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Technological competitiveness and emerging technologies in industry 4.0 and industry 5.0

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Abstract: Technological competitiveness and emerging technologies are more necessary in the organizational strategy to cope with industrial advances and improve the nation's economy. In this sense, technological innovation, computational developments, smart devices, and other technologies are shaping the new industrial revolutions. Therefore, the technological competitiveness and emerging technologies of industry 4.0 and industry 5.0 are holistically analyzed to identify the key elements of developed economies and emerging economies. For this, we used a bibliometric analysis with Biblioshiny, a systematic review of the literature and a content analysis. The results in terms of technological competitiveness in developed economies show the importance of the competences and engineering skills in the personnel approach; R+D+i and the supply chain in the organizational approach; and the use of emerging technologies such as the internet of things and big data. The comparison with emerging economies indicates the importance of key elements such as training and education, and skills in the personnel approach; sustainability and structure in the organizational approach; and emerging technologies such as the internet of things and digitalization.

Key words: bibliometric analysis, emerging economies, industry 4.0, industry 5.0, systematic review of the literature, technological competitiveness.

INTRODUCTION

The rapid pace of technological advances in Industry 4.0 (I4.0) and Industry 5.0 (I5.0), makes the organizational competition in all sectors and industries increasingly intense. Therefore, technological competitiveness is considered as a key element for organizations to differentiate themselves from competitors, anticipate the incursion of new markets, generate competitive advantages, and improve organizational performance and sustainability (Acur et al. 2010, Atuahene-gima 2005, Özdemir & Hekim 2018).

Competitiveness has evolved throughout history, from a static and dependent concept to another where it competes productively and with comparative and positioning advantages, until it reaches a dynamic, integrative, complex, multidimensional and systemic concept that also contemplates the capacity of people and that requires a human and technological balance in organizations (Dunning 2013, Fagerberg 1996, Forrest 1996).

In this regard, competitiveness has been widely studied in the company and academia in different sectors, nations, and continents (Alvarez-Aros 2018, Hiraoka 1998, Porter et al. 2001). However, technological competitiveness understood as the ability to compete and demonstrate competences with technical support, has been less studied. Mainly in emerging economies such as Latin America, and although this competitiveness is still being studied to clarify the key elements that conform, there is limited understanding (Acur et al. 2010, Castillo et al. 2016, Yoon et al. 2017).

Therefore, to measure the technological level and predict its evolution, statistical methods and indicators based on patents have been designed, since these represent a substantial effort of the areas of research and development and innovation (R+D+i) in organizations. In this regard, studies have been exemplified that have tried to make predictions of technological trends through the analysis of the keywords of scientific and technical articles, or even other works have developed indexes and used statistics to model and predict technological trends (Bernal et al. 2012, Jun 2018, Jun & Lee 2018).

Besides, it could reaffirm that there is an increasing need for technological development in nations and organizations, especially in emerging economies, since these types of economies are not usually at the forefront of technological competitiveness. However, this need requires that governments formulate effective policies in science and technology. Besides, the correct push and technology transfer between government, industry, and private initiative must be ensured (Alnafrah & Mouselli 2017, Lepkowski 1983, Papon 1975).

In this sense, technological competitiveness in organizations of emerging economies, based on the knowledge society, has been empirically related to greater success in production processes with soft technologies and R+D+i activities. Also, it highlights the importance of the role played by personnel and their intangibles, that is, their knowledge, skills, abilities, attitudes, and values (Domínguez et al. 2009, Garcia et al. 2003, Pontes et al. 2018).

However, the technological competitiveness seen from the role of personnel and business strategy is insufficient, since the technologies that emerge from the new waves of industrialization must be considered. These new technologies of I4.0 and I5.0 include those related to cyber-physical systems, artificial intelligence, smart devices, information and communication technologies, new materials, robotics, automation, sensors, mechatronics, among others. In this regard, developed economies take the lead in the practice and understanding of these technologies, while emerging economies have more limited knowledge and technology (Bednar & Welch 2019, Cobo et al. 2018, Santos et al. 2017).

For this reason, this work holistically analyzed the technological competitiveness and emerging technologies of I4.0 and I5.0 to identify the key elements in developed economies and emerging economies. For this, technological competitiveness analyzed from 1975 to 2019 and the emerging technology trends that are part of I4.0 and I5.0 also included. For this, was performed a bibliometric analysis, a systematic review of the literature (SRL), and content analysis, as they are techniques that provide a clear understanding of scientific performance when evaluating the literature review and identifying the main contributions of a topic (Ahmi et al. 2019, Cancian et al. 2018, Yoon et al. 2018).

In this sense, the main gaps found in the review of technological competitiveness are that, despite being an important topic in the strategy of nations and businesses, this has been less studied than organizational competitiveness or business technology (Alvarez-Aros 2018, Guo et al. 2015, Yoon et al. 2017). Besides, it highlights the fact that the initial efforts made on emerging technologies have been made mainly in developed economies (Luthra & Mangla 2018, Sinisterra et al. 2017, Zholdasbekova et al. 2015).

This work is new, considering the issues of technological competitiveness and emerging technologies of I4.0 and I5.0 and show differences between developed economies and emerging economies. Also, we worked with two databases (WoS and Scopus), three methodological techniques performed, combining quantitative and qualitative methods, highlighting the use of Biblioshiny software, and extending the results to a top 20 and not a top 10 as in others jobs. This work is dividing into the methodology, the findings and the discussion of each technique, and the conclusions.

MATERIALS AND METHODS

For the methodological design, it was decided to work with a mixed approach. That is, bibliometric analysis and content analysis were performed as quantitative techniques and as a qualitative technique, a study through an SRL. The order of the methods performed was first a bibliometric analysis to visualize the topic globally, then an SRL to identify the ideal documents to define the key elements of each type of economy and finally a content analysis that allowed measuring the key elements (Garza- Reyes 2015, Janik & Ryszko 2018, Yoon et al. 2018).

Bibliometric analysis is a spatial representation technique widely used in academic research because it allows the researcher to analyze large amounts of information with the help of specialized software. That also shows a panoramic perspective of a topic obtained, by knowing the trajectory, the main contributions, the relevant authors, the gaps in the literature, future research and the limitations of the subject among many other relevant information (Ahmi et al. 2019, Durmuşoğlu & Çiftçi 2018, Muhuri et al. 2019).

For example, in the bibliometric analysis, studies of the most common keywords have been carried out to appreciate other subtopics of interest related to the main topic, including such systemic processing of scientific, technological, and industrial keywords in articles and journals. It has been used in patent and intellectual property issues and is part of the R+D+i strategy of some organizations to improve technological competitiveness (Baker 2004, Cobo et al. 2018, Jun & Lee 2018, Jun & Park 2016).

For the compilation of the documents, we worked on the WoS and Scopus platforms, because they are the most extensive databases of academic and scientific research. Because they cover an enormous variety and repertoire of high impact journals, also, these documents are reviewed by high-quality peers and internationalization (Alvarez-Aros & Álvarez-Herrera 2018, Janik & Ryszko 2018, Trotta & Garengo 2018).

