Integrated Management Systems in Industry 4.0: Literature Review

Cátia Pinto[1)*)], Pedro Domingues[1)], Paulo Sampaio[1)] and Otávio Oliveira[2)]

[1)] Production and Systems Department, University of Minho, Azurém, Guimarães, Portugal

[2)] Production Department, UNESP - Paulista State University, Guaratinguetá, São Paulo, Brazil.

[*] Corresponding author contact: id8975@alunos.uminho.pt

ABSTRACT

Purpose: Management Systems (MS) are a global phenomenon, and their integration is justified by the benefits that they provide to organizations. Thus, the main purpose of this paper was based on the analysis of the existing literature, with a view to characterizing the current state of the art to understand the impact that Industry 4.0 (I4.0) will have on Integrated Management Systems (IMS).

Design/methodology/approach: For this study, exploratory bibliographic research was carried out to extract the most important ideas from the literature, to better understand the main concepts related to ISO 9001, ISO 14001, and ISO 45001, considering the fourth industrial revolution. The methodological basis used in this study followed the PRISMA guidelines and the research was carried out essentially through two databases, Scopus, and Web of Science.

Findings: The integration of MS will be one of the pillars of I4.0 and it aims to interconnect the different areas of an industry, whose objective is to extract data and information that will be used to carry out continuous improvements in the entire production process and in all the related support areas. This paper reviews, lists and organizes the different technological concepts and integration opportunities that have been explored within the scope of IMS in I4.0.

Research limitations/implications: Although this literature review is limited to the aforementioned databases, there is still not much information available regarding the focus of IMS in I4.0.

Originally/value: This study contributed to a better perception and systematization of the IMS considering the I4.0. It focuses on the motivation and importance of ISO certifications, related to quality (9001), environment (14001) and occupational health and safety (45001) in I4.0. Thus, the contribution of this work aimed essentially to provide information about possible benefits and difficulties that may occur due to the implementation of IMS in I4.0 context.

Paper type: Literature review.

Keywords: Integrated Management Systems; Industry 4.0; ISO 9001; ISO 14001; ISO 45001.

1. INTRODUTION

Research on the impact of I4.0 on IMS is still very limited and with this article we intend to review and integrate different concepts and examples existing in the literature, to understand the contributions of new technologies to IMS.

I4.0 created smart factories and created a new manufacturing paradigm based on the adoption of new technologies in relation to physical cyber systems, internet of things, internet of services, robotics, big data, cloud manufacturing and augmented reality (Frank et al., 2019). I4.0 has transformed industry value chains by combining embedded production system technologies with intelligent production processes to pave the way for a new era of business, where these technological revolutions will transform production and logistics processes into intelligent factory environments that will increase productivity and efficiency (Preuveneers & Ilie-Zudor, 2017).

Zhou et al. (2016) report on the strategic plan developed by Germany to implement an optimized transition from Industry 3.0 to I4.0 and in relation to the essential factors for efficient management, they disclose that large and complex systems will need to be managed efficiently through a didactic model built for management optimization (Zhou et al., 2016).

According to Sampaio et al. (2012), the integration of MS avoids the development of organizational "islands" between subsystems, causing a lack of communication and cooperation (Sampaio et al., 2012).

This research aims to present a synthesis of the main concepts, strategies, advantages, and disadvantages of IMS, based on I4.0, which were studied and analysed by different researchers.

2. RESEARCH METHODOLOGY

This study was carried out through a systematic literature review and the initial selection of research sources aimed to collect scientific works with high impact and citation rates, using the Scopus and Web of Science (WoS) databases. The choice of the WoS database was based on the fact that it covers indexed journals with an impact factor calculated such as the Journal Citation Report (Barbosa et al., 2021; Carvalho et al., 2013) and Scopus was chosen because it is the largest scientific knowledge base in the literature review (Barbosa et al., 2021; Morioka & Carvalho, 2016).

