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# INDUSTRY 4.0 AND LAST MILE LOGISTICS, NEW CHALLENGES AND APPROACHES: A BIBLIOMETRIC REVIEW

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# INDUSTRY 4.0 AND LAST MILE LOGISTICS, NEW CHALLENGES AND APPROACHES: A BIBLIOMETRIC REVIEW

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## Abstract

Discussions about the relationship between the fourth industrial revolution, also called Industry 4.0, and last mile logistics are an issue that has grown over time due to the development of new technologies that take on new industries and the lack of processes and innovation to accompany the evolution of Industry 4.0 and cover optimization needs in the last mile of the logistics chain. This article's main objective is to research the new challenges and approaches that arise in this fourth industrial revolution to face and optimize the last mile of the logistics chain. To fulfill this purpose, a systematic literature review was carried out, as well as a bibliometric analysis. 100 articles were reviewed in detail, the origin of these articles is 100% Scopus to ensure quality content in the research. The results show a constant development of the technologies that make up Industry 4.0 in organizations worldwide, which leads to large-scale growth, thus resulting in the need for process optimization for last-mile logistics.

## Keywords
Industry 4.0, Last Mile Logistics, Bibliometric Analysis, New Industry, Logistics Distribution.

## 1. Introduction

Last mile logistics is understood as the last link of the supply chain service that includes all movements related to commercial activities, supply and distribution of products for industry, marketing and consumption in cities (Alfieri et al., 2019). The supply chain is composed of different processes and the distribution of goods is of the last steps that encompasses the delivery of products or services to the final consumer, this step faces permanent challenges that seek the optimization of economic resources for the benefit of organizations and final consumers (Zhang et al., 2019). An important role involved in this stage is that of the most common end consumers which are business establishments, commercial, industrial, private homes and B2C (Ali et al., 2019). In order to achieve optimization solutions in this stage of the logistics chain, new technologies are presented as possible solutions, these are developed and are part of the new industry (Guo et al., 2019). There are new approaches that are embodied to meet the challenges of the exposed juncture, approaches that are developed from the need to cope with the technological growth that comes with contemporaneity in Industry 4.0 (Janjevic & Winkenbach, 2020). Implementing the use of emerging technologies such as Big Data analysis, Cyber Physical Systems, Autonomous Systems or Blockchain technology, are postulated as the main solutions for the optimization of processes deployed in the last mile (Li et al., 2020). in last mile logistics?

### 1.1 Objectives

Having stated the above, the main objective of this article is to analyze the evolution and new approaches proposed by Industry 4.0 for the processes involved in last mile logistics through a respective bibliometric study. That is why it is motivated to answer the following questions:
Q1: What is the current state of the literature regarding the implications of Industry 4.0 on last mile logistics process management?
Q2: What would be a correct definition of Industry 4.0 in the field of last mile logistics?
Q3: What other technology or technologies are involved in the pursuit of last mile logistics 4.0?
Q4: What is the impact of new technologies on last mile logistics?
Q5: What are the barriers that limit the implementation of these technologies?

## 2. Literature Review

The influence of the fourth industrial revolution is explained, emphasizing the fundamental change it has had on people's lives and work (Carvalho et al., 2020). The development of new technologies combining the physical, digital and biological world has influenced all scientific, economic, industrial and political aspects and disciplines. A generalization of new technological advances has been evidenced by developing artificial intelligence, biotechnology, nanotechnology and quantum computing technology, blockchain, internet-based technology and 3D printers (Díaz Martínez et al., 2020). Digital technology has unwrapped the apogee of the fourth industrial revolution, with internet technology being increasingly massive not only connecting millions of people around the world, but also becoming the basis for online commercial and transportation transactions. In addition to being the main means of learning for the development of new options for adapting to this new stage (Peña-Jimenez et al., 2021). Development alternatives are sought to accompany and cover new processes, areas and stages involved in the fourth industrial revolution, also called Industry 4.0 (Luthra et al., 2020). They seek to optimize processes that go hand in hand with the evolution that the world is having at the industrial level and describe the need for countries to be prepared to cope with various changes that are already occurring and will continue to occur in the world. The changes that occur not only have an effect on the different industries, but also on the lives of all human beings in general; however, this fourth industrial revolution is something that cannot be avoided, so everyone must be prepared to face the changes (Vrchota & Pech, 2019).

IR 4.0 is a new phase for the current trend of automation and data exchange in the manufacturing industry that focuses on cloud computing, interconnectivity, the Internet of Things, machine learning, cyber learning, and the creation of smart factories (M.S.R.A, N.R., & N.A.B., 2022). Industry 4.0 involves a set of technologies, organizational concepts, and management principles to improve the performance of manufacturing companies or supply chains driven by production cost optimization, mass customization requirements, connectivity, and factory digitization. (J. & M., 2021) Vaccine distribution: Recent events such as the Covid-19 vaccine distribution problems and the blockage of the Ever Given ship in the Suez Canal raised concerns about the fragility of the traditional supply chain. Last-mile customized fulfillment may play a catalytic role in the proliferation of Industry 4.0. This growing trend will reduce standard production, bringing manufacturing closer to the customer and ultimately reducing the supply chain to the last mile (D., L., & J.L., 2021). Real-time delivery system: In the pandemic situation, with the transformation of customer needs, online drug delivery in the last mile has increased. The retailer is under pressure to redesign delivery business models that respond to customer expectations of faster delivery, low cost, availability and contactless. The existing delivery model lacks end-to-end connectivity, leading to inefficiencies specifically in urban last mile delivery. The lack of end-to-end connectivity in last mile delivery leads to delivery delays, lack of transparency, mis-delivery, accidents and poor performance. The delivery operator (driver) is the primary link in highly responsive last mile delivery. To improve performance, it is imperative to monitor and control driver behavior to stop many traffic accidents. The application of artificial intelligence (AI) will play a crucial role in improving last mile delivery and customer experience. Through the advanced driver assistance system (ADAS), AI addresses the safety problem involving an algorithm to predict operator behavior. The Chapter proposes an artificial intelligence-based real-time alert system, which will provide an intelligent solution that will incorporate the delivery operator's behavior, such as driving pattern, fatigue control, blinker, braking and curved angles and other road conditions, alert notification on a real-time basis. time basis. The system will collect location data via GPS (Global Positioning System) and generate real-time information on driver performance, evaluated via cell phone. The objective is to evaluate driver behavior patterns in terms of safe and economical driving and provide the driver with feedback and suggestions for improvement. In last mile delivery, operator behavior managed through this smart solution will help avoid accidents,