To select the documents to be analyzed, they were searched by the title through the terms "technological compet*" OR "industry 4.0" OR "fourth industrial revolution" OR "smart factories" OR "smart manufacturing systems" OR "I4.0" OR "industry 5.0" OR "I5.0". On the one hand, the term "technological compet*" allowed the inclusion of technological competences (personnel approach) and technological competitiveness (organizational approach). On the other hand, additional terms represent the emerging technologies of recent industrial revolutions.

Other criteria to refine the search not was used (years, area of science, authors, type of documents, type of access, editors, keywords, etc.) because this is an exploratory study of these topics and for being able to visualize a more comprehensive analysis of it. These searches conducted on June 22, 2019, and 662 WoS documents and 2156 Scopus documents finally obtained, adding a total of 2818 documents, already removing the repeated documents.

As a final part of the bibliometric study, the selected documents analyzed with the help of specialized software. For this, the documents obtained processed with the help of the statistical software R, the open-source tool for the scientometric analysis called Bibliometrix, and its web interface application to show the presentation of the results graphically, in figures or in tables called Biblioshiny (Aria & Cuccurullo 2017, Gobbo et al. 2018, Trotta & Garengo 2018).

After the bibliometric analysis, an SRL and content analysis performed in which 181 documents from developed economies and 36 documents from emerging economies were selected, and the key elements of technological competitiveness and emerging technologies identified. These methods characterized by being ordered, structured, and objective in the selection of documents and quantification of elements. For this, the stages of the definition of the purposes of the study, the search criteria, the databases to be used, the collection of documents, the analysis of the documents, the development of a classification system, the quantification of the key elements and the presentation of the results (Arballo et al. 2019, Cancian et al. 2018, Manterola et al. 2013).

RESULTS AND DISCUSSION

The results are divided into two parts, those of the bibliometric analysis, and those of the SRL and the content analysis. From the bibliometric analysis, results obtained from documents per year, authors, affiliations, journals, countries, and most important collaborative networks.

Figure 1 shows a positive trend over time in technological issues. Of this, 91.1% of the documents belong to I4.0, 8.8% to the point of technological competitiveness, and only 0.1% are documents of I5.0. For its part, technological competitiveness began to study since 1975 with authors such as Papon (1975). After that, it continued discreetly publishing the subject with an approach in the competence of the organization, as stated by authors such as Dunning & Cantwell (1982), Lepkowski (1983), Patel & Pavitt (1987). However, it was until the 90's when technological competitiveness took two approaches: organizational and personnel. Subsequently, there have been growths of the subject in 1997, 2010, 2017, and 2019, and this could be due to the rise of each technological

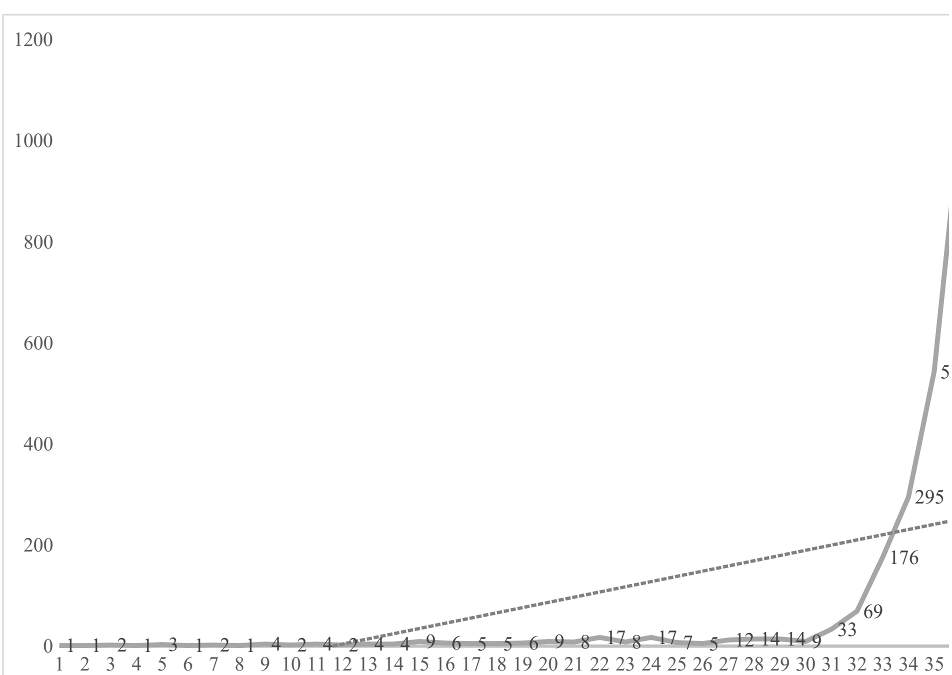

Figure 1. Documents per year.

issue after its initiation (technological competitiveness, I4.0, I5.0).

On the other hand, I4.0 or "smart factory" emerged in 2012 in a presentation at the Hannover Fair in Germany. I4.0 created by a German government initiative of a strategic project to transform manufacturing agents with physical systems to manufacturing agents with cyber-physical systems. From this topic, initial publications such as Gruber (2013), Jentsch et al. (2013), Hofmann et al. (2012) and Kagermann et al. (2013).

Some issues found about to I4.0 are automation processes, autonomous cars, the internet of things (IoT), artificial intelligence (AI), additive manufacturing, digitalization, big data, virtual reality, augmented reality, robotics, biotechnology, bioengineering. The topic of I4.0 also shows an exponential trend interest, although, in accordance with Gupta (2010), this has been more study in the industrial sector in developed economies.

Finally, of the recent issue of I5.0, only three documents were found in WoS and Scopus. These are those of Nahavandi (2019), Özdemir & Hekim (2018) and Sachsenmeier (2016). It is observed that, although the issue does not have a tendency, it not only highlights a strong emphasis on the technologies of I4.0, but generally begins to raise the challenges, interactions, the role of the human being and technological concerns on issues such as cybersecurity, vulnerability of integrated systems, collaborative robots, extreme connectivity, symmetric innovation and technological policies, such as some topics in this industrial wave. Another analysis performed was that of the authors with the highest frequency of documents in Figure 2.