In terms of scientific research, although these two sources guarantee quality and relevance to any field of research, they leave out a few works that could provide different perspectives and valuable contributions to this literature review. Thus, in a second stage, recent works were included, with

new research trends, limited impact, and non-academic perspectives. Google Scholar continues to be the most searched database by all and, considering its size, this was also included in the research.

The strategy used to choose the articles consisted of filtering by specific search keywords. In the first search, the keywords "quality", "environment", "safety", "industry 4.0" were applied as "Topic" in the WoS database and as "Article title, Abstract, Keywords'" in the Scopus database, resulting in 26 and 54 documents respectively, with a total of 80 articles. In the second research, the keywords "integrated management system", "industry 4.0" were applied as "Topic" in the WoS database and as "Article title, Abstract, Keywords'" in the Scopus database, resulting in 2 and 9 documents respectively, with a total of 11 articles. In the third search, the keyword "integrated management system" was used as a "Topic" in the WoS database and as "Article title, Abstract, Keywords'" in the Scopus database, resulting in 774 and 1566 documents respectively, with a total of 2340 articles. Due to the high number of articles obtained, a filtering was made taking into account the most recent articles (1) and the articles classified as "Review" (2), so in the years 2021 and 2022 (1) the sample was reduced to 48 articles in the WoS base (36 results referring to 2021 and 12 results referring to 2022) and for 117 articles in the Scopus base (91 results referring to 2021 and 26 results referring to 2022) and in filtering as “Review”, the sample was reduced to 11 articles in the WoS database and 80 articles in the Scopus database. This analysis is summarized in Figure 1.

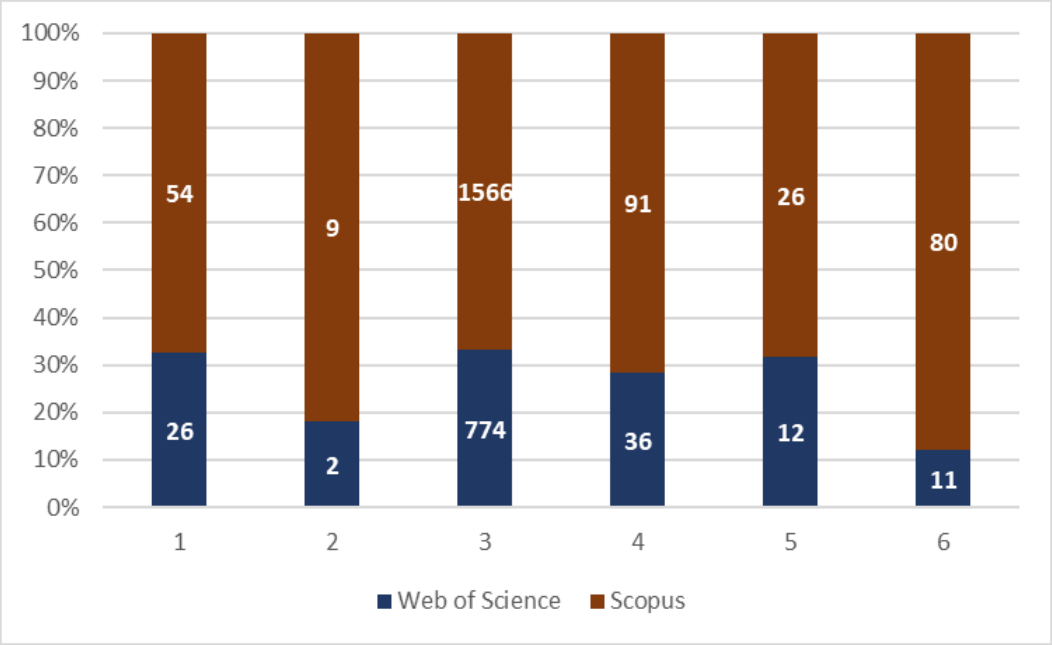

Figure 1: Summary of filtering found articles.

