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The titans sustainability and industry 4.0 working for the planet earth

A sustentabilidade dos titãs e a indústria 4.0 trabalhando para o planeta terra

José Salvador da Motta Reis[1]
Ronald Palandi Cardoso[2]
Dayana Elizabeth Werderits Silva[3]
Maria da Glória Diniz de Almeida[4]
José Glenio Medeiros de Barros[5]
Nilo Antonio de Souza Sampaio[6]
Luís César Ferreira Motta Barbosa[7]

[1] Master in Production Engineering, Centro Federal de Educação Tecnológica – RJ, Rua General Canabarro, 485, Maracanã, Rio de Janeiro - RJ, CEP: 20271-204. E-mail: jmottareis@gmail.com
Orcid: https://orcid.org/0000-0003-1953-9500
[2] Graduating in Mechanical Engineering, Universidade do Estado do Rio de Janeiro, Rod. Pres. Dutra, km 298, Polo Industrial, Resende - RJ, CEP: 27537-000. E-mail: ronaldpalandi0805@gmail.com
Orcid: https://orcid.org/0000-0002-7335-2280
[3] Master in Environmental Technology, Universidade do Estado do Rio de Janeiro, Rod. Pres. Dutra, km 298, Polo Industrial, Resende - RJ, CEP: 27537-000. E-mail: daywerder@gmail.com
Orcid: https://orcid.org/0000-0003-2397-4396
[4] Master in Environmental Technology, Universidade do Estado do Rio de Janeiro, Rod. Pres. Dutra, km 298, Polo Industrial, Resende - RJ, CEP: 27537-000. E-mail: gloria_uerj@yahoo.com.br
Orcid: https://orcid.org/0000-0002-0645-8907
[5] Doctor of Mechanical Engineering, Universidade do Estado do Rio de Janeiro, Rod. Pres. Dutra, km 298, Polo Industrial, Resende - RJ, CEP: 27537-000. E-mail: glenio.barros@gmail.com
Orcid: https://orcid.org/0000-0002-6902-599X
[6] Doctor of Mechanical Engineering, Universidade do Estado do Rio de Janeiro, Rod. Pres. Dutra, km 298, Polo Industrial, Resende - RJ, CEP: 27537-000. E-mail: nilo.samp@terra.com.br
Orcid: https://orcid.org/0000-0002-6168-785X
[7] Doctor of Mechanical Engineering, Centro Federal de Educação Tecnológica – RJ, Rua General Canabarro, 485, Maracanã, Rio de Janeiro - RJ, CEP: 20271-204. E-mail: luiscesarfmb@gmail.com
Orcid: https://orcid.org/0000-0002-9853-1939

Abstract

The history of industry is marked by revolutions, the Fourth Industrial Revolution provides opportunities for sustainability, and means to reduce environmental degradation and social inclusion. This article aims to identify which factors impact the sustainability of an organization. The exploratory research was carried out by means of literature review and bibliographic research to achieve the objective of conducting a bibliometric study, identifying the evolution of publications, and the authors that make up this field of knowledge. It is necessary for companies and industries to be introduced to the global changes that Industry 4.0 has introduced in the manufacturing environment, making it possible to develop sustainable processes and products.

Keywords: Industry 4.0. Sustainability. Triple Bottom Line. Sustainable Development.

Resumo

A história da indústria é marcada por revoluções, a Quarta Revolução Industrial oferece oportunidades de sustentabilidade e meios para reduzir a degradação ambiental e a inclusão social. Este artigo tem como objetivo identificar quais fatores impactam a sustentabilidade de uma organização. A pesquisa exploratória foi realizada por meio de revisão de literatura e pesquisa bibliográfica para atingir o objetivo de realizar um estudo bibliométrico, identificando a evolução das publicações, e os autores que compõem este campo do conhecimento. É necessário que as empresas e indústrias sejam introduzidas às mudanças globais que a Indústria 4.0 introduziu no ambiente de manufatura, tornando possível o desenvolvimento de processos e produtos sustentáveis.