Figure 2 shows four leading authors in the technological topics in the top 20, Di Li, I.O. Zharinov, A.V. Shukalov, and Ki Voigt have 18, 15, 14, and 13 publications, respectively. Of the previous authors, three can be mentioned, Di Li affiliated with South China University Technology with topics such as big data, internet of things,

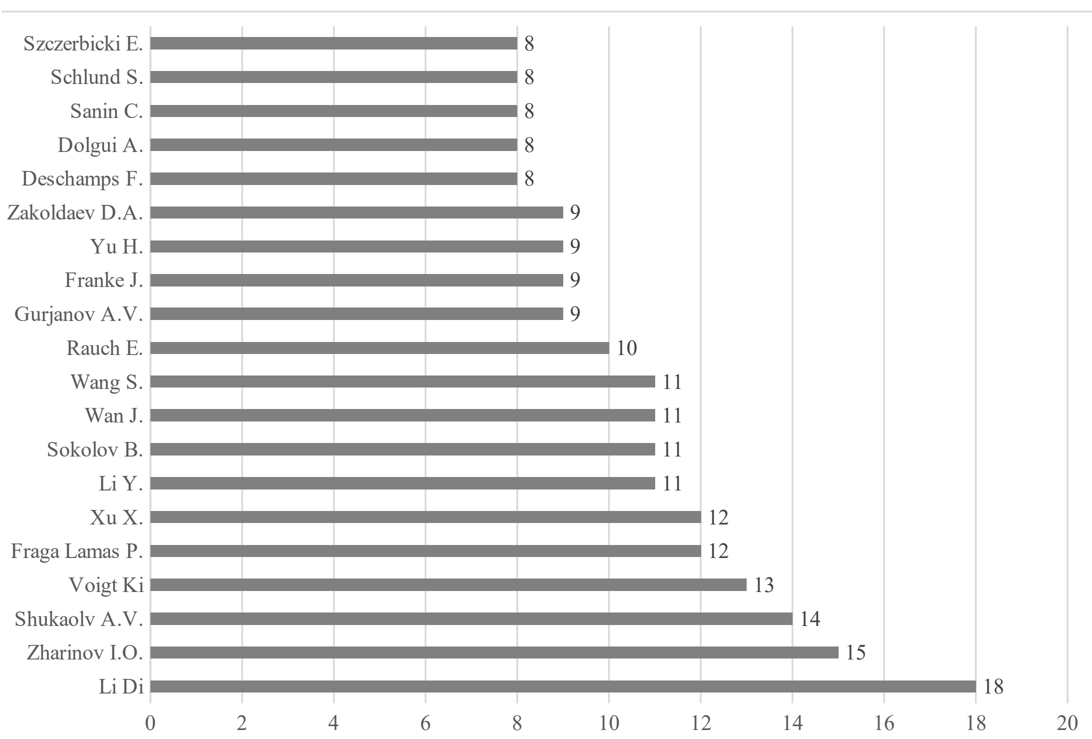

Figure 2. Authors.

custom manufacturing systems, and smart factories in I4.0.

Second, is the author I.O. Zharinov of the Saint Petersburg National Research University of Information Technologies, Mechanics and Optics in Russia, who also stands out on issues of I4.0 such as cyber-physical systems, computer control systems, automation, digital products, computer algorithms, smart factories. Third, this A.V. Shukalov who has worked together with I.O. Zharinov, and maintains a thematic similarity in the exchange of digital information and other topics.

After intermediate authors, with 12, 11, and 10 publications, they are Y. Li, B. Sokolov, Jiafu Wan, S. Wang and E. Rauch. Finally, other authors of the top, with nine and eight publications, these are A.V. Gurjanov, J. Franke, H. Yu, Da Zakoldaev, F. Deschamps, A. Dolgui, C. Sanin, S. Schlund and E. Szczerbicki.

At the top, there are no authors of technological competitiveness, although J.L. Dussourd of the Fluid Engineering Consulting in the United States stood out in the 90's with five publications. Currently, the authors stand out S.N. Gorshenina of the Mordovia State Pedagogical Institute of Russia, Aleksandr Ivanovich Kashirin from Rudn University, and the Rostec Corporation of Russia, Michal Munk from the University of Constantine the Philosopher in Nitra in Slovakia and Tetsuya Tanioka from the Tokushima University of Japan.

All of them with four publications related to the development and construction of digital technology skills and abilities, didactic technological competences, technological networks, and the theory of technological competence. On the other hand, of the I5.0, there are no frequent authors due to the few publications. Regarding the affiliation of researchers, Figure 3 is shown.

Figure 3 shows that the Technical University of Aachen in Germany (Rwth Aachen University) has 25 documents on the subject of I4.0 and

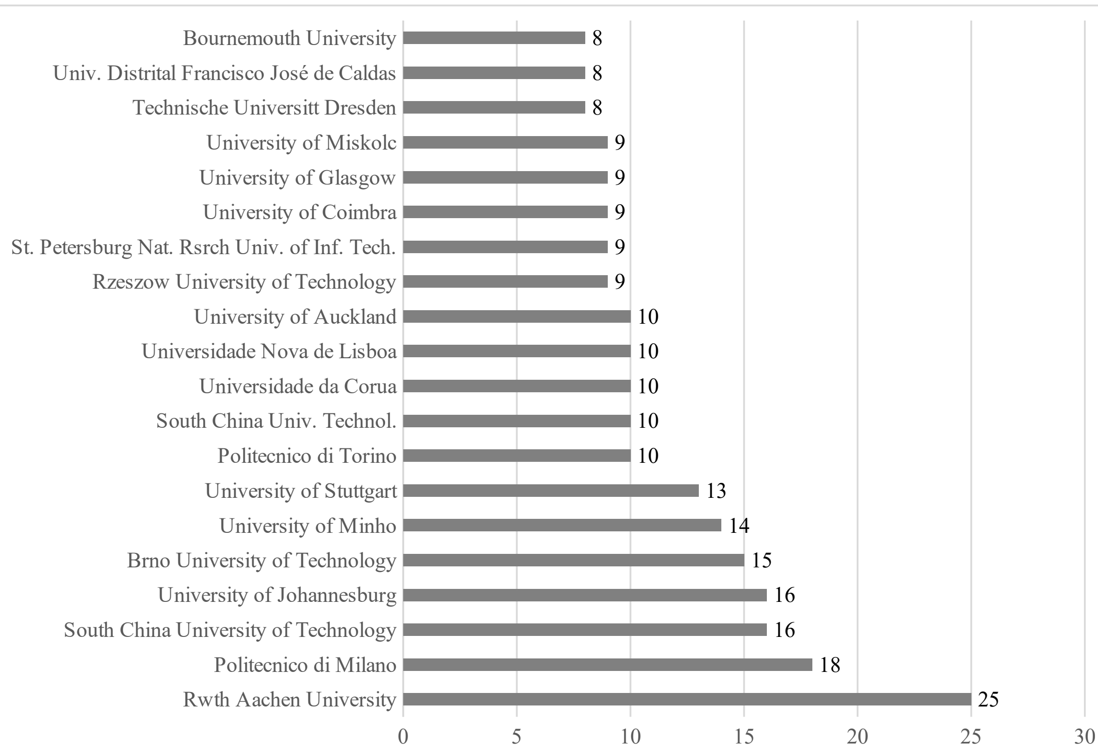

Figure 3. Affiliation.

remains at the top. In a second level there are six institutions, such as the Milan Polytechnic in Italy that has 18 publications, the South China University Technology with 16 documents, the University of Johannesburg in South Africa with 16 documents, the Brno University of Technology of the Republic Czech with 15 publications, the Minho of Portugal with 14 documents and the University of Stuttgart of Germany with 13 documents.