streamline processes, and ultimately improve the customer experience for timely product delivery in the UAE (L., V.K., & N., 2022).

Zero Touch delivery system: After the first lifting of the COVID-19 forced lockout, with consumers reluctant to shop in physical stores and online deliveries taking twice as long to arrive, in-store pickup, commonly known as "Click & Collect," has become a pragmatic alternative practice. Still, most retailers require their in-store pickup customers to wait in long lines before being served and then wait again for their orders to be picked up. Therefore, it is imperative that the Click & Collect business model be adjusted to minimize physical contact in order to avoid future government-imposed store closures, safeguard against the sharp decline in retail sales, and support the struggling economy during a potential recurring. COVID-19 related crisis. That is exactly where the proposed solution sets its vision with the objective of adapting "Click & Collect" to the new reality by introducing an innovative, completely contactless customer order delivery system. The proposed innovation is based on the rapidly expanding "van at the curb" model and enhanced with two technologies, i.e. Wi-Fi positioning system and augmented reality. It is intended to be highly scalable and support the retail industry in its battle against the pandemic by arming retailers with an easy to implement and use system, helping them overcome the challenges created by COVID-19. (S., E., G., K., & T.N., 2022).

## 3. Methods

This chapter will explain the methodology used. It is very important to establish a correct order of the steps in order to obtain the exact data for the analysis of the subject. The first and most important step of all was to search for and collect information; in a systematic review study, the most important thing is to study a large amountof information in order to understand the topic in depth. The second step was to perform a statistical analysis to obtainnumerical information and finally the last step was to perform a bibliometric analysis. The next step was to review and gather literature on our research topic which is Industry 4.0 and its application in last mile logistics. The methodology used was PRISMA in which questions and objectives were raised to define the scope of the research before starting the search for articles with information relevant to our topic. All this with the main objective of conducting a clean and focused research.

To begin the research, the topic of interest was defined using the central theme of the study. Since new technologies are continually being discovered and the times require new solutions, it was necessary to study the latesttechnological reviews. Obtaining a large number of articles on the topic studied will help us to guarantee the purposeof this research, which is to study the topic as much as possible in order to draw accurate and current conclusions.

### 3.1 Search/Collection of information

The first step for this SLR was the identification of the literature. In order to obtain a correct and current study and analysis, it was determined that the information collected should be journal articles in English language, mostly collectedfrom a reliable and recognized database, in this case Scopus was chosen as the database of choice. In order to maintainthe timeliness of the research, it was defined that the maximum date of acceptance of a journal article should be the year 2016. In the Scopus database, different searches were performed using combinations of words explained below.

Table 1. Combination of strings used in the overall search

| Search Terms | Applied Query | Search Results |
|---|---|---|
| "Industry 4.0" and "Lastmile logistics". | (TITLE-ABS-KEY (industry 4.0) AND TITLE-ABS-KEY (last AND mile AND logistics)) AND PUBYEAR > 2015 | 249 |
| "Industry 4.0" AND "Definition". | (TITLE-ABS-KEY (industry 4.0) AND TITLE-ABS-KEY (definition)) AND PUBYEAR > 2015 | 510 |
| "Last mile logistics" AND "Technology". | (TITLE-ABS-KEY (industry 4.0) AND TITLE-ABS-KEY (technology)) AND PUBYEAR > 2015 | 10 |
| "New technologies" AND"Last mile logistics". | (TITLE-ABS-KEY (industry 4.0) AND TITLE-ABS-KEY (new AND technologies)) AND PUBYEAR > 2015 | 9 |
| "Last mile logistics" AND "Challenges". | (TITLE-ABS-KEY (industry 4.0) AND TITLE-ABS-KEY (challenges)) AND PUBYEAR > 2015 | 3820 |

The first combination was carried out for the purpose of statistical and bibliometric analysis, it was decided to review all the information found in the different articles in the respective years in order to have a deep and current research. The use of software was necessary to have a better visualization of the findings on the subject and its evolution over time. The other combinations were made with the objective of answering the research questions proposed above.

