Industry 4.0 : Emerging Themes and Future Research Avenues

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Abstract

The fourth industrial revolution has received much interest in the last few years from all over nation. There are still no comprehensive reviews of the state of the art in this new industrial revolution phase in the existing studies. The goal of this research is to close this gap by looking into intellectual advancements in Industry 4.0.

A comprehensive literature study was conducted to examine scholarly publications released online between 2013 and 2020 on the topic of Industry 4.0. This research uses a bibliometric strategy based on a thorough assessment of the literature to investigate the influence of Industry 4.0 from a macro viewpoint. The major focus of this study is to conduct comprehensive evaluation and analysis of academic development in issues linked to the industry 4.0 for giving knowledge into the topic's past, present, and future. Our findings have significant theoretical and research consequences. They highlight the conceptual framework and narrative growth of this study area, allowing people to the field to have a critical view of the foundational articles as well as how the study topics have progressed till date.

A summary of Fourth industrial revolution is obtained by (1) listing notable publications and powerful conferences that publish Industry 4.0-related data, (2) illustrating the relevance of Industry 4.0 using keyword classifier, (3) the detection of existing studies initiatives as well as places in the present literature that have been overlooked recently; (4) an outline of Industrial 4.0 industry norms, technology, and infrastructure that are being utilised quite often. The study shows that there were 33 articles during 2016, followed by 687 in 2018 but increased rapidly during 2020 containing 2853 articles based on

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Industry 4.0. During the research period, the Relative Growth Rate (RGR) and Doubling Time (DT) shows higher and declining trend.

Our investigation may be used by experts to learn more about how Industry 4.0 is being implemented in different industries. Experts may understand the benefits of Industry 4.0 and bring awareness to respective business units.

Keywords : *Industry 4.0; meta - analysis; big data; IoT; Cyber Physical System; forth Industrial Revolution*

1. Introduction :

Ever since the early evolution in the 18th century, the industry has seen significant progress. Majority of the items, including food, clothes, shelter, weapons, equipment, and have been produced by hand or by working animals for centuries. With the advent of industrial technologies towards the end of the 18th century, this situation improved. The development of Industry 1.0's had been an enormous quick challenge leading up to the fourth revolution of industry, the future modern age.

The fourth industrial revolution is referred to as Industry 4.0, next step of a technology's life cycle in the enterprise and management of the whole value chain.

1.1 Industry 1.0 to 4.0 : The History of the Modern Ages

Industry 1.0 The late eighteenth century opened the industry of mechanical manufacturing plants. Machines powered by water and steam were built to aid laborer in the mass processing of products (Chaitanya, 2020). In 1784, the first weaving loom was introduced. With the growth of manufacturing Productivity and size, small companies have evolved from servicing a smaller range of clients to vast organizations providing a greater number of owners, administrators, and workers. Industry 1.0 can also be considered to be the emergence of an industry community that emphasizes consistency, Productivity, and scale in equal measure.(Nardo et al,2020,Thangaraj et al.,2018)

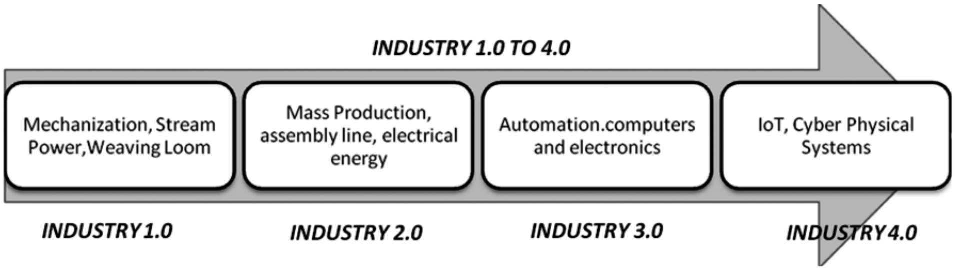

Figure 1: Evolution of Industrial Revolution.

Industry 2.0 The second revolution, Industry 2.0, began at the start of the twentieth century. The invention of computers operating on thermal power was the principal contributor to this revolution. As the main fuel source, electrical power has always been used. In terms of expense and skill, electrical devices were more effective to run and sustain versus water and steam-based machines that were comparatively slow and starving for energy. During this period, the first assembly line was also constructed, further streamlining the mass manufacturing process. A common practice was the mass manufacturing of products using the assembly line (Yin et al., 2018).

This period also saw the growth of the culture of business incorporated into the management curriculum of Industry 1.0 to increase the performance of production lines. The fundamental mechanisms contributing to higher efficiency and performance were enhanced by numerous supply management methods, such as labour division, just-in-time production, and lean manufacturing concepts.

Industry 3.0 Over the latter few years of the twentieth era, the second technological revolution leading to Industry 3.0 was driven and motivated by developments in consumer electronics. The innovation and development of a range of electronic components namely as circuits and transistors, automatically mated the devices, resulting in less work, faster processing, high accuracy, and indeed complete elimination of the human agent. One of the landmark developments that created automation through electronics was the Programmable Logic Controller (PLC), created in the 1960s. The introduction of electronic hardware into production processes has also produced a need for information systems to allow this electronic equipment to boost the demand for application development (Chen et al., 2017). The digital systems have also allowed many management processes, in addition to managing the machines, such as enterprise resource planning, inventory management, shipping logistics, inventory flow scheduling, and factory-wide monitoring. Using electronics and I.T., the entire business was more industrialized. With the developments in the electronics and I.T. industry ever since, development processes and technological systems have continually developed.