On a third level there are 13 other institutions, these are the Polytechnic of Torino in Italy with 10 documents, the South China University Technology also with 10 documents, the University of La Coruña of Spain with 10 documents, the new University of Lisbon of Portugal with 10 documents, the University of Auckland of New Zealand with 10 documents, the Rzeszów Technological University of Poland with nine documents, the Saint Petersburg National Research University of Information Technologies, Mechanics and Optics of Russia with nine documents, the Coimbra University of Portugal with nine documents, the University of Glasgow in the United Kingdom with nine documents, the University of Miskolc in Hungary with nine documents, the Technical University of Dresden in Germany with eight documents, the Francisco José de Caldas District University of Colombia with eight documents, and Bournemouth University from the United Kingdom with eight documents.

Of the technological competitiveness, the most outstanding affiliations are the Rudn University of Russia and the Sussex University of the United Kingdom with six and five publications, respectively. I5.0 does not highlight any. From the above, it can seem that the most prominent affiliations are from developed economies, except for South Africa and Colombia, and represent 10% of the top 20. On the other hand, journals with more publications on technological issues are shown in Figure 4.

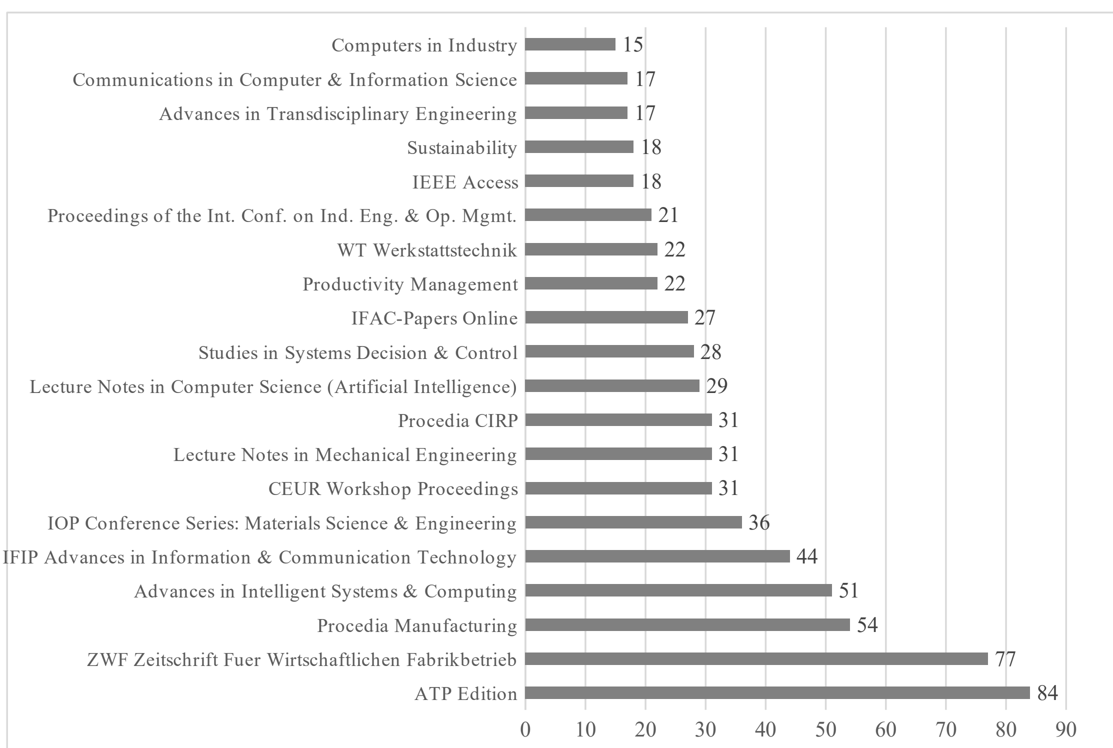

Figure 4. Journals.

Figure 4 shows the top 20 journals with more publications, two especially stand out, the ATP Edition of Russia with 84 publications, and the ZWF Zeitschrift Fuer Wirtschaftlichen Fabrikbetrieb of Germany with 77 publications. Other journals are Procedia Manufacturing of the Netherlands from Elsevier Publishing House with 54 publications, Springer's Advances in Intelligent Systems and Computing in Germany with 51 publications, and Springer's IFIP Advances in Information and Communication Technology in Germany with 44 publications. Finally, another 15 journals have up to 36 maximum publications and up to 15 minimum publications on technology topics.

Of the technological competitiveness, the journals with the most publications are the Journal of Fluids Engineering Transactions of the ASME with six 90's documents, the Journal of Medical Research, and Scientometrics with five publications and Research Policy along with other journals with at least four publications. The topic of I5.0 has published in OMICS to the Journal of Integrative Biology of the United States, Engineering of the United Kingdom, and Sustainability of Switzerland. Countries with more publications seen in Figure 5.

Figure 5 shows that Germany is the leading country in studies of I4.0 with 737 publications, in addition to being the forerunner of the concept. Italy is have appreciated with 270 publications. Below are countries like China, United Kingdom, United States, and Spain with 174, 168, 168, and 164 publications. Finally, 14 countries have 128 maximum publications and up to 36 minimum publications. A smaller presence of emerging economies such as Brazil, India, Mexico, and South Africa is confirmed (Dalenogare et al. 2018).

Of the technological competitiveness, the leading countries are the United States with 41, the United Kingdom with 18, Germany with 15, Russia with 15, and China with 14 publications. In new places emerging economies such as Brazil, Colombia, and India with five publications, and Mexico, Turkey, and South Africa, with