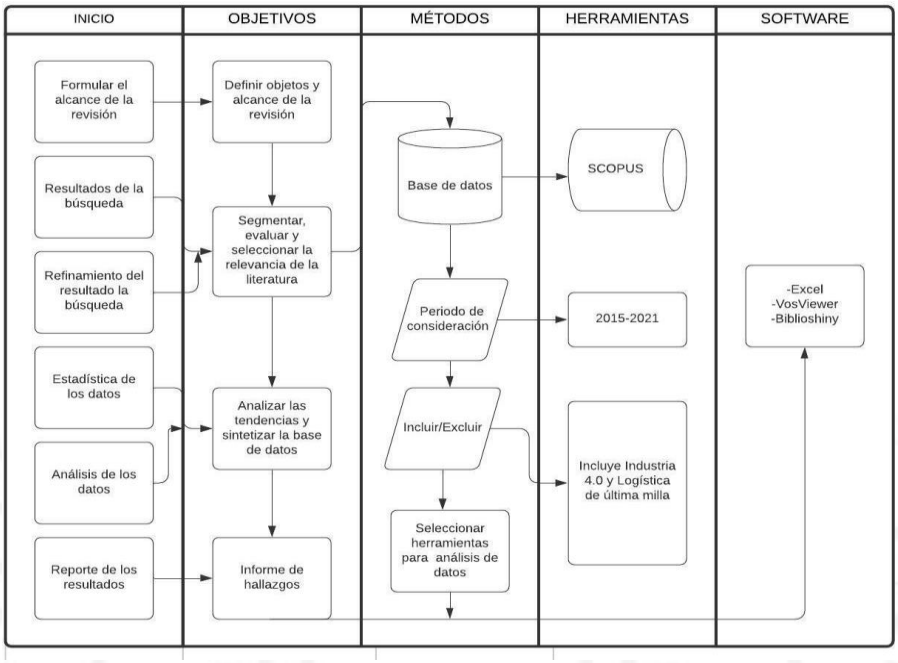


Figure 1. Flow of the Source Collection Process

Figure 1 shows step by step each action taken for the investigation of the respective topics, from the beginning of the investigation defining the necessary objectives to be fulfilled as well as the methods and tools used to gather the necessary information for a validated investigation. We also include the software used to build resources and information.

## 3.2 Bibliometric Analysis

The analysis was performed with the totality of articles collected according to the criteria in Table 2.1, collecting in total 259 articles found with the reference of Industry 4.0 and last mile logistics, this search consists in an extended way with exactly 787 authors, 1284 keywords, and more than 15 000 references. Regarding the number of publications by country, China is in the first place, which is a coincidence as it is a countrythat has been governed for the last two decades by engineers, in addition to having 72% of the population studying engineering and exact sciences.

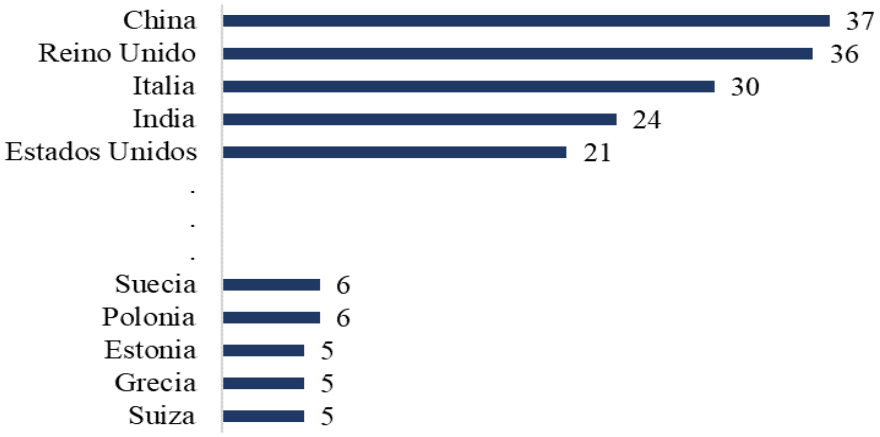

Figure 2. Distribution of Sources by Country

Figure 3 shows the contribution of each of the authors in the last 5 years of study. The article reviewed and used as references documents elaborated with the contributions of Banyai.T; Matt D.T.; Rauch. E; Prause. G; Kumar. V; and Dwivedi. A; because they have a nourishing knowledge of the subject that is still unknown to most researchers.

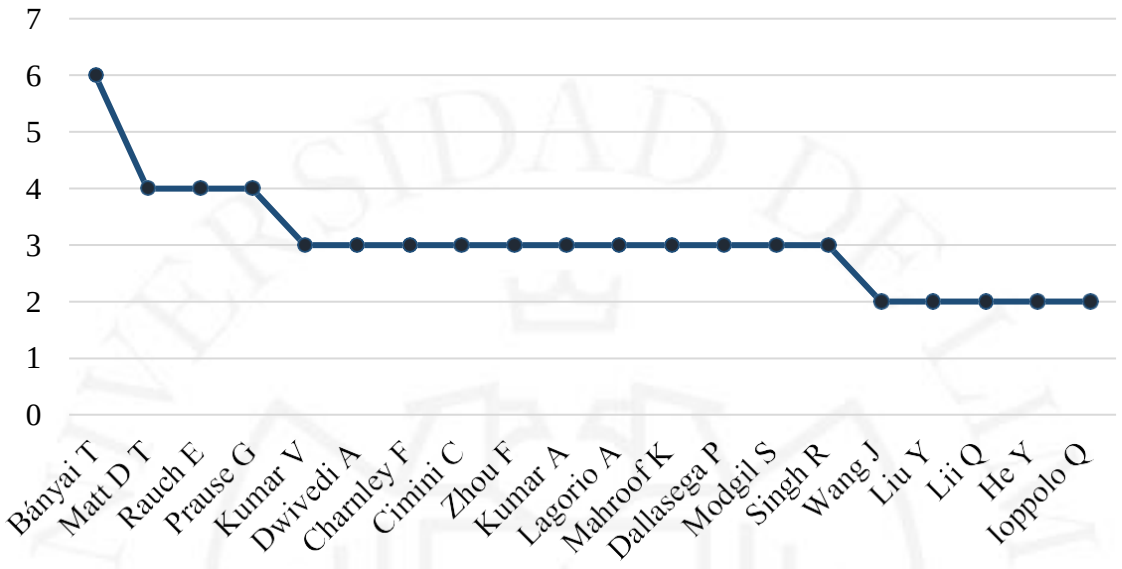


Figure 3. Authors' contribution in the last 5 years

For the word matching analysis, Figure 4, the Vos Viewer tool was used to show the relationship of keywords among the existing publications. As expected, the two most important and prominent clusters on the map are "Industry 4.0" and "Logistics" with 270 hits. Finally, the relationship with Supply Chain, Sustainability, Block Chain and Machine Learning can also be noticed.