Finally, we proceeded to the content analysis of the articles that include the sample to identify the main factors that will affect an IMS in I4.0.

3. LITERATURE REVIEW

With the Fourth Industrial Revolution, also known as "Industry 4.0", the need arose to renew the structures that managed organizational processes, making them able to face changes. The adoption of certified quality, environment, health and safety MS has the potential to be the key that supports organizations during their evolution and to be a successful approach towards sustainable development.

3.1. Integrated Management Systems

According to Ribeiro et al. (2017), according to ISO, standardized MS provide a model to follow when setting up and operating a MS. All ISO standardization results from a global agreement of experts and therefore offers the benefit of knowledge, experience, and good global management practices. Standardized MS can be applied in any organization, large or small, whatever the product and/or service and sector of activity (Ribeiro et al., 2017).

In order to design competitive advantages and achieve sustainable development, many organizations implement Quality Management Systems (ISO 9001), Environmental Management Systems (ISO 14001) and Occupational Health and Safety Management Systems (ISO 45001), which are have become a widespread practice in recent years around the world (Trierweiller et al., 2014).

With the revisions of the ISO 9001 and ISO 14001 standards published in 2015 and with the new ISO 45001 standard in 2016, it's possible to conclude that research in IMS isn't just an academic study, but a step necessary to implement them properly. The successive drafts published throughout the review process suggest that the new reviews will require companies to have a 360° view taking into account the context in which they develop their activity, an integrative concept (risk-based approach) and a high-level structure that is a common set of requirements that allow them to be easily integrated (Arora, 2018; Domingues et al., 2017; Thaís Vieira Nunhes et al., 2019).

An IMS is defined as a single set of processes sharing a single fund of human resources, information, materials, infrastructure, and financial resources to achieve a set of objectives related to satisfying a variety of stakeholders. IMS started with the publication of the ISO 9001 (Quality Management System) in 1987, after which the ISO 14001 (Environmental Management System)

was introduced in 1996 and OHSAS 18001 in 1999 (currently the ISO 45001, Occupational Health and Safety Management System, in 2016), and then different similar management systems emerged (Nunhes et al., 2016; Thomé et al., 2016).

According to the research work developed by Ribeiro et al. (2017), the future of the implementation of MS will be through the integration of an efficient IMS. Despite the benefits of integration, challenges inherent to this approach persist, namely regarding the evolution of human and financial resources. The authors concluded that organizations are more optimistic and begin to see a future with less difficulties in the integration process, however, when asked about future difficulties, they reported others similar to the current ones and only 25% admitted less difficulties (Ribeiro et al., 2017).

Currently, the main difficulties in terms of integration are lack of human resources with adequate training and knowledge, lack of involvement of top management, resistance to change, lack of financial resources. According to the organizations involved in the study, the greatest difficulties in the medium term will continue to be the lack of resources, although they are more optimistic, since the number of responses without difficulties has increased. The future trend for many management systems is full integration leading to an IMS (Ribeiro et al., 2017).

Figure 2 illustrates a Venn diagram that shows that all MS are interconnected, having common and specific elements.

Figure 2: Venn diagram applied in Certifiable Integrated Management Systems.

Recently, the work of Abisourour et al. (2020), who propose a framework to provide an adequate alignment of the objectives of IMS and strategic management using value stream mapping and cost implementation tools and Algheriani et al. (2019) who developed an integrated risk approach.

The ideas of gurus such as Deming, Juran, Crosby and Ishikawa are the foundations of the Total Quality Management (TQM) movement, whose roots are intertwined in four premises: quality, people, organizations, and leadership. TQM is the basis of current management models, with continuous improvement being an essential element and a critical criterion in all MS, certificates and related benefits (Sanchez-Ruiz et al., 2019; Santos & Martins, 2020).