Industry 4.0 In the 1990s, the Internet and telecommunications industry boomed, which transformed the way we interacted and shared data. This also resulted in technological breakthroughs in the automotive sector and conventional development practices that combined the real and virtual world boundaries. This frontier has been further disrupted by Cyber-Physical Systems (CPSs), resulting in several recent technical disruptions in the sector

(Saldivar et al., 2015). With virtually minimal physical or spatial boundaries, CPSs empower devices to interact more smartly with one another. Industry 4.0 uses cyber-physical networks to exchange, evaluate and direct intelligent behaviour for different industrial operations. CPPs often allow an industry from a remote location to be digitally visualized, tracked and controlled, thereby bringing a new dimension to the development process (S. Wang et al., 2016). It brings computers, individuals, systems, and processes into a common interconnected framework that made it extremely effective for smooth functioning. If the cost-of-technology curve gets wider each day, technological disruptions can occur at many reduced costs and fundamentally change the manufacturing environment even more rapidly. Industry 4.0 is still in its initial days, and businesses are already in the process of the new systems' implementation. To remain competitive in the market, industries must implement new technologies as soon as possible. This paper reviews various collective action efforts were undertaken to understand how features of Industry 4.0 can be effectively used in cooperatives. The goal of this research is to understand the extend of digitalization through Industry 4.0 also to explore the logic in the application of Industry 4.0 in the working of cooperatives for their development with the help of Indian cooperative cases.

Review of Literature

All selected articles are subdivided into three sections, according to the contents available in the literature: 1) Articles related to the definition and description of Industry 4.0. 2) Articles about the technology and operations in Industry 4.0.

Industry 4.0 description

This part of the literature presents the paper, which includes what exactly is Industry 4.0 and how it aims at creating a transparent, smart manufacturing infrastructure for the implementation of technologies. It also focuses on issues and challenges in various sectors.

To boost operating performance and maintenance control, conventional equipment is being turned into self-aware and self-learning devices by Industry 4.0 with the communication around them (J. Lee et al., 2014). Industry 4.0 aims at creating a transparent, smart manufacturing infrastructure for the implementation of industrial knowledge networks (Bahrin et al., 2016). The key criteria of Industry 4.0 are real information management, inventory availability and positions tracking, as well as maintaining guidelines for managing manufacturing processes. (F. Almada-Lobo, 2015)

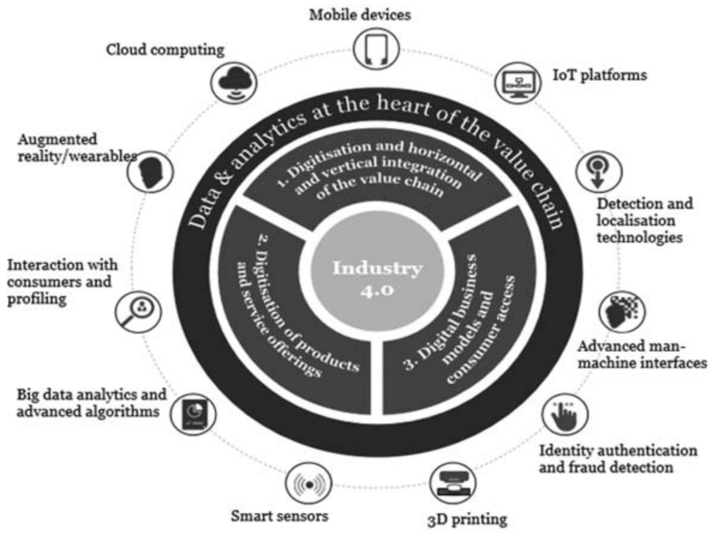

Figure 2: Features of Industry 4.0 technology and contributions to digitalization

Source : Industry 4.0 : Building the digital enterprise, 2016 global industry 4.0 survey, PwC engineering, & construction

The definition of Industry 4.0 encompasses not only direct production in the sector but also the whole supply chain from suppliers to consumers, as well as all business operations. Industry 4.0 is a 21st-century technological innovation that allows industries to produce intelligent goods and services while cutting prices and rising performance. The human aspect is critical for the process, and the research is focused on the current study in the field. The paper introduces the smart factory concept for automated services, thus increasing the efficiency of operations (Chaitanya Vijay Bidnur,2020)

The aim of Industry 4.0 is not only to reach a better degree of organizational efficiency and competitiveness but also to greater automation (Haseeb et al., 2019). This research intended to overcome a number of issues and challenges about technology advancement in the area of Industry 4.0. Based on the findings, the paper reveals that industry 4.0 aspects such as big data, the Internet of Things, and the smart factory play a constructive part in supporting I.T. adoption, which leads to long-term market success.

The basic notion of Industry 4.0 is still in infancy, with the incorporation of physical networks on a cyber network (Aulbur and Singh, 2014) in India. A substantial chunk of the industrial sector is under development process, with technologies restricted to devices that run independently of one another. A lack of maturity is a big factor for the poor acceptance and deployment of Industry 4.0 technologies (Oesterreich et al, 2016). The benefits of Industry 4.0 through sustainable business models are manifold (Machado et al., 2020). It focuses on the discussion of sustainable production and Business 4.0, as well as the relations between the two principles. The results suggest that the Industry 4.0 area is real but not established and that it is developing as a result of the emergence of modern business frameworks and the incorporation of value chains.