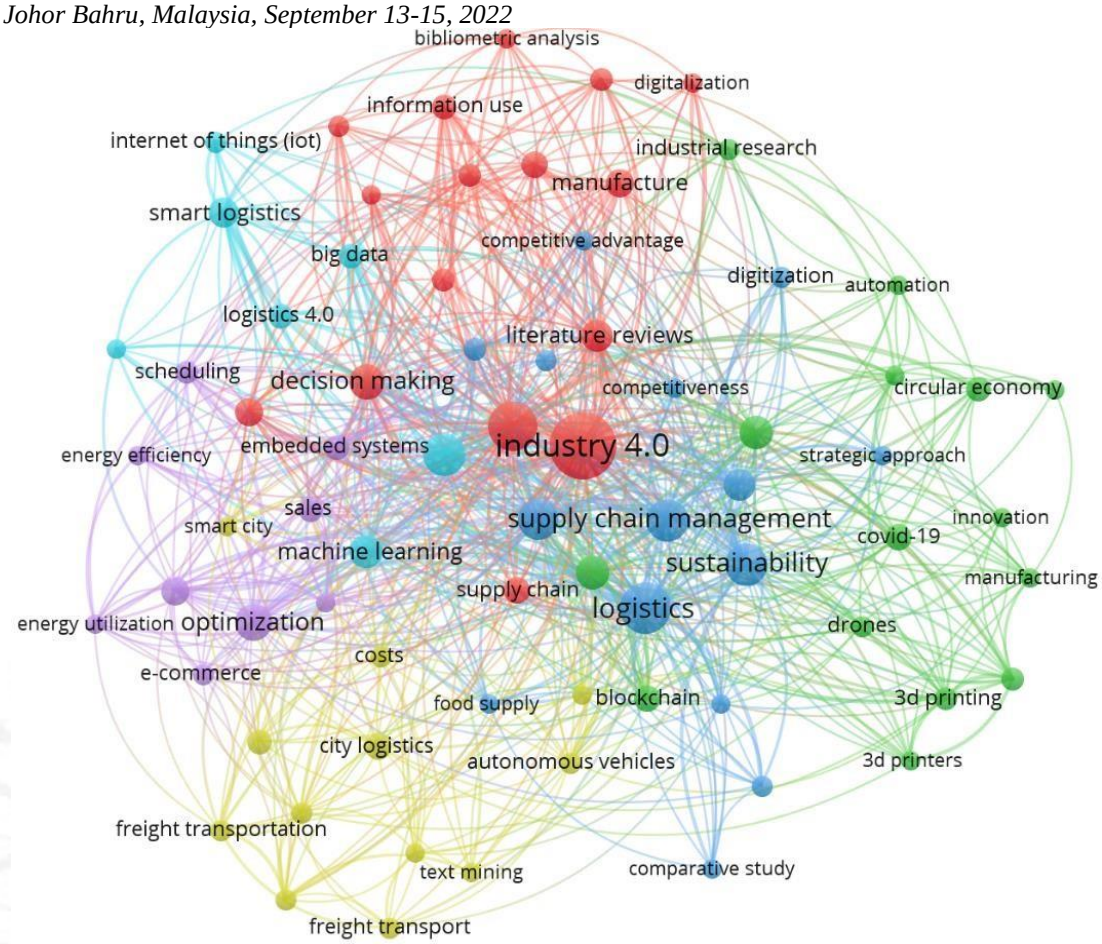


Figure 4. Word matching analysis

## 4. Results and Discussion

The involvement of Machine Learning in the structure for the development of solutions that optimize the processes involved in the last mile is important because it generates new aggregated technologies that accompany and are an important part of the Industry 4.0 boom. The added value of Machine Learning is expressed in the storage cluster, where algorithms are used to read handwritten documents, events that are digitized and recorded to detect future eventualities. This allows the tool to focus on identity validation, matching names and distribution addresses, using supervised learning techniques with good accuracy results.

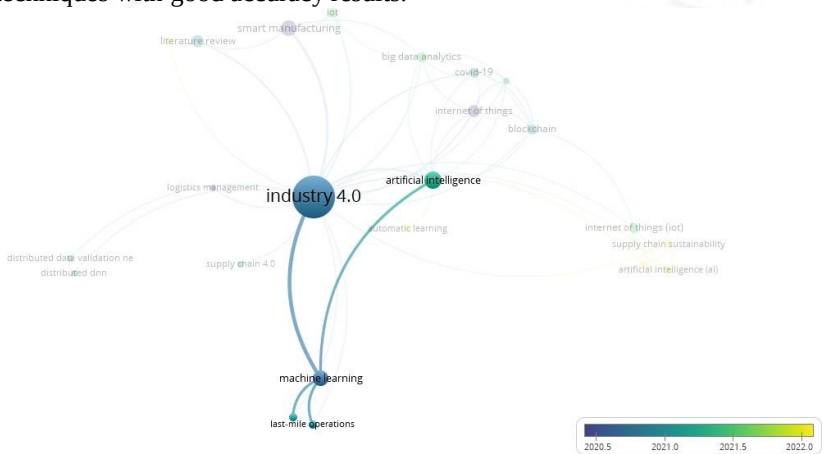

Figure 5. Cluster focus related to Machine Learning

The visual perspective provided by Machine Learning, expresses the direct relationship that exists between last mile operations as an opportunity for research and development through a tool such as machine learning that has been explored and is postulated as one of the main ones in development for Industry 4.0. Big Data is a very important part of Industry 4.0, due to the fact that nowadays the accelerated development of transactions generates a large number of actions that are recorded in massive data in all types of industry. In this context, Big Data analysis allows to generate information through trends to better manage operational processes, in order to reduce costs and generate satisfactory results for customers. Big data analysis can show points of conflict in the last mile operation, such as problems in routes, communication or different incidents that reflect the analyzed information. Therefore, the tool is presented as important and fundamental for companies with adequate investment capacity, thus generating satisfactory results in their development.