Palavras-chave: Indústria 4.0. Sustentabilidade. Triple Bottom Line. Desenvolvimento Sustentável.

Introduction

Studies indicate that if consumption patterns continue at current levels, it will take three planets identical to Earth to supply all these natural resources that have been used, and the population by 2050 will be about 9.6 billion people. To improve the global quality of life, it is necessary to adapt consumption to nature's regenerative capacity. Sustainable development has proven to be a strategy that is able to enhance economic growth, protect the

environment, and boost society (Bahar et al., 2020; Rajalakshmi & Devi Mahalakshmi, 2016; Reis et al., 2021).

The challenge of sustainability needs to be implemented to have a real impact on the reduction and consequently elimination of environmental detriments. For this, the innovation proposals of the Fourth Industrial Revolution (FIR) present themselves as one of the main allies to this goal. Due to its pioneering spirit, Germany leads the ranking of research and academic publications related to the subject, followed by the United States and China, and the result of these materials are initiatives such as the advanced manufacturing, partnership project and the plan, which aim to initiate the integration process between technology and industry in their respective countries (Lasi et al., 2014; Lee et al., 2015; Lu, 2017; Reis et al., 2021).

Thus, in terms of economic and production transformations, Industry 4.0 is considered as an important strategy for organizations to remain competitive in the future and for the direct development of products and services. Society demands solutions from industries and governments to reverse the negative consequences caused by the current way of growing. Therefore, to meet society's new demands, concepts such as ethics, social responsibility and sustainable development are playing an increasingly important role in the strategies of organizations (Frank et al., 2019; Liao et al., 2017; Zhong et al., 2017).

In counterpoint to all this technological progress, the planet is experiencing the greatest ecological crisis in history. The inconsequent use of natural resources has brought humanity to the brink of their exhaustion and the erosion of structures that are essential to life on Earth, such as the ozone layer and ecosystems. Aware of this risk, the concept of sustainability has become increasingly popular, as it seeks a lifestyle in which progress does not conflict with the life of the planet (Ghobakhloo, 2020; Müller et al., 2018; Reis et al., 2022). How technological development, especially Industry 4.0 technologies, can help organizations become more sustainable? To answer this question, this paper aims to identify what factors impact the sustainability of an organization.

Theoretical Referential

In 1987, through the Brundtland report, the United Nations (UN) contributed decisively to the implementation of the concept of sustainable development, defining it as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Elkington, 1998; Lozano, 2020; Reis et al., 2021). From that time on, sustainability began to be a progressively popular topic among organizations,

academia, and global society. Most recently, in 2015 the UN developed 17 goals for sustainable development based on five main categories: People; Planet; Prosperity; Peace; and Partnership. These goals are part of the 2030 Agenda, and all countries should strive to achieve them collaboratively (Araujo et al., 2021; Espuny et al., 2021; Li & Hu, 2020; Reis et al., 2021).

Sustainability itself seeks ways to minimize the negative impacts that occur in the social, environmental, and economic environments, addressing climate change, pollution, and the unrestricted use of resources. It is worth mentioning that sustainability is used to call a business management, which as far as possible seeks to avoid some environmental problems and has as its main objective to ensure that the effects of production do not exceed the environmental resources that are inserted in that environment, and thus the organization obtains sustainable development (Espuny et al., 2021; Lozano, 2020; Narazaki et al., 2018; Rezende, 2016).

FIR has merged new technologies and innovations much more quickly and extensively than in previous revolutions. Phenomena like Uber, Airbnb, WhatsApp, and Facebook were virtually unknown or did not even exist until a few years ago. Artificial Intelligence (AI) has changed the way humans relate to others and to the world, from autonomous cars, drones, virtual assistants, to translation software. The speed and intensity of this revolution deserves further study, since its proposals are so ambitious that they may represent innovations even more impactful than those achieved by previous revolutions (Braml et al., 2022; Ho et al., 2016; Mack & Veil, 2017).

