement of its productive and operational processes. In addition, the technology adopted depends on the line of business and depends a lot on the technologies explored and adopted for each case. Finally, it is clear that the technological trends are IoT and Big Data as well as data analysis.

It can also be concluded that more research and development is required in the companies themselves to measure all production parameters and thus be able to analyze, evaluate and improve production processes with the adoption of new technologies. This research is limited to the analysis of emerging technologies declared in the methodology.

This article allows generating relevant information for future research. More quantitative research is needed to show the results of adopting promising new emerging technologies such as robotics and the digital twin to improve manufacturing processes.

## FINANCIAL SOURCES

The research was not funded.

## CONFLICT OF INTEREST STATEMENT

No potential conflict of interest was reported by the author(s).

## CONTRIBUTION OF THE ARTICLE TO THE LINE OF RESEARCH

This study aims to contribute to the analysis of productivity when new emerging technologies are adopted. This phenomenon is little studied and opens a huge field of research to identify how to explore and exploit new Industry 4.0 technologies in manufacturing companies.

## CONTRIBUTION STATEMENT OF EACH AUTHOR

Researcher Kleber Morillo did the literature review and tabulated the results of the study as well as identified and classified the technologies used in the studies.

## ACKNOWLEDGMENTS

We thank all the professionals who, with their knowledge of various technologies, were able to clarify the areas of action of these technologies within the companies.

## REFERENCES

- [1] Z. Cao and X. Shi, "A systematic literature review of entrepreneurial ecosystems in advanced and emerging economies," *Small Business Economics*, vol. 57, no. 1, pp. 75–110, Jun. 2021, doi: 10.1007/s11187-020-00326-y.
- [2] A. Kotsev, M. Minghini, R. Tomas, V. Cetl, and M. Lutz, "From spatial data infrastructures to data spaces—A technological perspective on the evolution of European SDIs," *ISPRS Int J Geoinf*, vol. 9, no. 3, 2020, doi: 10.3390/ijgi9030176.
- [3] K. Fukuda, "Science, technology and innovation ecosystem transformation toward society 5.0," *Int J Prod Econ*, vol. 220, Feb. 2020, doi: 10.1016/j.ijpe.2019.07.033.
- [4] F. Wiesböck and T. Hess, "Digital innovations: Embedding in organizations," *Electronic Markets*, vol. 30, no. 1, pp. 75–86, Mar. 2020, doi: 10.1007/s12525-019-00364-9.
- [5] European Investment Bank, "Financing the digitalization of small and medium-sized enterprises The enabling role of digital innovation hubs Executive summary," Jun. 2020. doi: 10.2867/210258.
- [6] CEPAL, "Tecnologías digitales para un nuevo futuro," 2022. Accessed: Apr. 30, 2022. [Online]. Available: [https://repositorio.cepal.org/bitstream/handle/11362/46816/1/S2000961\\_es.pdf](https://repositorio.cepal.org/bitstream/handle/11362/46816/1/S2000961_es.pdf)
- [7] H. Wen, Q. Zhong, and C.-C. Lee, "Digitalization, competition strategy and corporate innovation: Evidence from Chinese manufacturing listed companies," *International Review of Financial Analysis*, vol. 82, p. 102166, Jul. 2022, doi: 10.1016/j.irfa.2022.102166.