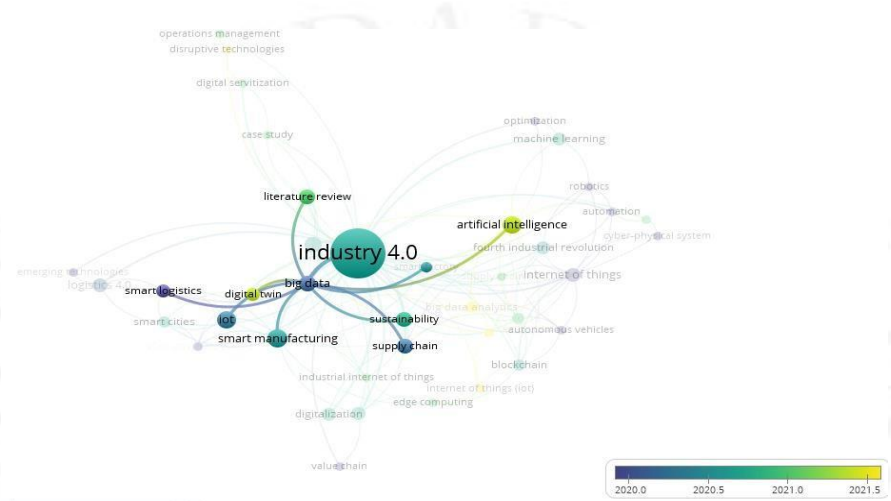


Figure 6. Focus of the cluster related to Big Data

As shown in the figure, one of the main relationships that handles Big Data is Industry 4.0 and Smart Logistics, this structure is given jointly; since Big Data is part of the industry 4-0 as a tool that is used in logistics processes willing to be digitally transformed. The Artificial Intelligence approach has enabled a general change in the functioning of all industries, this has been driven by the explicit development in the interaction of man and machine. This tool is the fundamental engine of Industry 4.0, as it has become the most disruptive technology whose mission is to revolutionize all types of management models in business and industry.

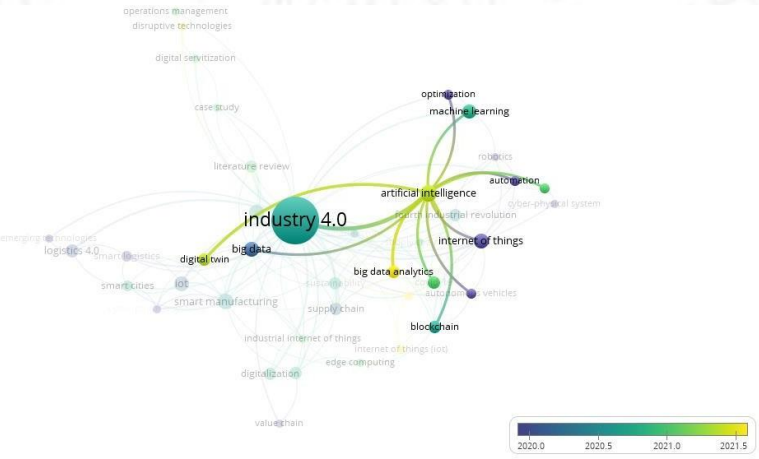


Figure 7. Focus of the cluster related to Artificial Intelligence

Nowadays, the clear participation of Artificial Intelligence in the development of other tools involved in Industry 4.0 is shown. Consequently, the application of Artificial Intelligence in industries reveals positive effects in terms of economy, quality and research development worldwide. Technology is advancing at a rapid level allowing companies to have a competitive advantage by making use of these, the ease of carrying out faster and more effective processes, improving the user experience, makes the updating and use of these new technologies vital for the survival of the company in its respective area.

## 5.1 Proposed Definition

After conducting an extensive study on Industry 4.0 and its implication in last mile logistics, it will be propose a definition that will demonstrate more emphatically its relationship: "At a time when Industry 4.0 is being increasingly used with the purpose of quantitatively and qualitatively improving different processes to obtain greater automation and connection between the parties involved, its definitive uses stands out in the last stage of an important process such as last mile logistics which currently according to the environment in which it is located needs a rapid change of direction in order to meet the challenges presented by the current needs of customers or final recipients in order to ensure the quality of service by optimizing processes achieving an increase in their profitability."

## 5.2 Immersed technologies

Blockchain is a large, distributed, consensus-based ledger of transaction records and in most cases is immutable or untraceable (Galati, 2022). With the continuous improvement of blockchain-based infrastructures, blockchain technology can provide more reliable proof of the existence of various digital assets (M. Liu et al., 2023). It also has enormous potential in IoT security, data privacy preservation, security auditing, anonymous authentication and anonymity protection. (Y. Liu et al., 2022). blockchain provides a reliable solution to the problems of poor exchange, low effectiveness and weak security in data management (Sun et al., 2022).