FIR is at the root of the digital disruption we are witnessing, connecting resources, services, and people. It is based on the adoption of digital technologies that, in real time, gather and analyze data, producing information to drive the entire manufacturing system. For this reason, I4.0 is also known as Internet of Things (IoT) and through it we are witnessing the transformation of traditional factories into Smart Factories (Alladi et al., 2019; Manavalan & Jayakrishna, 2019; Zhang & Chen, 2020).

I4.0 enjoys a breadth that is reflected in its applicability, not only in the manufacturing industry, but also, for example, in mining, logistics, food supply chain, healthcare, commerce, energy management, construction, apparel, among others. FIR, while providing a profound cycle of benefits, with increasingly impactful prospects in the coming decades, has also generated great challenges in equal measure (Fernandez-Carames & Fraga-Lamas, 2018; Khan et al., 2020; Mastos et al., 2020).

As with previous revolutions, FIR or I4.0 will involve profound transformations in the economic, political, and social spheres. Among these technological transformations are changes in the processes of production and distribution of goods and services. In this context, companies assume a prominent role, since: they are the main engines of economic development and have the financial resources, technological know-how, and institutional capacity to program green solutions (Frank et al., 2019; Lee et al., 2015; Liao et al., 2017).

In the social pillar of sustainability, the I4.0 will help in less physically demanding work conditions, greater inclusion of people with disability or advanced age, greater qualification of employees, among others I4.0 will also have impacts on the environmental pillar of sustainability such as: reduced energy consumption, reduced consumption of raw materials, lower pollution levels, among others. In the economic pillar, I4.0 will increase the company's productivity and revenues, new opportunities for small and medium-sized companies, a more collaborative value chain, among others (Ghafoorpoor Yazdi et al., 2018; Ghobakhloo et al., 2021; Jamwal et al., 2021).

There are several distinctions between I4.0 and traditional manufacturing coming from the third revolution, such as intelligent features, improved flexibility, automation, high integration and consequently sustainability, matching different criteria such as high volumes, different production speeds and variety of data, leading organizations to a high level of sustainable manufacturing, facilitating environmental metrics in precision, quality and obtaining data in real time (Lasi et al., 2014; Mohan & Katakojwala, 2021; Reis et al., 2021; Vrchota et al., 2020).

Scientific Method

The research in question can be classified as applied, of an exploratory nature, and qualitative in approach. As method and technical procedures were adopted, respectively, the bibliometric research and the literature review (Alvarenga et al., 2021; Cardoso et al., 2023; Espuny et al., 2022; Kothari & Garg, 2019; Silva et al., 2021). Data collection was carried out through research in articles related to the advantages and disadvantages of Industrial Sustainability, based on its three pillars, social, economic, and environmental.

We used the articles cited in the Google Scholar and SciELO databases in the month of February 2021. Two groups of keywords were used in the search: 1) "Industry 4.0" or "Industria 4.0" or "Industrie 4.0" or "Manufacturing 4.0" or "The Fourth Industrial Revolution" or "4.0" or "Triple Bottom Line" or "Smart Manufacturing" or "Smart Factories"

and 2) "Sustainability" or "Sustainable" or "Corporate Sustainability" or "Enterprise Sustainability" or "Sustainable Companies".

First, only articles related to the Tripod of Sustainability were selected in the research, for being the largest source of data related to the subject by which we chose to be the body of this article. Finally, content analysis was performed to identify the main definitions in the literature.

Results

In this topic is classified the main technologies of I4.0 within the TBL (Table 1), and their respective benefits, thus making something clearer and perceptive of the need for implementation and its impacts on the pillars of environment, society and economy, within the table are the topics and conditions that the technologies in question provide, and they directly fit into the context of the means mentioned in the theoretical foundation relating to the three pillars, initially the economic with IoT technologies, Cyber Security and Big Data. In the second environmental pillar comes the additive manufacturing technology, and finally the last social pillar is the automation and Cyber Security technologies.