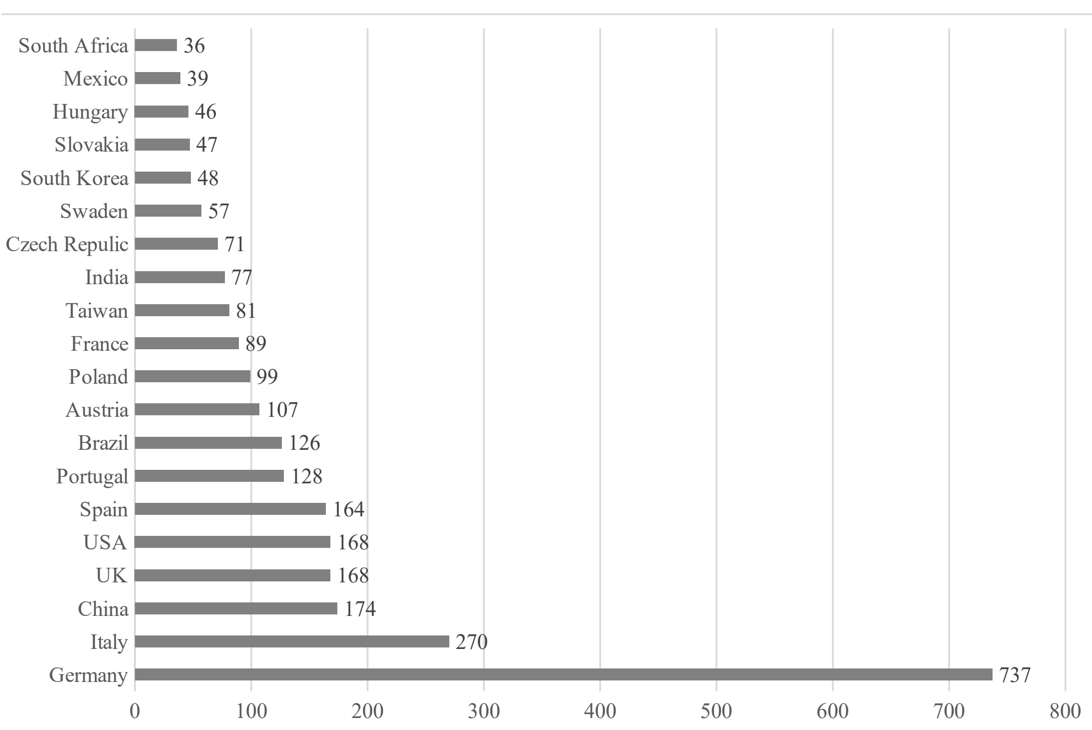

Figure 5. Countries.

three publications, perceived. As for I5.0, it has published in developed economies such as the United Kingdom, China, Canada, Australia, and emerging economies such as Turkey and India (authors affiliation), so it concluded that the participation of emerging economies is minimal. Regarding collaboration networks, Table I appreciated.

Table I shows 10 collaboration groups. The largest group studies topics related to I4.0 such as reconfigurable smart factories, custom manufacturing systems, big data, radio frequency identification (RFID), fuzzy conglomerates, industrial wireless networks, industrial internet of things, software, simulation , cyber-physical systems, cloud computing, industrial ethernet, open network platforms, knowledge sharing, and agent-based manufacturing architectures among others.

This group represented by researchers such as Di Li, Jiafu Wan, Shiyong Wang and Chunhua Zhang of the South China University Technology, Athanasios V. Vasilakos of Lulea University of Technology of Sweden, Zhibo Pang of the ABB Research Corporation of Sweden and Chengliang Liu of Shanghai in Xi'an Jiaotong University of China.

The previous group closely linked with the second group of four researchers who work on topics such as smart manufacturing systems, and internet of things, automated guided vehicles, radio frequency identification, smart products and services, and I4.0. They are Ray Y. Zhong, Xun Xu, and Honghui Wang of the Auckland University of New Zealand and Yongkui Liu of the Chang'an University of China.

A third group that studies I4.0 with topics such as asset management by layers, smart devices, open architecture, technical and collaborative systems, discrete manufacturing, industrial internet of things, technological communication systems, automation. This group is represented by Tizian Schröder, Christian Diedrich, and Alexander Belyaev of

Table I. Collaboration networks

Group	Authors
1	Di Li, Jiafu Wan, Shiyong Wang, Chunhua Zhang, Athanasios V. Vasilakos, Zhibo Pang & Chengliang Liu.
2	Ray Y. Zhong, Xun Xu, Honghui Wang & Yongkui Liu.
3	Tizian Schröder, Christian Diedrich, Alexander Belyaev, Zdenec Bradac, Tomas Benesl, Frantisek Zezulka & Jakub Arm.
4	Michele Gattullo, Michele Fiorentino, Antonio Em Uva, Mónica Bordegoni & Francesco Ferrise.
5	Andrej V. Gurjanov, Anatolij V. Shukalov, Igor O. Zharinov & Danil A. Zakoldaev.
6	Dmitry Ivanov, Boris Sokolov & Alexandre Dolgui.
7	Fabricio Junqueira & Paulo E. Miyagi
8	Erwin Rauch & Dominik T. Matt.
9	Edward Szczerbicki & Cesar Sanin.
10	Yun Li & Hongnian Yu.

Source: Elaboration from WoS and Scopus documents.

the University of Magdeburg Otto Von Guericke of Germany, Zdenec Bradac, Tomas Benesl, Frantisek Zezulka and Jakub Arm of the Brno Technological University of Czech Republic.

In the fourth network of I4.0 with maintenance and augmented reality, are Michele Gattullo, Michele Fiorentino, and Antonio Em Uva of the Polytechnic University of Bari in Italy, Mónica Bordegoni and Francesco Ferrise of the Polytechnic of Milan of Italy.

A fifth network is made up of five authors who have participated in conferences as IOP Conference Series of Materials Science and Engineering. They address issues such as cloud services, digital factories, digital twins, cyber-physical systems, automated systems, digital and computational control systems, network models, algorithms, manufacturing processes, organization of work projects, information exchange, product models digital, transportation systems. They are Andrej V. Gurjanov of the Electroavtomatika Experimental Design Office of Russia, Anatolij V. Shukalov, Igor O. Zharinov, and Danil A. Zakoldaev of Saint Petersburg National Research University of Information Technologies, Mechanics and Optics in Russia.

A sixth network is formed by the trio of Dmitry Ivanov of the Berlin School of Economics and Law in Germany, Boris Sokolov of Saint Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences of Russia and Alexandre Dolgui of the IMT School of Engineering Atlantique of France. They have worked with issues of I4.0 such as digital technology, supply chain management, additive manufacturing, blockchain, big data, programming in production systems, control systems, digital supply chain, algorithms, information processes, business management, sustainability, flexible assembly systems, cyber-physical supply networks, and material flows.

Finally, other networks composed of investigator duos are observing. One of them is that of Fabricio Junqueira and Paulo E. Miyagi of the Polytechnic School of the University of São Paulo in Brazil, and they have studied topics such as big data, machine-machine integration, internet of things in the cloud, industrial modeling, flow schemes of production, cloud-based manufacturing.

Another duo is that of Erwin Rauch and Dominik T. Matt of the Free University of Bozen-Bolzano in Italy, they have published I4.0 and supply chains, implementation barriers, user experience, engineering design and manufacturing, sustainability, production processes, visual monitoring systems, knowledge transfer, smart store floor management, functional requirements, customer needs, reverse engineering, business model innovation, SMEs (small and medium-sized enterprises) 4.0, evaluation models, mass production and techniques of parametric design among others.

Other pairs of authors such as Edward Szczerbicki of the Gdansk University of Technology in Poland and Cesar Sanin of the University of Newcastle of Australia are also appreciated, these authors have addressed topics such as smart product design, virtual engineering factories, product innovation, and smart innovation engineering among others.

A final duo is the one formed by Yun Li of the University of Glasgow in the United Kingdom and also affiliated with the Dongguan University of Technology in China, and Hongnian Yu affiliated with the Bournemouth University of the United Kingdom. Both have addressed issues such as energy efficiency, smart design, administrative practice, attributes and predictive personalization of needs, diffuse grouping, product design configuration, simulation, human resources management, self-organization, and cyber-physical integration among others.

As for I5.0, there are still no workgroups due to the few publications. Regarding technological competitiveness, the most representative group is made up of A.L. Porter, J.D. Roessner, N. Newman, D. Roessner, X.Y. Jin, N.C. Newman and D. M. Johnson. Subsequently followed by the group of S. Jun, J. Kim, and S. Park. Then two other duos follow, that of T. G. Stanford and D. A. Keating, and other of W. D. Yu and S. S. Lo.

