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Review

Systems-based approach to contemporary business management: An enabler of business sustainability in a context of industry 4.0, circular economy, competitiveness and diverse stakeholders

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ABSTRACT

Sustainability is a core feature of 21st-century businesses for which the management approach can serve as a lever. Fourth Generation Management arises as a systems-based approach for managing contemporary businesses before the advent of Industry 4.0 and during low awareness of the Circular Economy. While 4th Generation Management provides value to business by considering several resources, stakeholders, and interactions, making businesses customer-oriented, it fails to address the sustainability issue for contemporary businesses in the current context of Industry 4.0, Circular Economy, Competitiveness, and Stakeholders. Indeed, it fails to make businesses more contemporary (i.e., more open and sustainable) to adapt to their context. Moreover, in the literature, there is no work discussing how Sustainability, Industry 4.0, Circular Economy, Competitiveness, and diverse Stakeholders as contemporary issues are accounted for in business management. The main aim of this study is to propose a Re-engineered 4th Generation Management as a systems-based approach, enabling today's business to be oriented toward customer and sustainability. We have reviewed 181 articles published between 2005 and 2022 from Scopus, Web of Science, and Science Direct databases to pursue such a goal. The novelty of this work relies on presenting a systems-based approach, which is best suited for sustainable businesses in the context of Industry 4.0 digitalization technologies (e.g., Artificial intelligence, Blockchain, Cloud computing, and Big data analytics), Circular Economy, Stakeholders, and Competitiveness. Furthermore, propositions are formulated to reflect on the suggested framework based on recent literature. At the end of this work, research implications and future directions are provided.

1. Introduction

Businesses in the 21st century operate in an evolving and highly competitive environment (Hallioui et al., 2022). Furthermore, the 21st-century business landscape can be characterized by volatility, uncertainty, complexity, and ambiguity (VUCA) (Bennis and Nanus, 1985). Volatility is the nature and dynamics of change and the nature and speed of change forces and catalysts. Uncertainty is the lack of predictability, the prospects for surprise, and the sense of awareness and understanding of issues and events. Complexity describes the multiplex of forces, the confounding of the problems with no cause-and-effect chain, and the confusion surrounding business organizations. Finally, ambiguity has related to the haziness of reality, the potential for misreads, and the mixed meanings of conditions; cause-and-effect confusion. Arguably, navigating the landscape of VUCA in business involves managing styles. A selected management approach can make all the difference in a new brave world of crisis after crisis.

Moreover, it has been suggested that businesses should rethink their processes and strategies to consider a highly dynamic and competitive environment (Valamede and Akkari (2020). Clearly, there is a need to

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consider business as a system, including parts, interactions, and operating environments. In general, for any system or phenomenon, regardless of its nature and complexity, our way of seeing, perceiving, explaining, acting, and managing it depends on our thinking style (Hallioui and Herrou, 2020b). In this perimeter, it is crucial to underline the significant transition of the business from a traditional organization based on analytical (i.e., systematic) thinking to a contemporary one based on systemic thinking (Hester and Adams, 2013). Joiner (1994) defined four management generations; in other words, he classified management styles into four families: *the 1st generation management—management by doing:* we do the task ourselves. Assuming we possess the necessary knowledge, skills, abilities, and technology, this is an effective way of ensuring that tasks are done to our personal requirements (Pyzdek and Keller, 2013); *the 2nd generation management—management by directing:* people found that they could expand their capacity by telling others exactly what to do and how to do it: a master craftsman giving detailed directions to apprentices (Pyzdek and Keller, 2013); *the 3rd generation management—management by results:* as it is called, the manager reward or punish his people based on how well they do tasks (Pyzdek and Keller, 2013); and *the 4th generation management—systems-based approach:* in opposition to the first three management generations characterizing the traditional organization (i.e., organization closed to its stakeholders) and described by bureaucracy and the ancient role of the manager creating barriers between him and his people, it is a holistic approach that allows the business to be managed as a system (i.e., as a whole) while making it open to its stakeholders (i.e., involving stakeholders) but only customer-oriented (i.e., quality-oriented). The 4th generation management was the first management style for businesses to transit from a traditional organization toward a contemporary one at the time.

Indeed, in the last 20th century decades, there has been a need among business managers and employees, in general, to learn to live and breathe a system-oriented, data-based customer focus and to trust each other. That was why in the 1990s, Joiner (1994) intended to launch a quality-oriented business generation through a customer-driven systems-based approach, so-called the 4th generation management—which was a worthy successor to the work of Pr. W. Edwards Deming. According to Joiner's (1994) own words, the 4th generation management represents a significant step forward in understanding how to be effective managers and lead our businesses to improved performance. He defined the key elements of the 4th generation management as follows: (i) Quality—understanding that quality is defined by the customer, developing an obsession for delighting customers—not being satisfied with merely getting rid of what annoys them but going beyond to understand their current and future needs deeply, to surprise them with products and services they did not even know were possible. This understanding is no longer the domain of special groups within an organization; instead, it is shared with and further developed by every employee. (ii) Scientific approach—learning to manage the business as a system, developing process thinking (i.e., systems or systemic thinking in the business landscape), basing decisions on data, and understanding variation. (iii) All one team—believing in people, treating everyone in the business with dignity, trust, and respect; working toward win-win instead of win-lose for all stakeholders, such as customers, employees, shareholders, suppliers, and the communities in which we live; in other words, building an organizational environment where everyone from the front lines to the executive suites, understands and acts like they are all on the same team, working together to enhance customer satisfaction continually.