Tbl	I4.0 technologies	Benefits	References
Economic	IOT	❖ Massive data exchange. ❖ Increased automation in manufacturing. ❖ Mass customization.	León et al., (2010); Lin et al., (2017)
	CYBER SECURITY	❖ Access blocking. ❖ Service monitoring. ❖ Threat correction. ❖ Contingency failures and auditing changes.	Ardito et al. (2019); Bodkhe et al. (2020); Xu & Duan (2019)
	BIG DATA	❖ Large amounts of data stored by the company, which are produced in real time and used for: ❖ Information management ❖ Collections ❖ Cross-referencing data ❖ Search ❖ Analyses for decision making.	Lee et al. (2014); Qi & Tao, (2018); Wang et al. (2016)
Environmental	ADDITIVE MANUFACTURING	❖ Less material uses ❖ Less production waste generation ❖ Less extraction of matter from nature ❖ Lower power consumption.	Ashima et al. (2021); Ceruti et al. (2019); Dilberoglu et al., (2017); Gaub (2016); Sepasgozar et al. (2020)
Social	AUTOMATION	❖ Greater efficiency in your processes. ❖ Transforming manufacturing operations ❖ Making processes and systems more responsive, all according to the needs of the customer.	Kamarul Bahrin et al. (2016); Kolberg & Zühlke (2015); Oesterreich & Teuteberg (2016); Wollschlaeger et al. (2017)
	CYBER SECURITY	❖ Blocking digital threats ❖ Security in the virtual space	AL-Salman & Salih (2019); Flatt et al. (2016); Rahman et al. (2021);

	❖ Data protection ❖ Protection against copyright infringement ❖ Prevents data falsification.	Sołtysik-Piorunkiewicz & Krysiak (2020)

Table 1. Identification of research gaps from the 50 most cited articles.

Discussions

In the economic pillar we have technologies such as the IoT this interconnection cited in the table formulates that the IoT in I4.0 provides, and generates unprecedented opportunities, creating a large circle of added value to products and services that use it. Moreover, in I4.0, all areas and systems end up interconnected, either by the internet, by a cloud service or even with some connection to the outside world.

All this decentralization of information opens security gaps that did not exist before, so Cyber Security becomes an increasing need within companies, it provides Access Control that define and make digital identifications and access restrictions of employees to sectors and infrastructure areas, the Digital Signature is an effective way to maintain the security of your data, isolation of connection helps a lot to maintain data protection is to adopt an Intranet, periodic monitoring of networks make a periodic checkup of the security of your network.

Big Data is a term focused on the treatment of large volumes of information and applies in I4.0, mainly because of the IoT, which consists of several sensors that collect information in real time of the entire production process, generating greater speed in the delivery of information from large masses of data, in various formats, from various sources. Additive Manufacturing, in addition to lowering costs, this technology allows small companies to compete with large industries in the sector and seal modern and attractive products, capable of capturing the interest of consumers. Automation systems can provide visibility into processes and allow you to control a single task or the entire production, bringing even the possibility of failure and error prevention, using simple control logic or even artificial intelligence, depending on the complexity of the problem. Cyber Security in the social environment aims to protect the individual and the company from cyber threats and attacks from criminal hackers.

Conclusion

The objective of the article was reached, answering the research question, where it was identified which factors have an impact on the sustainability of an organization. The main academic contribution was the verification that the theme of Industry 4.0 and Sustainability

present considerable material, which allows the expansion of the deepening of studies of both associated themes. It is observed that the volume of citations related to what was addressed has an expressive number of materials for analysis and has presented a significant growth every day. The method and technical procedures adopted were, respectively, bibliographical research and literature review. As a contribution of this research, we point out the critical analysis of the factors that impact the sustainability of an organization.

As a limitation, one can point to the fact that the research was conducted taking into consideration only the papers indexed in Google Scholar and SciELO. It is noteworthy that this fact may, to some extent, provide a limited view of the studies on the theme. It is suggested, therefore, that the method used in this research be replicated in other databases such as Scopus, Web of Science, Science Direct, among others, enabling a broader view of the studies conducted. It is noteworthy that this research does not exhaust the subject and that new studies on this theme are being carried out.

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