In conclusion, it can be affirmed that the general panorama of technological competitiveness and emerging technologies is mostly worked and studied in developed countries (Lasi et al. 2014), so it highlights the need to better assimilate and apply these topics in emerging economies to reduce the existing technology gap (Acosta & De 2015).

Regarding the results of the SRL and the content analysis, the key elements of technological competitiveness are presented from two approaches: those focused on personnel and those focused on the organization. The personnel approach considers the competences, skills, and capabilities of the personnel, while the path to the organization finds elements of the technological structure in organizations. And finally, the emerging technologies of I4.0 and I5.0 present in each type of economy studied are also presented.

The key elements represent those successful ingredients in technological competitiveness from both approaches and emerging technologies in organizations. For example, one of the most used in technical research and R+D+i are patents, as they serve as the basis of the scientific and technological activity of organizations (Cho & Park 2015, Ferraro et al. 2017, Narin et al. 1987, Zhang & Guan 2019), although, the key elements of technological competitiveness and emerging technologies are more than a component, so a thorough review was carried out, and the results shown in Table II.

Table II shows that the key elements of technological competitiveness, and the emerging technologies of I4.0 and I5.0 are different between developed and emerging economies, because while in the former regularly work on very specific and oriented to technological enablers, in the latter mostly work on the issues in a general way, issues related to mature technologies still developed and challenges are yet addressed on essential technologies as stated by Luthra & Mangla (2018).

This is why, while developed economies deal with issues related to the explanation and efficient linking of interactions between devices, value chain actors through the industrial internet of things, big data algorithms for load balancing of smart machines, cyber-physical systems architecture and its real-time interaction between virtual and physical through internet of things, cloud computing as a secure method for real-time information exchange between cyber-physical systems, digital application twins real-world or for the replication of a physical element, the object of virtual engineering, artificial intelligence, collaborative robots, bioengineering, STEM (science, technology, engineering and mathematics) education, the symmetric innovation of I5.0, and other issues aimed at solving how things done, that is, the use of technological enablers rather than just a simple emerging technology.

On the contrary, in emerging economies, necessary technology issues that are part of the second and third industrial revolution are addressed, such as automation, digitalization, electronics, robotics with limited interactions, and information and communication technologies. Although emerging technologies such as big data, internet of things, machine learning, and robotics are also appreciated, but

Table II. **Technological key elements in developed economies and emerging economies.**

Economy	Authors	Countries	Key Elements
Developed economies	Burlaka (2011), Cho & Park (2015), Jun & Park (2016), Lasi et al. (2014), Lee et al. (2015), Nahavandi (2019), Özdemir & Hekim (2018), Sachsenmeier (2016), Santos et al. (2017), Shafiq et al. (2015), Svobodova & Hedvicakova (2017), Zakoldaev et al. (2018).	Austria, Australia, Canada, China, Czech Republic, Denmark, European Union, France, Germany, Greece, Hungary, Italy, Japan, Netherlands, Poland, Portugal, Russia, Slovakia, Spain, South Korea, Sweden, Switzerland, Taiwan, United Kingdom, United States and others.	Supply chain management, artificial intelligence, big data algorithms for load balancing, smart manufacturing algorithms, cyber-physical systems architecture, extreme automation, big data analytics, secure big data, bio circuits, bioengineering, synthetic biology, collaborative robots, technological skills, extreme wireless connectivity, cloud computing, advanced digitalization, STEM (science, technology, engineering and mathematics) education, tertiary education, man-machine balance, digital twins, engineering skills, information and communication technologies, symmetric innovation, technological innovation, high-speed internet, internet of things, advanced manufacturing, patents, object of virtual engineering, mass customization, R+D+i, virtual reality, networks of technological competence, robotics, sensors, simulation.
Emerging Economies	Acosta & De (2015), Castillo et al. (2016), Dalenogare et al. (2018), Gupta (2010), Luthra & Mangla (2018), Mayindi & Kachienga (2008), Mittal et al. (2015), Sinisterra et al. (2017), Zholdasbekova et al. (2015).	Argentina, Brazil, Colombia, Ecuador, India, Kazakhstan, Malaysia, Mexico, South Africa, Turkey and others.	Technological exploitation, automation, big data, supply chain, cyber-physical systems, cloud computing, control, skills and competences development, digitalization, electronics, technological strategies, organizational structure, additive manufacturing, skills, technological indicators, technological innovation, internet of things , R+D investments, lean, mass manufacturing, business model, technology policy, augmented reality, results, robotics, sensors, innovation systems, integrated manufacturing systems, sustainability, information and communication technologies.

Source: Elaboration from WoS and Scopus documents.

it not known if these issues are equally frequent than in developed economies. Therefore, a content analysis performed for each type of economy in Figure 6.

Figure 6 shows that in developed economies, the key elements of technological competitiveness in personnel approach are technological competences (7th with 4.4%), engineering skills (6th with 4.6%), and decision making and problem solving (14th with 2.6%). In the organizational approach, R+D+i (8th with 4.3%), supply chain (11th with 2.9%), product design (15th with 2.6%), human resources management (17th with 1.4%) and knowledge management (20th with 1.0%).

Regarding the use of emerging technologies in smart manufacturing systems (1st with 29.1%), the internet of things and industrial internet