According to the study of Algheriani et al. (2019), in recent years, the most important factors that encourage organizations to implement the various MS are business pressure, government regulations and laws, competitiveness, public pressures on environmental protection due to pollution, and health and safety risks of workers and customer satisfaction. Such factors required organizations to implement international standards in order to limit them, such as the implementation of ISO 9001 whose main objective is the effective management of risks that can adversely affect the quality of products, ISO 14001 that aims to control risks that can endanger the environment and ISO 45001, which aims to reduce the risk of accidents at work (Algheriani et al., 2019).

Algheriani et al. (2019) developed a risk model for the IMS that has several characteristics that help organizations in its application by the following common approaches: risk-based thinking with risk management as an important factor in identifying, evaluating, and handling of common risks in all standardized systems. The process approach is used to manage and evaluate the performance of each process in the model and the Deming cycle operates as a continuous improvement cycle, ensuring that processes are adequately resourced, well managed and that opportunities for improvement are determined. This model can be implemented in any organization, regardless of type, size and product, as it integrates the most common international standards used by most organizations worldwide (Algheriani et al., 2019).

3.2. Industry 4.0

The concept “Industry 4.0” is applied to a set of rapid transformations in the design, manufacture, operation and service of industrial systems and products. The designation 4.0 means that this is the fourth industrial revolution in the world, the successor to three great industrial revolutions that caused quantum leaps in productivity and changed the lives of people all over the world (Davies, 2015; Khanzode et al., 2021). In other words, the I4.0 is transforming industry value chains by combining embedded production system technologies with intelligent production processes to pave the way for a new age of business by increasing productivity and efficiency (Chiarini et al., 2020; Santos & Martins, 2020).

So far, the three industrial revolutions have led to paradigm shifts in the industrial domain: mechanization and steam power; mass production with assembly lines and automation through the use of information technology (Thoben et al., 2017; Xu et al., 2018). However, in recent years, across the world, practitioners, together with researchers and policymakers, have increasingly advocated a continuing fourth industrial revolution better known as I4.0.(Rafael et al., 2020). Figure 3 depicts the four industrial revolutions, the evolution of the industry from 1784 to the present (Szada-Borzyszkowski, 2022).

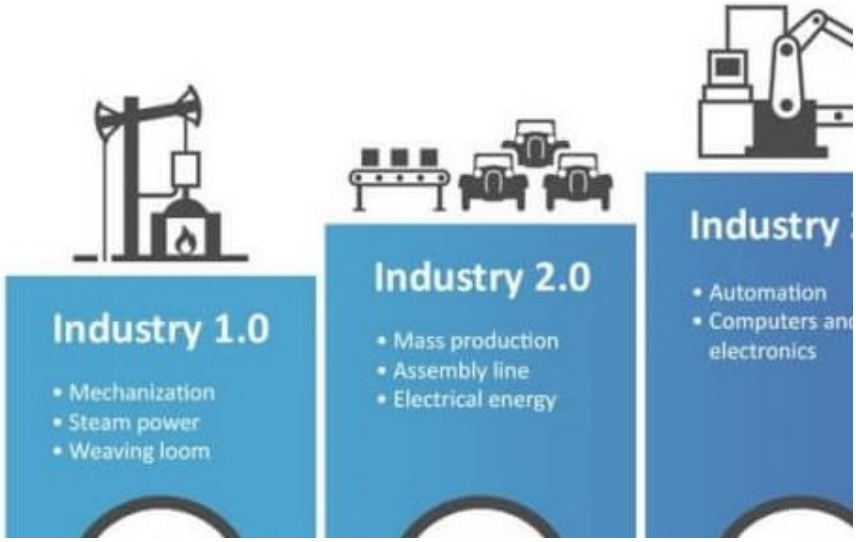

Figure 3: Industrial evolution.

Fonte: Szada-Borzyszkowski (2022).