2.2 Technology and Industry 4.0

The literature in this section describes the various aspects of Industry 4.0, such as, the IoT, big data as well as the smart factory, and how they play a beneficial impact in encouraging the adoption of information technology (I.T.), that contributes to long-term productivity.

Vaidya, Ambad, Bhosle (2018) explored the nine pillars of Industry 4.0, including Big data and analytics, Industrial of Things, cloud computing, artificial intelligence, autonomous robots, etc. These pillars will change independent and improved operations to a highly integrated, automatic, and optimized method. As a result, conventional relationships among suppliers, users, and consumers, including humans and computers, become more productive and improve. Faster processors, intelligent devices, compact sensors, and less costly equipment for storage and transmission of data could enable devices to connect and benefit from one another. The nine pillars will help in identifying the obstacles and problems that will face Industry 4.0 adoption. It also suggests that as this concept of Industry 4.0 increases, new streams of research in this field should be built, including recent analysis sources, such as open and coordinated supply chain, data gathering from production, and information utilization for the usage of efficient equipment.

To boost operating performance and maintenance control, conventional equipment is being turned into self-aware and self-learning devices by Industry 4.0 with the communication around them. The key criteria of Industry 4.0 are Reliable data monitoring, inventory availability and positions tracking, as well as maintaining guidelines for managing manufacturing processes (J. Lee et al.,2014).

With the introduction of Information and communication technologies (ICT), the industries have got opportunities to compete in international markets (Bahrin et al.,2016). Along the lines of such developments, the automation industries are playing a vital role in the introduction of technologies about industry 4.0. In industries, automated robots have recently been developed and used to perform risky tasks for individuals, accomplish quicker and more efficient manufacturing procedures, and minimize the price of goods. Since competition is growing in today's market, manufacturers want smarter systems to make smarter decisions. The Indian automobile industry is at the forefront of introducing Industry 4.0's main elements. Automotive industries have been compelled to implement important elements of Industry 4.0, such as robotics, due to emerging technologies, growing innovation, and cost of manpower. In India's automotive sector, there are 58 robots per 10,000 workers (Roehricth, K.,2016)

The Internet of Things

In the twenty-first century, Industry 4.0 combines the Internet of Things (IoT) and industrial strategy to enable devices to communicate, evaluate, and apply data to guide human intelligence. Advanced engineering, automation, intelligent systems, virtual reality, and other computational technologies are frequently used (Atzori, 2010). In the growing wireless communication environment, the Internet of Things (IoT) is a novel idea that is growing rapidly. The central principle related this theory is the ubiquitous existence of several items or artefacts around us, such as Radio-Frequency Identification (RFID) tags, sensors, actuators, smartphones, etc., which can communicate with special addressing schemes (Hozdic, 2015).

Big Data and Analytics

Manufacturing equipment and applications, and also company and consumer management systems, would all benefit from the analysis and methodical evaluation of data via numerous studies in order to improve ultimate decision (M. Rüßmann et al., 201. Big Data consists of four aspects, according to Forrester's definition: the amount of data, data variety, the frequency with which fresh data is produced and analyzed, and also the significance of the information (K. Witkowski, 2017).Previous evidence was statistically analyzed to classify the threats that occur earlier in the industry in different industrial methods, as well as to identify existing problems and potential solutions to eliminate them from arising in the future.(Bagheri et al., 2015).

The Cloud

The cloud-based I.T. interface acts as the technological pillar for linking and communicating the various components of the Industry 4.0 Technology

Centre (Landherrer et al., 2016).Organizations require improved information sharing for business 4.0 i.e. attainment of response times in milliseconds or much faster across platforms and businesses (M. Rüßmann et al., 2015). 'Smart manufacturing' is the concept of connecting many computers to the same cloud in order to share information, which may be enhanced to include systems from the production line as well as the entire facility. (E. Marilungo, 2017).

Autonomous Robots

In industries, automated robots have recently been developed and used to perform risky tasks for individuals, accomplish quicker and more efficient manufacturing procedures, and minimize the price of goods. Since competition is growing in today's market climate, manufacturers want smarter systems to make smarter decisions (Bahrin et al., 2016).

Table 1.
Autonomous robots used in different industries (Sipsas et al., 2016)

Sr.No.	Robot Name	Company	Feature of Robot
1	Kuka LBR iiwa	Kuka	Light and delicate robot for critical manufacturing activities
2	Baxter	Rethink Robotics	Intelligent robot as a means of packaging
3	BioRob Arm	Bionic robotics	Usage for humans in the near vicinity
4	Roberta	Gomtec	6-Axis industrial robot used to automate flexibly and efficiently.

Simulations :

In operation, simulations may be utilized to explore the real-time data including technologies, commodities, and people to replicate the actual environment, thereby minimizing system startup periods and boosting performance (M. Rüßmann et al., 2015). 2D and 3D simulations may be created for virtual designing and visualisation of cycle durations, energy use, and durability aspects of a manufacturing plant. In addition to reducing and altering downtimes, the adoption of manufacturing process models helps reduce production mistakes during the starting phase (Simons et al., 2017). With simulations, decision-making efficiency may be technically improved effectively and quickly (G. Schuh et al., 2014).