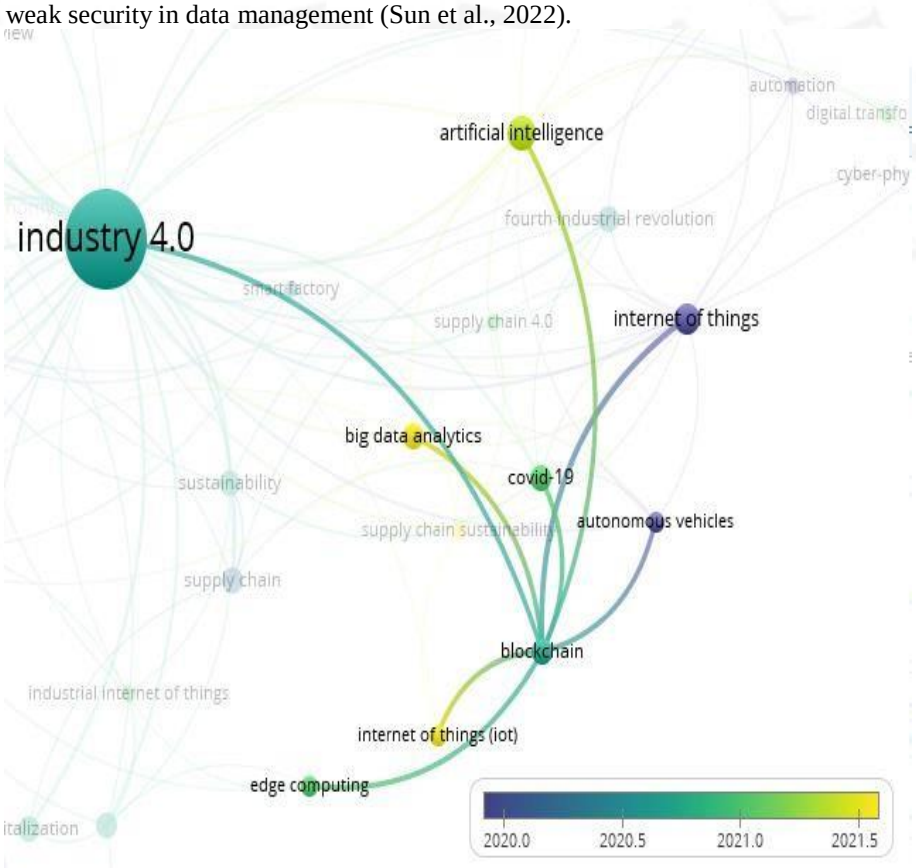


Figure 8. Blockchain cluster focus.

Drones are defined as unmanned aerial systems (UAS), unmanned aerial vehicles (UAV) or aircraft that operate without a human on board (J. Liu et al., 2021). Drones are remotely controlled and consist of different sensors that can capture and record visual and audio data for monitoring and mapping operations. (Wubben et al., 2022). The dronehas been found to be a promising development that can improve the delivery of products to consumers in the "last mile,"

both from an economic and environmental perspective. (Ren et al., 2022). From an economic perspective, drones are not restricted to a discrete set of static roads and can move flexibly in three dimensions (Rejeb et al., 2021). This capability allows them to bypass traffic congestion or accidents and, as a result, travel at more constant and higher average speeds, which can substantially reduce delivery times. UAVs (drones) are evolving rapidly and provide a powerful technical approach for many applications in protected areas, e.g., crop condition mapping, zonal yield prediction, disease detection.

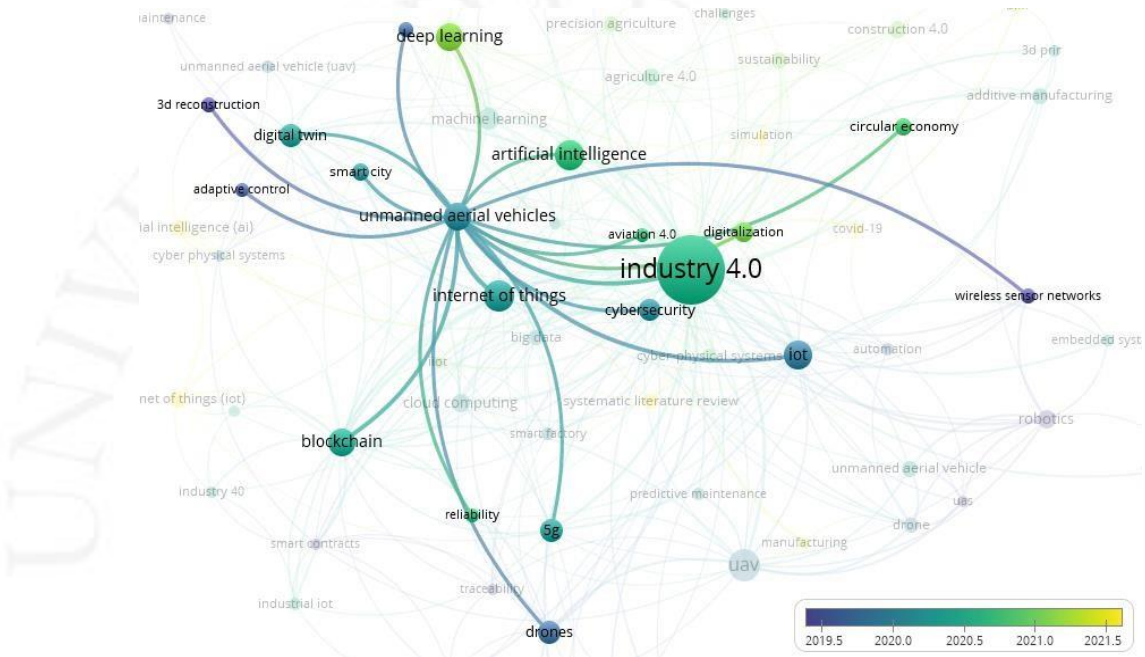


Figure 9. UAV Cluster Focalization

## 5.2. Impact of new technologies

During the research it was concluded that Industry 4.0 brings many innovative tools for their respective application to last mile logistics, having already defined a couple of new technologies, the next step will be to proceed to define the application of these and the impact they generated when implemented to solve the respective problems studied in the scientific articles briefly explaining their operation and results.