For Silva et al. (2020), I4.0 describes the fourth industrial revolution, which leads to smart, connected and decentralized production, representing a new level of organization and regulation of the entire value chain of a product throughout its life cycle. Advances in data storage and new computing capabilities, along with developments in technologies such as computational intelligence, automation and robotics, additive industry, and human-machine interaction, are triggering innovations that change the nature and content of manufacturing itself. Industry leaders and researchers agree that digital industry technologies will transform all aspects of value chain industry systems (Silva et al., 2020).

3.2.1. What will change with Industry 4.0?

In the industry of the future, humans and machines will be able to work together. For a specific task, individuals can be quickly directed to the right tool that will automatically know the next step of the task and define the correct calibration for the specific part that the individual intends. Smart tools will also be able to record the operation, to ensure quality control and eliminate manual login (Davies, 2015).

According to Westkämper (2014), the four major topics for the development of industry are illustrated in Figure 4:

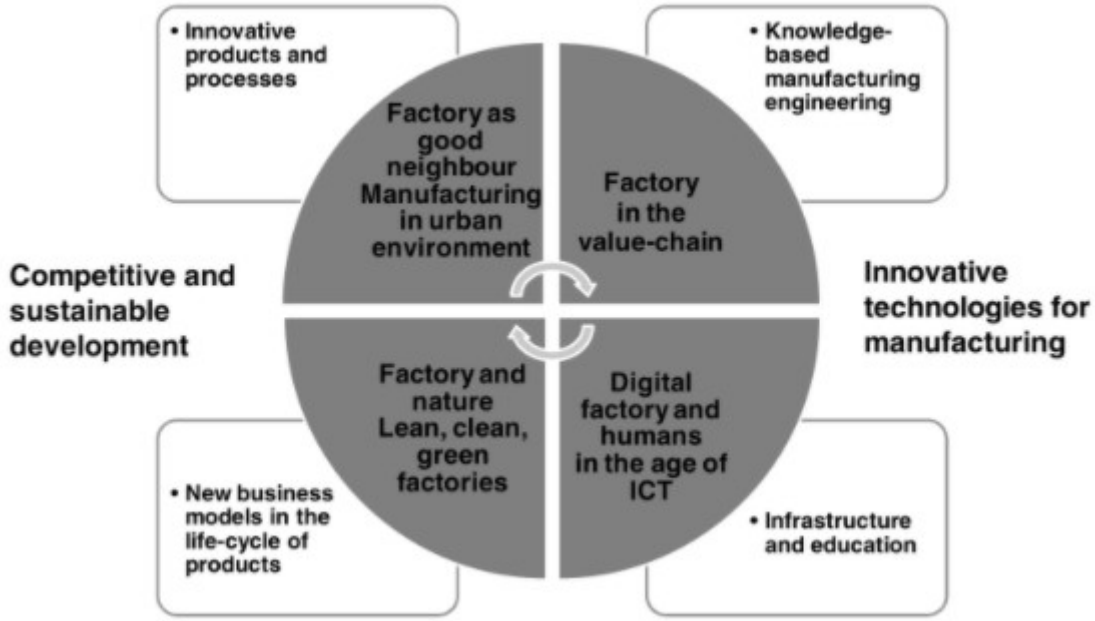

Figure 4: The four main topics for the industry of 2030.

Fonte: Adapted Westkämper (2014).

Human-machine collaboration is considered essential for the success of companies with high productivity demanded by competition, through the use of I4.0 principles (Lorenz et al., 2015; Romero et al., 2016).

4. RESULTS AND DISCUSSION

In this chapter, it will be done an analysis of the main highlights taken from the studied articles.

According to Dahlin & Isaksson (2017) the main advantages of IMS are document reduction, cost reduction, operational improvements and better communication between departments. The main disadvantages are lack of human resources, lack of employee motivation, differences in standards and complexity in integration (Dahlin & Isaksson, 2017).

In the research developed by Nawaz & Koç (2018), sustainability management has been carried out as a distinct concept, rather than the IMS existing. Sustainability has increased in the business world, and it has been one of the strengths of companies, since economic, quality, environment, health and safety and social challenges can be managed through the application of this framework. The operational advantages of the proposed framework include stakeholders involvement, greater transparency, adaptability, development and evaluation of organized systems (Nawaz & Koç, 2018).