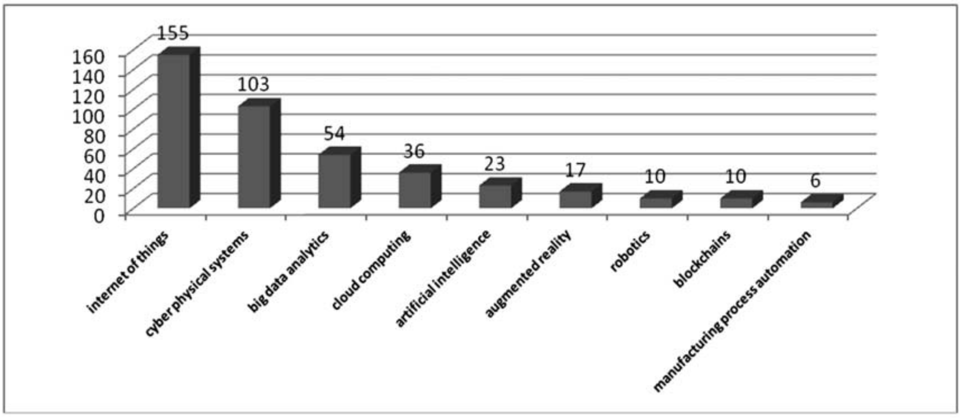

Figure 3 : Industry 4.0 technology contributions towards digitalization.

As shown in figure 3, the Internet of Things (IoT) is discussed many times in these documents, followed by Cyber-Physical Systems (CPS), and then Big Data. Also, in subject areas, big data, CPS, and the IoT are perhaps the basic elements in Industry 4.0, implying that they are also the significant key features for Industry 4.0. The research will help researchers evaluate the needs of market growth and enhance mutual trust between academia and enterprises.

Various academics had studied Industry 4.0. (S. Wang et al., 2016) proposed a comprehensive architecture of IoT, CPS, IoS, and RFID. Similarly, (Lu et al., 2017) published a survey paper focusing on Industry 4.0 technologies and applications. In a systematic review on Industry 4.0, (Colantoni et al., 2019) reviewed the present state and future possibilities of farming with in perspective of Industry 4.0. (Lezzi et al., 2018). (Dallasega et al., 2018) looked into the ways in which the technologies may help to facilitate in building supply chains. (Li et al., 2015) reviewed commercial wireless network research in the context of Industry 4.0. The work on industrial 4.0 cyber security was filtered out by (Lezzi et al., 2018). (Ding, 2018) conducted a study on pharmaceutical supply chains that are sustainable. (Dallasega et al., 2018) looked into how industry may help to facilitate creating the supply chains. (Li et al., 2015) reviewed commercial wireless network research in the context of Industry 4.0. (Pereira et al., 2018) exclusively looked at the Industrial 4.0 research between 2011 and 2017.

Trappey et al., (2017) categorised the patents and normal framework of IoT into four layers: perception, transmission, computation, and use. Each layer has its own set of technical specifications and patent eligibility requirements. The main actors in the Internet of Things and the technology's implementation matrix were explored in depth during the patent landscape review. According to the paper, it will take approximately ten years to fully streamline Industry 4.0 technology. To bridge the gap between mass customization and mass personalization,

Through a comprehensive literature analysis of the research article, Yin et al. (2018) discuss the gap in the advancement of Industry 4.0. The article was searched using the phrases "the fourth industrial revolution," "the fourth industrial revolution," "Industry 4.0," and "Industry 4.0." To discuss the prospective research agenda, the reviewer examined a maximum of 224 articles. The author concentrated on identifying the most basic Industry 4.0-related terms, as well as the technology that is most commonly used to describe the phrase.

3. Methodology

The knowledge utilized and generated as a result of study determines the consistency of scientific publications. Metrics analyses are critical for studying the evolution of a field and enhancing the quality of study. This research uses a bibliometric strategy based on a thorough assessment of the literature to investigate the influence of Industry 4.0 from a macro viewpoint. Our analysis is split into three steps: first, determine what Industry 4.0 is; second, define the fundamental technologies of Industry 4.0; and third, examine the present status of Industry 4.0 research and practise.

4. Results and Discussion

4.1 Industry 4.0 : Across the globe

The notion of Industry 4.0 has caught the interest of several nations across the world. Here's a look at a few of the nations that are attempting to adopt Industry 4.0.

Germany

The Industry 4.0 paradigm was founded in Germany in the early part of the 21st century. Existing factories are transformed into self-contained, self-adaptive scientific and technical structures under Industry 4.0. (Smart Factories) through the use of technology and automation of industrial applications, enabling intellectual value chains to be developed. The idea of Industry 4.0 also has an impact on environmental issues (Olah,2020).

In 2012, the German Government introduced an implementation strategy identified as 'High-Tech Policy 2020.' Annually, this initiative provides billions of euros to implement the new developments in the automotive sector (Liao et al., 2017). In 2018, for its latest cars, Volkswagen launched the 48V radical electric and diesel engines that are mild hybrids.

South Korea

South Korea's "Innovation in Manufacturing 3.0" plan, launched in 2014, defined goals and objectives for the country's manufacturing growth as reported by Ministry of Trade Industry and Energy of South Korea in 2014. A new automated vehicle, the Hyundai Genesis sedan, has been developed by Hyundai, which is good at detecting moving vehicles, preventing crashes, operating on limited lanes, identifying traffic signals and road speed indicators.