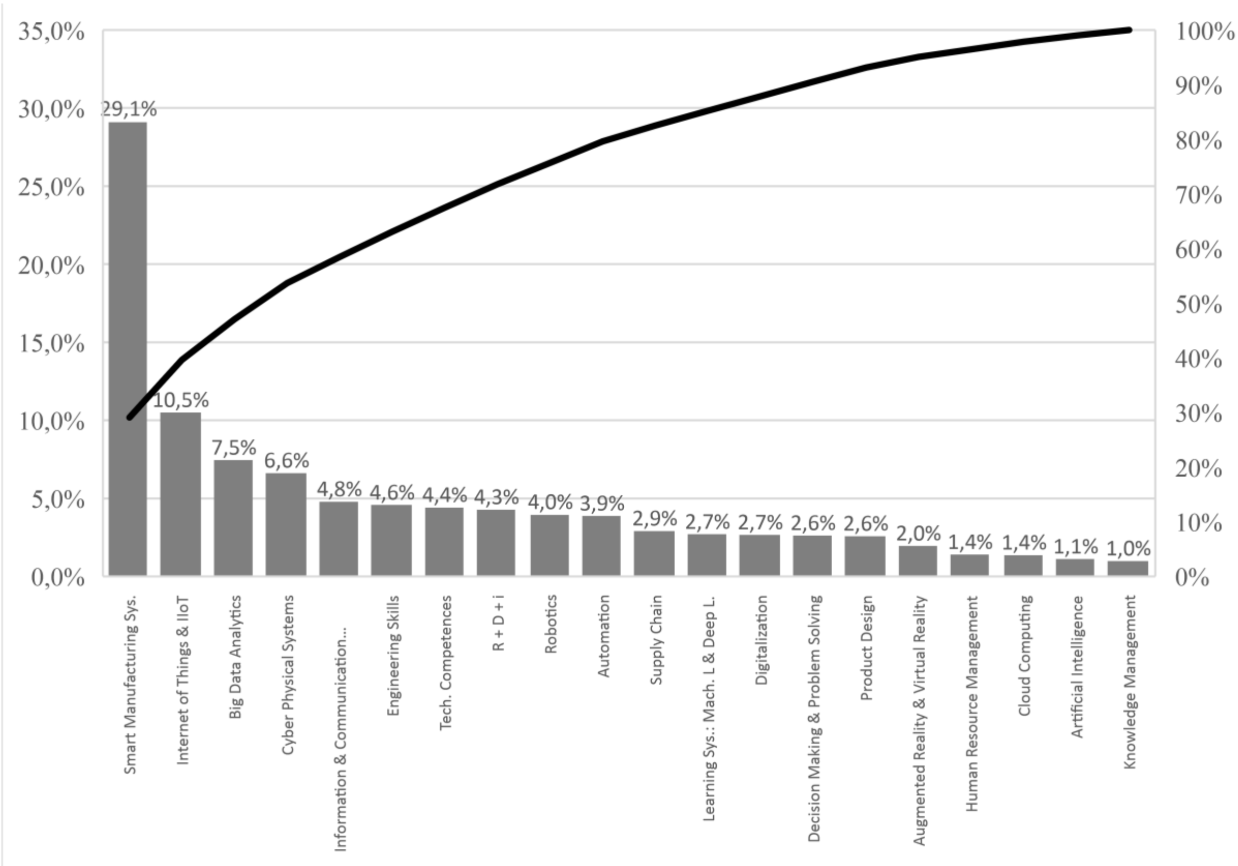

Figure 6. Technological key elements in development economies.

of things (2nd with 10.5%), big data analytics (3rd with 7.5%), and cyber-physical systems (4th with 6.6%), information and communication technologies (5th with 4.8%), robotics (9th with 4.0%), automation (10th with 3.9%), learning systems as machine learning and deep learning (12th with 2.7%), digitalization (13th with 2.7%), virtual reality and augmented reality (16th with 2.0%), cloud computing (18th with 1.4%) and artificial intelligence (19th with 1.1%).

From the previous Figure, a strong presence of the most representative emerging technologies of recent industrial revolutions seen, and also these identified technologies were more specific in their research. For example, the internet of things recognized with more detailed variations such as the industrial internet of things, the internet of things and services, the industrial internet, and the protocols of the internet of things, among others. Therefore, it concluded that these economies are avant-garde in technological issues.

Figure 7 reaffirms that in emerging economies, the key elements of technological competitiveness and emerging technologies are not as specific as the technological enablers of developed economies, even some are strictly related to past industrial revolutions or topics most usual in the organizations.

Regarding technological competitiveness, the organizational approach shows that elements such as sustainability organizational (3rd with 6.7%), organizational structure (4th with 6.7%), results organizational (7th with 4.0%), supply chain and logistics (9th with 2.3%), innovation (10th with 2.1%), lean (11th with

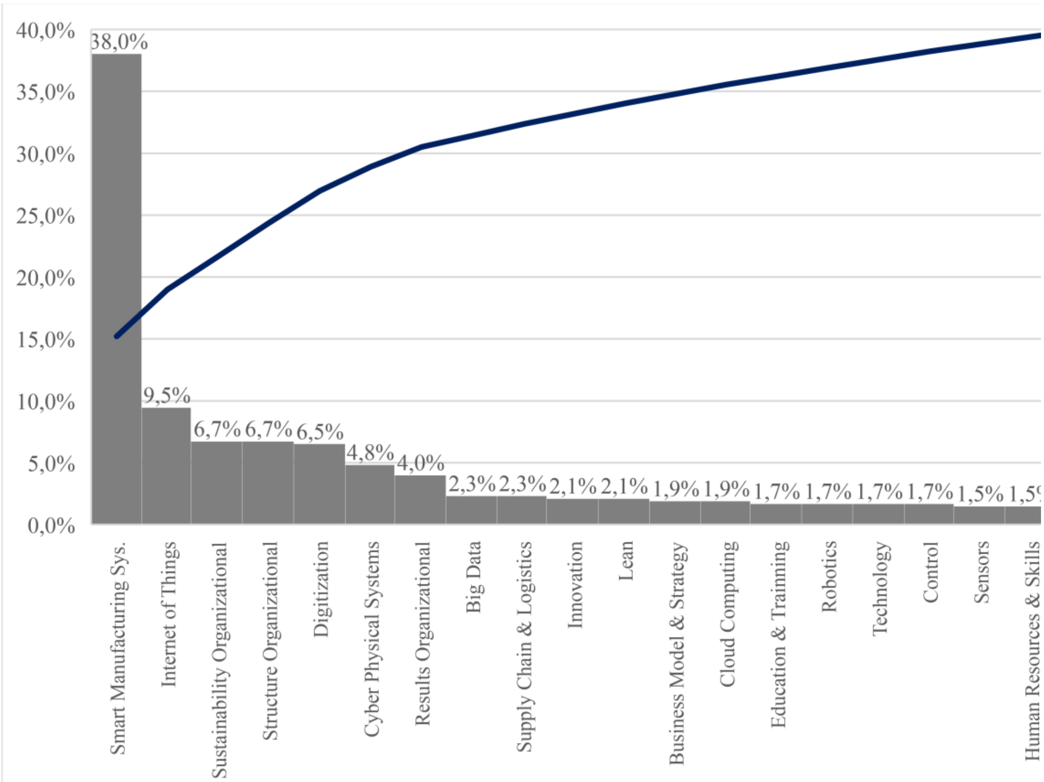

Figure 7. Technological key elements of emerging economies.

2.1%), business model strategy (12th with 1.9%), technology (16th with 1.7%), and control (17th with 1.7%), are key elements of this type of economy. In the personnel approach, elements such as education and training (14th with 1.7%), skills of human resource (19th with 1.5%), and decision making (20th with 1.5%) appreciated.

As for emerging technologies in smart manufacturing systems (1st with 29.1%), fewer technologies are perceived than in developed economies, for example, the use of the internet of things (2nd with 9.5%), digitalization (5th with 6.5%), cyber-physical systems (6th with 4.8%), big data (8th with 2.3%) , cloud computing (13th with 1.9%) , robotics (15th with 1.7%) and sensors (18th with 1.5%).

Of the above, technological competitiveness with an organizational approach, developed economies (five with 12.2%) have fewer key elements than emerging economies (nine with 29.2%), although many of the key elements of emerging economies are oriented to common themes of companies, for example, organizational structure, sustainability organizational, structure organizational, business results, lean, strategic business model and control systems.