According to the study by Nunhes et al. (2019), the words "sustainability" and "sustainable development" are classified as emerging terms in the context of the IMS, giving rise to the same tendency to link IMS with sustainable development approaches (Thaís Vieira Nunhes et al., 2019).

Barbosa et al. (2021) mention that many companies, regardless of nationality, follow the guidelines of integration MS and this procedure brings many benefits, such as improving the organization's image for the stakeholders, promote sustainable development, improve the quality of working life, increase the competitiveness of the corporation, and improve workplace health. The authors argue that IMS bring internal benefits (they can improve performance and reduce organizational costs, as well as how to improve the work environment and stakeholders satisfaction) and external (improve the interaction between the company and entities such as the government, the competition and society) (Barbosa et al., 2021).

The research carried out by Mora-Contreras (2019) concludes that the IMS implementation methodology supports the fulfilment of the organizational model, avoids redundancies and duplicities in the IMS implementation, contributes to the establishment of effective processes and procedures for the creation and control of reliable documents. Thus, these changes can be summarized in the reduction of time and errors during the preparation of public deeds, the elimination of operational control that is part of ineffective bureaucracy to increase the effectiveness of said activity, the reduction of paper consumption and the reduction of associated costs to document management (Mora-Contreras, 2019).

Table 1 summarizes the main advantages and barriers associated with the IMS and the research of Ispas & Mironeasa (2022) will be used as a basis as it‘s a very complete work.

Table 1: Main advantages and barriers associated to IMS by different authors.

Fonte: Adapted Ispas & Mironeasa (2022).

Advantages	Barriers
Reduction of duplicate and written documentation. Simplification of system procedures. Implementation of management systems in a shorter time. Reducing the time and unifying the audits. Unifying and reducing the time the training. An organization that already has an IMS has an advantage over an organization that doesn´t have an IMS. Reducing organization costs. Restructuring human resources, the strategies of organizations, the allocated financial resources, the definition of responsibilities, the organization's processes and communication. Social advantages. Customer satisfaction. Improving the image of the organization and the quality of products or services, the environment and the human health and safety.	The lack of information, training, communication with the work team, employees motivation for IMS implementation, ISO promotion of IMS integration. Variety of MS standards and purpose. Different cultures/personalities obstruct the integration of MS. The fear of failing in the IMS implementation. Employees aren't aware of the new changes and lack the concept of integration. Inadequate benefits from IMS implementation. Permanent updating of regulations. Lack of experience of the management representative in implementing the IMS. Underestimation of requirements from a certain MS.

5. CONCLUSION

This study presents an analysis of the models proposed by different researchers, providing an overview of the most used MS and at this stage it was important to mention the advantages and barriers associated with the implementation of IMS.

One of the concepts of I4.0 is to have a greater integration between the processes and sectors of the factories, exchanging information in a faster and more efficient way for a faster decision making to increase productivity, reduce losses, optimize resources, and take digital transformation into industries. Recent investigations indicate that Artificial Intelligence will guide international trade at the end of this decade, getting involved in the production and distribution chain of products, being necessary to study the impact that this new technological revolution will have on IMS to categorize new risks and develop new assessment methods.

Sustainable development is one of the current and emerging topics linked to IMS. Many stakeholders question companies on this topic and there is a trend in the search, collection, and storage of information in this sense and whoever responds in this area is already the manager of MS.

It's important to mention that the number of studies with a quantitative approach in measuring the benefits arising from the IMS is still low, and no studies were identified that mapped and quantitatively analysed the intensity of the impacts of each MS (quality, environment and occupational health and safety) when implemented in an integrated manner. This indicates an opportunity for the development of additional studies, where it's necessary to develop more theoretical and practical research (with case studies) to determine what is the real impact of the IMS considering the fourth industrial revolution.

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