China

In 2015, two actions were initiated simultaneously by China's Government, i.e. the 'Internet Plus' and 'Made in China 2025' policies. To improve China's industrialization, ten main facets of the manufacturing industry are given priority (Chen et al.,2017). The Government, in 2018, declared the abolition of legislation forcing car makers like General Motors to partner with a local group to establish industries. China hopes the action would help international firms in bringing other sophisticated technologies into China to satisfy electric transportation requirements.

Malaysia

By conducting numerous strategies to enable market players to adopt Industry 4.0 through the introduction of automation and smart manufacturing, the Malaysian Government has taken proactive steps. The Government put light on several new incentive programs in the 2017 budget to boost the development and acceptance of Industry 4.0 and innovation in Malaysia. Supermax Company Bhd, for example, was a gloves production sector that will be funded by the Government under automation by stimulus schemes to stimulate industry growth. Malaysia's former Prime Minister, Datuk Seri Najib Razak, has launch a proposal to introduce TVET (Technical and Vocational Education and Training) in the industry. This would be to facilitate the future growth of Business 4.0 by growing the workforce's skills. Within the scheme, the Government contributed RM50 million to increase their quality and Productivity of the workforce that will assist in the economic growth of the country. Thirty per cent of the Human Resources Development Fund (HRDF) funds are committed to this Plan solely for TVET.

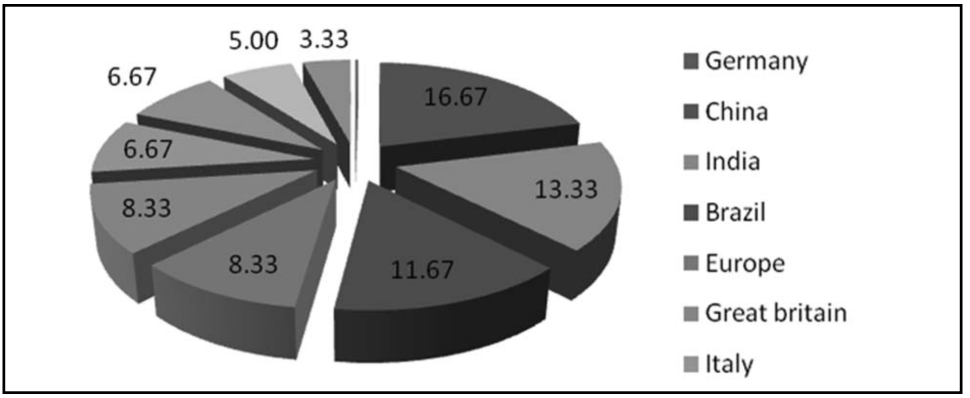

Figure 4: Distribution of the publications across different countries

The research demonstrates the distribution of the published articles throughout different nations. The database has 7 countries that published several publications(figure 4). As per the articles in our database, Germany attributed 20% of publications that ran above the list. It is the first nation to follow the Industry 4.0 definition. Germany is followed by China(16.67%), India(13.33%), Brazil(11.67%) and other countries as shown in figure.

4.2 Status of Industry 4.0 in India

Based on a strong emphasis on Industry 4.0 as part of the "Make in India" strategy for future growth, India is the sixth-largest manufacturing country. By 2022, the Government plans to grow the Manufacturing's proportion of GDP from the existing 16-17 per cent to 25 per cent. Many regulatory changes, such as GST adoption and FDI policy liberalization are implemented by the Government.

India is reportedly lagging behind its global counterparts where Industry 4.0 implementation is considered. The basic notion of Industry 4.0 is still in infancy, with the incorporation of physical networks on a cyber network (Aulbur and Singh, 2014).

India is on the way of building the right model of establish its "small factories" on, as shown by its success in two crucial supporting Industry 4.0 innovations, namely IoT and Big Data. In the manufacturing sector, the use of the IoT industry accounts for 60% of the IoT market of India.

The concept of "Make in India" occupied 32% of the total global market share (Nishimura, T, 2018). About $2 billion markets have emerged in India for big data analytics. This number is increasing at a faster pace making it around $1.6 billion by the year 2025.

In India, the big data analysis industry is projected to rise at a CAGR of 26%, hitting around.

The Indian automobile industry is at the forefront of introducing Industry 4.0's main elements. Automotive industries have been compelled to implement main features of Industry 4.0, such as robotics, due to emerging technologies, new innovation, and increasing cost of workers. In India's automotive sector, there are 58 robots per 10,000 workers (Roehricth, K. 2016).

Table 4: 2019 Robot Count in Manufacturing Industries (Count of Installed Industrial Robots per 10,000 employees

Name of country	Count	Name of country	Count
South Korea	855	China	187
Japan	364	UK	71
Germany	346	Brazil	10
United States	200	India	4
Canada	165		

Source : International Federation of Robotics, Industrial Robots.

The Indian automobile sector has started to adopt Industry 4.0. Bajaj Auto, for example, started automating its activities in 2010. It currently employs 100 to 120 "collaborative robots” (Co-bots) in its manufacturing operations. Maruti Suzuki hires approximately 1700 robots to operate seven process shops and five assembly lines. With the aid of 437 robots, Ford can run its assembly lines at its Sanand factory. Hyundai has implemented 400 robots in order to decrease labour expenses. Tata Motors has over 100 robots on its Tata Nano production lines. Renault is trying to avoid accidents by automation. An intelligent system is used by a multinational corporation headquartered in Mumbai to link all devices and analyze the pace of work and performance. The system facilitates waste avoidance and production flow organization. Another packaging company in Bengaluru has linked machines across a network that offers a monthly report of machine status.