Data control in the food sector: As defined in a previous subtitle, the Blockchain is a tool for secure and reliable data management, for this same reason the application of this in the food industry was carried out. There are different types of data such as temperature of perishable products that could jeopardize the quality of the food as well as the reputation of the company, one of the challenges for IoT technologies in the context of food safety is the need to provide detection of acceptable quality for compliance verification. In today's delivery processes, temperature checksare performed at key points to ensure food safety compliance. The intermittent nature of these readings means that they record the temperature at a specific point but provide limited information on temperature changes that may haveoccurred during the time since the last reading. There is an opportunity to gain more information through constant temperature monitoring, which can be useful for companies and customers. These observations informed the application scenario for the PROoFD-IT system, which was designed to improve current food safety monitoring practices implemented by companies by introducing continuous monitoring of food temperature throughout the delivery process, increasing the availability of food safety data and reducing the need for paper-based record keeping.(Markovic, Jacobs, Dryja, Edwards, & Strachan, 2020). We argue that companies using IoT should comply with verysimilar monitoring standards to avoid problems during inspections (Markovic, Jacobs, Dryja, Edwards, & Strachan, 2020). Blockchain-based

solutions offer potential benefits in food safety, food security, food integrity, and waste management (Kamilaris et al., 2019). Decreased delivery time for home deliveries: Drones have certain advantages compared to conventional ground vehicles. For example, drones are not limited to road infrastructure, allowing themto be used in areas with a poor road network (Ackerman & Strickland 2018). We will explain three home delivery models in which drone use is key to their operation: FTRPD, STRPD, and MTRPD. FTRPD is a hybrid delivery model consisting of a single truck with one or several ($K \geq 1$) UAVs. Both the truck and the UAVs can deliver packages to customers. The UAVs can be launched from the truck at the depot or at the customer's premises. Therefore, the truckserves as a mobile hub for UAVs to effectively extend the service range of UAVs. The objective of this problem is tofind the routes of the truck and UAVs to minimize the sum of all customer waiting times. The STRPD model assumes that once a UAV is launched from a truck, the UAV can rejoin the truck at a location different from its original launch location. This model can be used in urban environments where trucks cannot easily find a parking spot. Therefore, they have to dispatch a UAV and retrieve it at another location on the truck's route. The MTRPD model assumes that, if the truck launches any UAV, the truck must stop at the launch site to retrieve it. Therefore, if a UAV is launched atlocation i, it is also recovered at location i. This model can allow the driver to take control of UAV launches and retrievals when a lower level of technology is available (Moshref-Javadi, Hemmati, & Winkenbach, 2021). Numerical results show that all three models can significantly reduce customer waiting times. The FTRPD, for example, can reduce customer waiting time by more than 60 % in some of the problematic instances compared to the truck-only scenario (Moshref-Javadi, Hemmati, & Winkenbach, 2021).

## 5.4 Barriers

Barriers in the implementation of these new technologies can be defined as the difficulties encountered when making use of it in a real scenario with different variables that could affect its operation, among them the applicationin real life cases, understanding and design of the variables necessary for its effectiveness, cost of implementation and evaluation of profitability for certain specific processes. In the case of blockchain technology, this pilot project has revealed a number of challenges that need to be addressed before solutions, such as the PROoFD-IT system, can be implemented in real delivery processes. The most prominent challenge is the difficulty of translating existing human-centric guidelines, such as HACCP, into instructions that can be used by intelligent software systems. While these food safety management systems initially appear to have clear guidelines, for example, on critical temperature limits,they are designed first and foremost to be used by humans. Our experience with real-world delivery workflows highlights the need for such guidelines to be much more detailed and deterministic, clearly stating the expected outcomes in a variety of situations. (Markovic, Jacobs, Dryja, Edwards, & Strachan, 2020). As for the implementationof drones for use in home deliveries, this reduction in customer wait times is highly dependent on the parameters of the models, including the number of UAVs, the UAV-to-truck speed ratio, the UAV flight time limit, and the UAV service time. Among all parameters, the models are very sensitive to the number of UAV parameters. The savings incustomer waiting time are higher for problems with highly congested and clustered networks compared to uniformlydistributed networks. The results show that there is a considerable trade-off between minimizing customer waiting times and minimizing the costs of distributions, and therefore the correct objective function must be chosen carefully.(Moshref-Javadi, Hemmati, & Winkenbach, 2021).

## 6. Conclusion

The present research study has focused on a topic that has not been fully explored and related because it is in a constant transition of research and technological innovation that allows it to be adapted to the needs of the subject under study. The context of the Last Mile has demanded the need to implement new technological tools of Industry 4.0, tools such as Machine Learning, IoT and Big Data have facilitated and provided the optimization of various processes involved in the last mile, in addition they have served as a starting point for the exploration and implementation of new solutions. However, there are limitations and disadvantages that directly and indirectly affect the traditional development of last mile logistics, so it is important to focus future research on the adaptation and role that Industry 4.0 tools take. It is important to make impetus on the comprehensive analysis conducted of the role of Industry 4.0 in the large number of studies of last mile logistics through a systematic literature review approach. Currently, large companies are looking for Industry 4.0 coupling as part of the digital transformation process in order to obtain current optimization methods that easily adapt to future changes. The reading indicates that the development of new platforms, methods and means to be used in the development of last mile logistics are directly related to the digitization and virtualization used by its tools, since these provide flexibility and a quick adaptation level that serve as an answer to the needs of the companies. Finally, after performing the bibliometric and statistical analysis, it is evident that the research of Industry 4.0 tools for the benefit of last mile logistics is constantly growing and is still a niche with great potential for exploitation. It is now where companies are responsible for implementing the tools provided by Industry 4.0, adapting them to their digital transformation process and developing research for the benefit of optimizing their processes in the last mile of their logistics. The suggested review is designed to explain the link between Industry 4.0 and Last Mile Logistics and the implication of its tools for the development of new methods that can be implemented in the future.