From this approach, the common or comparable key elements are the supply chain, R+D+I, and product design of developed economies (three key elements with 9.8%) concerning to key elements such as supply chain, innovation, and technology in emerging economies (three key elements with 6.1%). Other differentiated elements are management knowledge and human resource management of developed economies (two key elements with 2.4%) that are not equally present at the top in emerging economies.

Regarding technological competitiveness with an approach on personnel, both economies have three key elements, although developed economies (11.6%) study this approach for emerging economies (4.6%). A common element is decision making, although in developed economies (2.6%), it is studied more than in emerging economies (1.5%). Another common element is the skills, although these are studied in different intensity and focus, since in developed economies they are visualized from an engineering orientation (4.6%), while in emerging economies the skills are not as specific (1.5%). A third element is technological competences in developed economies (4.4%) and education and training in emerging economies (1.7%).

As for emerging technologies, developed economies (12 with 76.2%) study more key elements than emerging economies (eight with 66.2%). Of the technological elements, there are seven common key elements (smart manufacturing systems, internet of things, big data, cyber-physical systems, robotics, digitalization, and cloud computing), however, although developed economies (61.7%) study a little less such elements that in emerging economies (64.7%).

In addition, a common element is smart manufacturing systems (38.0% in emerging economies and 29.1% in developed economies). This fact maybe because, in developed economies, more specific topics are being worked on, while in emerging economies, work continues on issues more general of technology. Other key elements unique to developed economies (five key elements with 14.5%) are information and communication technologies, automation, learning systems as machine learning and deep learning, augmented reality and virtual reality, and artificial intelligence.

CONCLUSIONS

The study aimed to determine the key elements of technological competitiveness and emerging technologies of I4.0 and I5.0 in developed and emerging economies. In this regard, two types of approaches identified through a review of different studies of technological competitiveness. The first was the personnel approach. Here, models and strategies of the efficient management of intangibles are designed, like the competences, the capacities, the abilities, and the skills of the human resources. To respect, intangibles do not belong to the company, and these are an organizational pillar of the economies and societies of knowledge.

From this approach, it can observe that in developed economies, elements like the competences, abilities, and skills of the personnel are more oriented to engineering techniques such as STEM (science, technology, engineering, and mathematics) education, technological knowledge and soft skills. On the other hand, in the emerging economies, the need to develop the general skills of the persons is raised, although this need is not a priority, nor does it represent the same commitment as in developed economies.

The second, the organizational approach to technological competitiveness in developed economies obtained key elements as R+D+i, the supply chain, decision making, and knowledge management. These elements of the organizational structure help to convert tacit knowledge into explicit and keep it in the organization. In emerging economies, key elements such as corporate sustainability, model and strategies, organizational structure, organizational results, innovation, and lean identified.

From the previous findings, it concluded that developed economies prioritize technological advances through a more comprehensive R+D+i system to build technology and prioritize the operability throughout the supply chain. Emerging economies attend main aspects like sustainability and business survival that is reflected in the results and its structure. They don't prioritize the technological vanguard or the understanding of the entire supply chain. Emerging economies prefer the adoption or appropriation of technology. However, they support innovation schemes and lean improvement in manufacturing and administrative operations.

In general, technological competitiveness is very different. For example, in emerging economies, it is necessary to work hard in the public policy of science, technology, and innovation, because these currently do not contribute to the significant development of these nations. Also, there are no programs of financing truly capable of providing the necessary impetus and direction, so that governments are concerned with designing a collaborative ecosystem between them and society, business, and the education sector for the development of nations.

In agreement with Gruber (2013), Jentsch et al. (2013) and Hofmann et al. (2012), smart manufacturing systems are recognized in both economies as a primary element of the I4.0 (Figure 6 and Figure 7). However, developed economies are building and implementing more avant-garde and technologies oriented toward a society 5.0, such as automation, artificial intelligence, deep learning, machine learning, information and communication technologies, virtual reality and augmented reality.

The previous findings also agree with Özdemir & Hekim (2018), and Bednar & Welch (2019), who explains that a set of technologies is required to evolve to extreme automation. For example, the development of autonomous vehicles requires artificial intelligence, machine learning, deep learning, big data analytics, and high-speed internet of things. Other examples are automated supermarkets and automation in manufacturing processes with the help of robotics.

On the other hand, the development of collaborative models and the creation of new business models continue to increase. In this sense, information and communication technologies allow direct feedback between customers and suppliers through digital networks and interaction between users. In addition, smart devices with technologies such as virtual reality and augmented reality are essential elements for the development of new industrial waves, as they will support decision making and manipulation of the environment (Bednar & Welch 2019).

Finally, some worrying points of I4.0 are the systemic cyber threats and the lack of regulation of extreme connectivity, the disruptive change of the labor supply and new occupations, and the timely inclusion of SMEs in new technological developments. All these points are worrisome and could collapse to the entire network and unbalance the control and governance of the systems (Bednar & Welch 2019, Özdemir & Hekim 2018).

On the other hand, in agreement with Bednar & Welch (2019), Nahavandi (2019), Özdemir & Hekim (2018) and Sachsenmeier (2016), in I5.0 highlights the role of humanity in the balance of nature and Technological development towards intelligent innovation and a society 5.0. In this sense, some technological advances best used will be firmly based on artificial intelligence, integrated sensors, extreme and smart automation, secure and co-produced big data, massive cloud computing, complex and hyperconnected digital networks, and mass manufacturing with autonomous and customizable character.

Points like the one that collaborative robots (cobots) and humans must link together to work intimately in a brain-machine interaction also stand out. In addition, the intensification of remote work will require an ideal mix between technical skills and soft skills and an interdisciplinary collaborative capacity. Therefore, in agreement with Nahavandi (2019) and Sachsenmeier (2016), a new generation of public policies with a responsible, harmonious, sustainable, and comprehensive nature on technical-scientific, socio-economic, political and ethical aspects is required.

Next-generation of technological policies could have a design of an ecosystem of symmetric and three-dimensional innovation. The system must have three main characteristics. First, it has a safe exit strategy. Second, it contemplates an equal emphasis between the acceleration and slowdown of innovation. Third, it considers global governance of emerging technologies with an ethical, humanistic, and social sense (Bednar & Welch 2019, Özdemir & Hekim 2018).

In future research, it is suggested to include intellectual property information and patents, and use techniques such as the Delphi method with experts. This document identified the key elements of technological competitiveness and the most used emerging technologies in developed and emerging economies, so it represents a starting point, especially in emerging economies for entrepreneurs, academics, and policymakers.

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Erick Leonardo Alvarez-Aros: The main contributions of the first author were information search, introduction elaboration, literature review, methodology, results and conclusions. As well as the adaptation of the work to the English language. The main contributions of this work are the methodological and novel treatment through the R software, Biblioshiny and Bibliometrix. In addition, obtaining results in terms of technology competitiveness for developed economies as well as for undeveloped or emerging economies. César Augusto Bernal-Torres: The main contributions of the second author were the revision and improvement of the introduction, the literature review, the methodology, the results and the conclusions. As well as details regarding the style format of the entire manuscript in general. It is important to emphasize that the second author also set out to find a way to show emerging technologies in each type of economy.