Matrix Tools and Solutions (Matrix), a firm based in Pune, develop product prototypes and assists with the implementation of emerging technology for the transformation of manufacturing methods. Kirloskar Brothers (KBL) employs 3D printing and the Internet of Things (IoT) in its manufacturing processes, especially casing in foundries. They also hire tonne in the handling of water in factories. The plants are managed from a distance using a remote management system. Raymonds' enterprises are rapidly incorporating emerging technology. To produce textiles, the organization has introduced robots, big data, and material science technology (TNN and Agencies, 2016).

Healthcare has benefited from emerging technologies in a variety of aspects. The growing utilization of electronic health records, telemedicine, the system for health management and online health resources has enhanced the usage of patient data and facilitated visualization of health information and electronic medical records digitization trends. At Fortis and Max hospitals, robot-assisted surgery is practised.

Although the nation was quickly changing, industries in India tend to be optimistic about their growth prospects. According to the eighth Digital I.Q, in a survey conducted by PwC, 71 per cent of Indian respondents are optimistic about digital development shortly. In India, as in the rest of the world, there is a heavy emphasis on technology for increasing sales, improving consumer service, and reducing costs. The survey revealed that while industries are extremely focused on organic growth and cost reduction initiatives, many industries in India tend to be solely focused on growth.

This indicates that businesses are progressing to digitalization but have yet to incorporate technology to enhance their growth as per the recent Global Digital I.Q. The survey, the challenge now is how to work effectively in a digital environment.

Table 5: Technologies that are making substantial investments in India

Technologies	Per cent
Internet of Things	64 %
Robotics	27 %
Artificial intelligence	42 %
Virtual reality	16 %
Blockchain	7 %
3-D printing	10 %
Augmented reality	10 %
Drones	3 %

Source : PwC, Global Digital IQ® Surveys

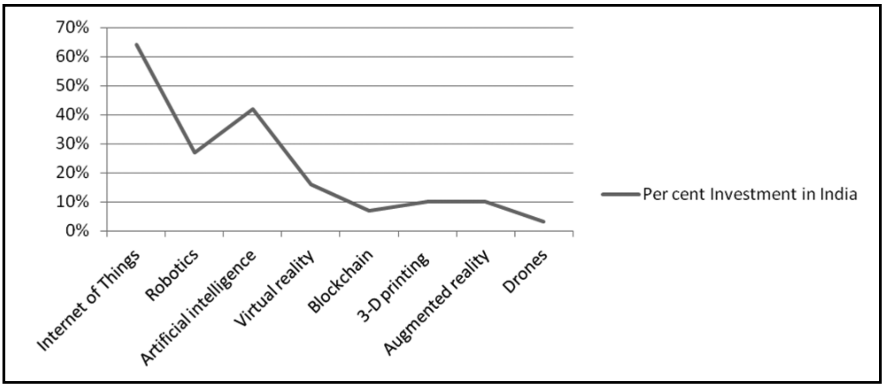

Figure 5 : Technologies making substantial investments in India

As shown in the figure 5, in India, businesses started to be investing heavily in artificial intelligence (A.I.), the Internet - of - things (IoT), and robotic systems, but, in the next three years, the emphasis would undoubtedly turn to virtual reality and blockchain. The growing emphasis on IoT and robotics also suggests a shift of attention toward cost reduction.

4.3 Analysis and Interpretations

The data for this study were collected from EBSCO and Google scholar databases, in the years 2013-2020, using search terms namely 'Industy 4.0' in title. To increase the accuracy of the content we get, researchers narrowed the search to documents that are more relevant to the topic and of higher quality. We were unable to locate any papers prior to 2013; therefore we examined those published between 2013 and 2020.

4.3.1 Literature statistics

A total of 5289 records were downloaded as under. Figure 6 shows how the trend of Industry 4.0 has been more popular in recent years.

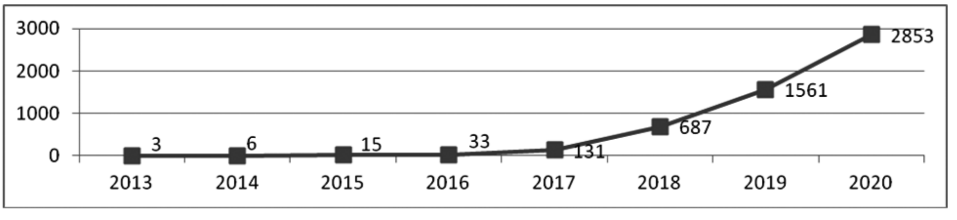

Figure 6 : Growth in publications

Out of 5289 articles from the literature, 956 articles are taken from well known publications like elsevier, taylor & francis, emerald publishing limited, thomas publishing company, springer nature and others as shown in figure 7.