- [8] A. Kamalaldin, L. Linde, D. Sjödin, and V. Parida, "Transforming provider-customer relationships in digital servitization: A relational view on digitalization," *Industrial Marketing Management*, vol. 89, pp. 306–325, Aug. 2020, doi: 10.1016/j.indmarman.2020.02.004.
- [9] S. A. Zahra, W. Liu, and S. Si, "How digital technology promotes entrepreneurship in ecosystems," *Technovation*, 2022, doi: 10.1016/j.technovation.2022.102457.
- [10] R. Grandinetti, M. V. Ciasullo, M. Paiola, and F. Schiavone, "Fourth industrial revolution, digital servitization and relationship quality in Italian B2B manufacturing firms. An exploratory study," *TQM Journal*, vol. 32, no. 4, pp. 647–671, Jul. 2020, doi: 10.1108/TQM-01-2020-0006.
- [11] F. Pirola, X. Boucher, S. Wiesner, and G. Pezzotta, "Digital technologies in product-service systems: a literature review and a research agenda," *Computers in Industry*, vol. 123. Elsevier B.V., Dec. 01, 2020. doi: 10.1016/j.compind.2020.103301.
- [12] M. F. Tuysuz and R. Trestian, "From serendipity to sustainable green IoT: Technical, industrial and political perspective," *Computer Networks*, vol. 182, Dec. 2020, doi: 10.1016/j.comnet.2020.107469.
- [13] M. Paiola and H. Gebauer, "Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms," *Industrial Marketing Management*, vol. 89, pp. 245–264, Aug. 2020, doi: 10.1016/j.indmarman.2020.03.009.
- [14] J. Rueb, H. Bahemia, IEEE Technology Engineering and Management Society., and Institute of Electrical and Electronics Engineers, "The Examination of the Corporate Organization and Implementation of Industry 4.0 in a High Value German Manufacturing Firm.," Jun. 15, 2020. doi: 10.1109/ICE/ITMC49519.2020.9198634.
- [15] J. Bonnin Roca, P. Vaishnav, G. M. Morgan, E. Fuchs, and J. Mendonça, "Technology Forgiveness: Why emerging technologies differ in their resilience to institutional instability," *Technol Forecast Soc Change*, vol. 166, May 2021, doi: 10.1016/j.techfore.2021.120599.
- [16] D. Sjödin, V. Parida, M. Jovanovic, and I. Visnjic, "Value Creation and Value Capture Alignment in Business Model Innovation: A Process View on Outcome-Based Business Models," *Journal of Product Innovation Management*, vol. 37, no. 2, pp. 158–183, Mar. 2020, doi: 10.1111/jpim.12516.
- [17] B. Tronvoll, A. Sklyar, D. Sörhammar, and C. Kowalkowski, "Transformational shifts through digital servitization," *Industrial Marketing Management*, vol. 89, pp. 293–305, Aug. 2020, doi: 10.1016/j.indmarman.2020.02.005.
- [18] A. Sestino, M. I. Prete, L. Piper, and G. Guido, "Internet of Things and Big Data as enablers for business digitalization strategies," *Technovation*, vol. 98. Elsevier Ltd, Dec. 01, 2020. doi: 10.1016/j.technovation.2020.102173.



- [19] H. Endres, S. Huesig, and R. Pesch, "Digital innovation management for entrepreneurial ecosystems: services and functionalities as drivers of innovation management software adoption," *Review of Managerial Science*, vol. 16, no. 1, pp. 135–156, Jan. 2022, doi: 10.1007/s11846-021-00441-4.
- [20] S. Ribeiro-Navarrete, D. Botella-Carrubi, D. Palacios-Marqués, and M. Orero-Blat, "The effect of digitalization on business performance: An applied study of KIBS," *J Bus Res*, vol. 126, pp. 319–326, Mar. 2021, doi: 10.1016/j.jbusres.2020.12.065.
- [21] G. Dalmarco, F. R. Ramalho, A. C. Barros, and A. L. Soares, "Providing industry 4.0 technologies: The case of a production technology cluster," *The Journal of High Technology Management Research*, vol. 30, no. 2, p. 100355, Nov. 2019, doi: 10.1016/j.hitech.2019.100355.
- [22] V. Jafari-Sadeghi, A. Garcia-Perez, E. Candelo, and J. Couturier, "Exploring the impact of digital transformation on technology entrepreneurship and technological market expansion: The role of technology readiness, exploration and exploitation," *J Bus Res*, vol. 124, pp. 100–111, Jan. 2021, doi: 10.1016/j.jbusres.2020.11.020.
- [23] L. Li, F. Su, W. Zhang, and J. Y. Mao, "Digital transformation by SME entrepreneurs: A capability perspective," in *Information Systems Journal*, Nov. 2018, vol. 28, no. 6, pp. 1129–1157. doi: 10.1111/isj.12153.
- [24] A. Farrokhi, R. Farahbakhsh, J. Rezazadeh, and R. Minerva, "Application of Internet of Things and artificial intelligence for smart fitness: A survey," *Computer Networks*, vol. 189. Elsevier B.V., Apr. 22, 2021. doi: 10.1016/j.comnet.2021.107859.

## BIOGRAPHICAL NOTE



Kleber R. Morillo-Aguilar. **ORCID iD**  <https://orcid.org/0000-0002-2839-3104> is a researcher at the National University of Loja. Master in Project Management at the University of the Armed Forces, Master in Industry 4.0 at UNIR and Engineer in Electronics and Control at the National Polytechnic School. His line of research is the new emerging technologies and DT for industry and manufacturing.





This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