## References

Ali, S. S., Deka, S., Ahmad, Z., Ahmed, S., Jaswal, M., & Alsulami, H. Feasibility of drone integration as last mile delivery. Emerald Emerging Markets Case Studies, 9, 1-17, 2019.

Alfieri, A., de Marco, A., & Pastore, E. Last mile logistics in Fast Fashion supply chains: A case study. IFAC-PapersOnLine, 52, 1693-1698, 2019.

Carvalho, A. V., Chouchene, A., Lima, T. M., & Charrua-Santos, F. (2020). Cognitive manufacturing in industry 4.0 toward cognitive load reduction: A conceptual framework. Applied System Innovation, 1-14.

Díaz Martínez, M. A., Román Salinas, R. V., Santiago, A. D., Barrios, C. M., & Cruz, R. Z. Industry 4.0 and digitalization towards job satisfaction in organizations in Tampico, Tamaulipas, Mexico. Revista de Métodos Cuantitativos Para La Economia y La Empresa, 43-57, 2021.

Galati, F. Blockchain adoption in supply networks: a social capital perspective. 17-32, 2021.

Guo, X., Lujan Jaramillo, Y. J., Bloemhof-Ruwaard, J., & Claassen, G. D. H. On integrating crowdsourced delivery in last-mile logistics: A simulation study to quantify its feasibility. Journal of Cleaner Production, 241, 2019.

Janjevic, M., & Winkenbach, M. Characterizing urban last-mile distribution strategies in mature andemerging e-commerce markets. Transportation Research Part A: Policy and Practice, 133, 164-196, 2020.

Li, X., Gong, L., Liu, X., Jiang, F., Shi, W., Fan, L., Gao, H., Li, R., & Xu, J. Solving the last mile problem in logistics: A mobile edge computing and blockchain-based unmanned aerial vehicle delivery system. Concurrency Computation , October, 1-14, 2020.

Liu, J., Xiang, J., Jin, Y., Liu, R., Yan, J., & Wang, L. Boost precision agriculture with unmanned aerial vehicle remote sensing and edge intelligence: A survey. Remote Sensing, 13, 2021.

Liu, M., Zhang, Z., Chai, W., & Wang, B. Computer Standards & Interfaces Privacy-preserving COVID-19 contact tracing solution based on blockchain. Computer Standards & Interfaces, 83, 103643, 2023.

Liu, Y., Zhang, L., & Zhao, Y. Deciphering Bitcoin Blockchain Data by Cohort Analysis. 1-7. 2022.

Luthra, S., Kumar, A., Zavadskas, E. K., Mangla, S. K., & Garza-Reyes, J. A. Industry 4.0 as an enabler of sustainability diffusion in supply chain: an analysis of influential strength of drivers in an emerging economy. International Journal of Production Research, 58, 1505-1521, 2020.

Peña-Jimenez, M., Battistelli, A., Odoardi, C., & Antino, M. Exploring skill requirements for theindustry 4.0: A worker-oriented approach. Anales de Psicologia, 37, 577-588, 2021.

Rejeb, A., Rejeb, K., Simske, S., & Treiblmaier, H. Humanitarian Drones: A Review and Research Agenda. Internet of Things (Netherlands), 100434, 16 May 2021.

Ren, S., Malof, J., Fetter, R., Beach, R., Rineer, J., & Bradbury, K. Utilizing Geospatial Data for Assessing Energy Security: Mapping Small Solar Home Systems Using Unmanned Aerial Vehicles and Deep Learning. ISPRS International Journal of Geo-Information.

Sun, Z., Han, D., Li, D., Wang, X., Chang, C. C., & Wu, Z. A blockchain - based secure storage scheme for medical information. EURASIP Journal on Wireless Communications and Networking.

Vrchota, J., & Pech, M. Readiness of enterprises in Czech Republic to implement industry 4.0: Index of industry 4.0. Applied Sciences (Switzerland), 9, 2019.

Wubben, J., Morales, C., Calafate, C. T., Hernández-Orallo, E., Cano, J. C., & Manzoni, P. ImprovingUAV Mission Quality and Safety through Topographic Awareness. Drones, 6-3, 2022.

Zhang, Y., Fan, X., & Zhou, L. Analysis and Research on the "last mile" distribution innovation model of e-commerce express delivery. Journal of Physics: Conference Series, 1176, 2019.

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**Juan Carlos Quiroz-Flores** is an MBA from Universidad ESAN. Industrial Engineer from Universidad de Lima. Ph.D. in Management and Business Administration at Universidad Nacional Mayor de San Marcos, Black Belt inLean Six Sigma. Current is Undergraduate teaching at Universidad de Lima. Expert in Lean Supply Chain andOperations with over 20 years of professional experience in the direction and management of operations, processimprovement, and productivity; specialist in implementing Continuing Improvement Projects, PDCA, TOC, and Lean Six Sigma. Leader of transformational projects, productivity, and change generator. Capable of forminghighperformance teams aligned to company strategies and programs for "Continuous Improvement". "He haspublished journal and conference papers. His research interests include supply chain management and logistics, leanmanufacturing, lean six sigma, business process management, agribusiness, design work, facility layout design, systematic layout planning, quality management, and Lean TPM. He is a member of IEOM, IISE, ASQ, IEEE, and CIP (College of Engineers of Peru).

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