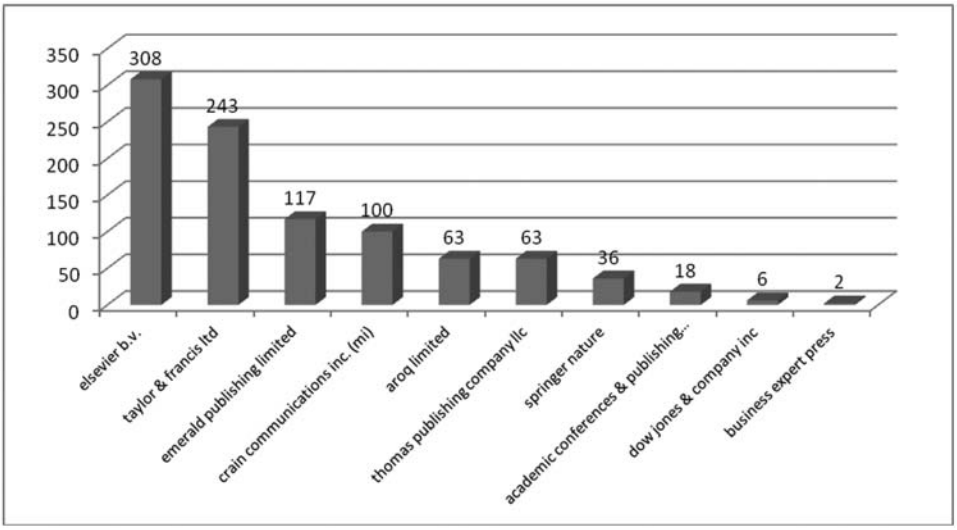

Figure 7 : Number of publications in various journals

It's quite important to mention which terms were most frequently included in the text fragments grouped together in the study. A tag cloud of the most frequently cited terms is depicted in Figure 8.

Figure 8 : Word cloud involving various technologies in Industry 4.0

4.3.2 Forms of Publications

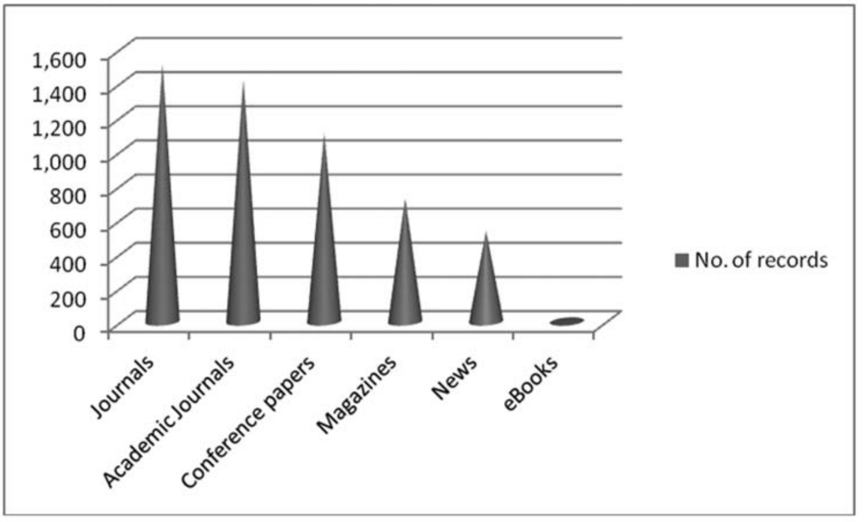

Figure 9 : Forms of Publication

The figure 9 reveals that the main source of publication in EBSCO database on Industry 4.0 is Journals and academic journals each with 1,507 publications (28.34%) followed by conference papers with 1,076 publications (20.23%). Publications in magazines and news are 13.41% and 9.61% respectively followed by e-books which are less than one percentage.

4.3.3 Relative Growth Rate (RGR) and Doubling Time

Two parameters namely; Relative Growth Rate and Doubling Time are identified to analyze the growth in publications. The rise in the amount of posts or pages per unit of time is referred to as the Relative Growth Rate (RGR). The following expression can be used to measure the relative growth rate (R) over a given span of interval. (Mahapatra, 1985):

Relative Growth Rate (RGR) = X2 – X1/ T2-T1

X1= Log X1 (log of initial number of articles)

X2= Log X2 (log of final number of articles after a specific period of interval)

T2-T1- the unit difference between the initial time and the final time

The year can be taken here as the unit of time.

Doubling time is characterised as the time it takes for articles to double from their current level and is directly related to relative growth rate (RGR). It is therefore defined that if the amount of literature in a context doubles in a given time, the difference between logarithms of numbers at the beginning and end of that period must be the logarithm of 2. The value of

Loge2 by using the Napier Logarithm is 0.693.

Doubling Time (DT) = 0.693/R. Table 3 shows Relative growth rate (RGR) and Doubling time (DT) of publications

Table 3: Calculation of RGR and DT for the publications

Year of publication	No. of records	Total (Cumulative)	X1	X2	RGR	DT
2013	3	3	0	0	0.00	0.00
2014	6	9	1.10	2.20	1.10	0.63
2015	15	24	2.20	3.18	0.98	0.71
2016	33	57	3.18	4.04	0.86	0.80
2017	151	208	4.04	5.34	1.29	0.54
2018	696	904	5.34	6.81	1.47	0.47
2019	1561	2465	6.81	7.81	1.00	0.69
2020	2853	5318	7.81	8.58	0.77	0.90

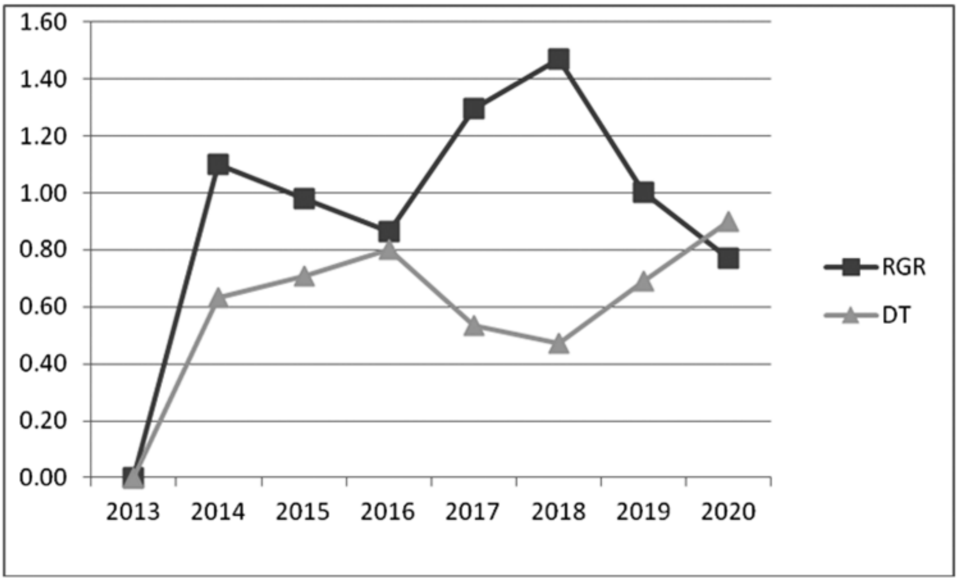

Figure 10 : Graph showing RGR and DT

The above figure shows many variations in the Relative Growth rate (RGR) and the doubling time (DT) of the published literature in the journals undertaken for the study. It indicates that the RGR decreased from 2013 to 2016. It increased in 2017. In 2018, the RGR was high, further which decreased in 2020. It can be noticed that during the year 2017 to 2019, there was a tremendous increase in the growth of literature. The DT increased from 2013 to 2016.Futhermore, it began decreasing from 2017 which further increased in the year 2020.

As a result, the relative growth rate is declining; this indicates that the pace of expansion is poor in terms of volume, as evidenced by the fact that the doubling time of articles is greater than the relative growth rate. It is observed that there is double in the rate of publications related to the technologies in Industry 4.0 each year.

8. Findings & Implications of study

To discuss the prospective research agenda, the reviewer examined a maximum of 5289 articles. By evaluating 956 relevant articles from the EBSCO database released between 2013 and 2020, this research implemented a bibliometric method to examine the research on Industry 4.0 and its status in various sectors. The article was searched using the phrases "the fourth industrial revolution," "the fourth industrial revolution," "Industry 4.0," and "Industry 4.0.” The author concentrated on identifying the most basic Industry 4.0-related terms, as well as the technology that is most commonly used to describe the phrase.

A summary of Fourth industrial revolution is obtained by (1) listing notable publications and powerful conferences that publish Industry 4.0-related data, (2) illustrating the relevance of Industry 4.0 using keyword classifier, (3) the detection of existing studies initiatives as well as places in the present literature that have been overlooked recently; (4) an outline of Industrial 4.0 industry norms, technology, and infrastructure that are being utilised quite often.

The major aim of this study is to conduct a comprehensive evaluation and analysis of academic development in issues linked to the industry 4.0 for giving knowledge into topic's past, present, and future. Our findings have significant theoretical and research consequences. They highlight the conceptual framework and narrative growth of this study area, allowing people to the field to have a critical view of the foundational articles as well as how the study topics have progressed till date.

Practical Implications

This research added to the base of information by evaluating the function of Industry 4.0 in various fields. As this study is one of the few to examine the role of Industry 4.0 in technology innovation, it expands avenues for academics to explore. A rather multidisciplinary approach to future study on Industry 4.0 might also be beneficial. The majority of the explanations are techno-centric, mentioning a variety of contemporary technology techniques. Complicated possibilities and comprehensive evaluations of what these changes may indicate for individuals or the society are lacking from reviewed body of research. Our investigation may be used by experts to learn more about how Industry 4.0 is being implemented in different industries. Experts may understand the benefits of Industry 4.0 and bring awareness to respective business units.

Conclusion

As a result, Industry 4.0 has been identified as a method for independent process operations in the manufacturing and service industries. Furthermore, it has the potential to transform labour-intensive enterprises into technology ventures and to transform large-scale production into high-volume product design. Furthermore, Fourth industrial revolution has a wide space ranging from social insurance to communication industry; development to bring industries along; and collaboration to protect industries. Big data, the Internet of Things, and the smart factory are all aspects of Industry 4.0 that help to encourage the use of information technology (IT), which leads to long-term business effectiveness. Diversifying the practice, innovating and collaborating with others, and using emerging technology are all essential to perform more effectively and sustainably.

Industry 4.0 is clearly a collection of technology that businesses may use to improve their operations. Various limitations should be considered when assessing the findings of this study. To begin, publications were gathered from the largest abstract database for peer-reviewed literature, as well as multidisciplinary database (Google scholar) as supplements. Second, current Industry 4.0 studies conducted in certain languages was omitted due to the search parameters restricting the language of gathered papers to English. From a comprehensiveness standpoint, this evaluation might be more thorough if other databases and languages were considered. Nevertheless, in order for a systematic literature review to be viable, suitable limits must be defined.

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