In general, systemic thinking facilitates the understanding of complex systems. A key characteristic of "systems" as a concept is that systems are made up of parts. These parts are not isolated but closely interlinked, forming a dynamic complex structure and operating in an environment (i.e., external environment or context). A random conglomeration of the elements does not characterize a system. On the contrary, all of its components are subject to a particular order, and each part of a system naturally can be a system (Vester, 1976). This lends a great deal of importance to systemic thinking. It helps to describe complex systems and their interrelations (i.e., interactions) by using approaches that facilitate globalizing thought, avoiding, therefore, the inconveniences of simplifications or reductionism (i.e., Cartesianism) as analytical thinking (Seiffert and Loch, 2005). So, through our dynamic vision of the systems approach (i.e., systems-based approach, systemic, system approach, or systemic approach) attached to systemic thinking recognizing the holistic behavior of the system, this later includes classes of subsystems and internal and external interactions; each class has subsystems involved, including their dynamic interactions (Hallioui and Herrou, 2020a). According to Rosnay (1975), the systems-based approach encompasses all the elements of the system studied and their interactions and interdependencies. It must be applied in the case of high complexity systems, made up of a vast diversity of elements linked by strong interactions. To consider a system in its totality, complexity, and dynamics. In contrast, the analytical approach seeks to reduce a system to its simplest components by studying them in detail and understanding the types of interactions between them. Moreover, the analytical approach has become a classic in applications of scientific approaches and methodologies after the 2nd half of the 20th century. It is favorable for simple systems, while the systems approach is more suitable for uses where complex systems are involved. According to Brandenburg and Wojtyna (2006), a system (i.e., an open system according to the systems approach) as a concept can be defined by Borders (i.e., what is inside and what is outside); Exchange with its external environment (i.e., what happens at its borders); An interior with a set of elements linked together (i.e., the interacting subsystems); A certain stability (i.e., the system is maintained even in a changing external environment) (Hallioui and Herrou, 2020b).

Since the UN 2030 Agenda for Sustainable Development announcement in 2015, the need to be more contemporary (i.e., more sustainable and open) systems has grown among businesses worldwide. Today, from a business management perspective, it is momentous to highlight the transition from a systems-based approach orienting businesses toward the customer (i.e., 4th generation management) to another (i.e., re-engineered 4th generation management) aiming at making them more contemporary by driving them toward sustainability and customer. Regarding contemporary business, there are two eras where it is managed as a system, as indicated in Fig. 1. Industry 4.0 and Circular Economic awareness are the elements promoting the difference. Given sustainability has become an increasingly important aspect for businesses to consider not only essential to comply with laws and regulations that encourage business sustainability, but it has also become a way for businesses to be more competitive (Bengtsson, 2020), besides literature recently proving the centric role of Industry 4.0 digitalization technologies (e.g., artificial intelligence, blockchain, cloud computing, and big data analytics) and the Circular Economy as two new related matters enabling sustainability (Chauhan et al., 2019, 2022; Demestichas and Daskalakis, 2020; Kristoffersen et al., 2020; Upadhyay et al., 2021; Acerbi et al., 2021; Rejeb et al., 2022; Silva and Sehnem, 2022), our motivation for this study that expands on previous research by Hallioui and Herrou (2020b) which was limited to the system analysis as a tool of the systems approach and suggests implications for Cartesianism as classical thinking (i.e., analytical thinking), is to demonstrate that a system-based management style (i.e., re-engineered 4th generation management) is best suited for sustainable business in the context of Industry 4.0, Circular Economy, stakeholders, and competitiveness. This research goes beyond classical thinking to include more holistic thinking meant to address issues in the current business landscape.

Until today, no management style considers sustainability as an orientation to manage the business as a system. So, the core challenge of our study is to be based on the literature to gather the four components of the current context of businesses—Industry 4.0, Circular Economy, Competitiveness, and Stakeholders—with sustainability under a contemporary business management approach. While different

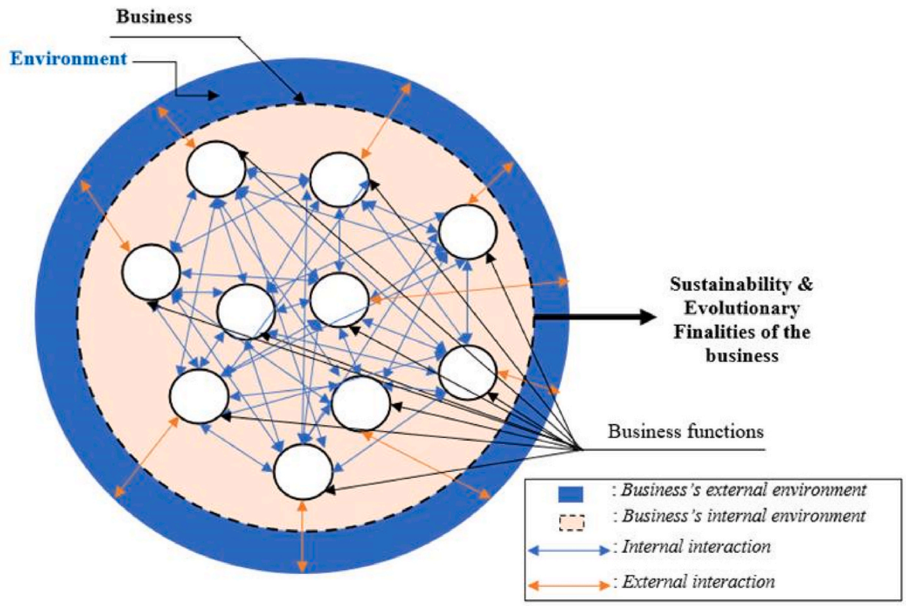

Fig. 1. A more holistic view of the contemporary business landscape.

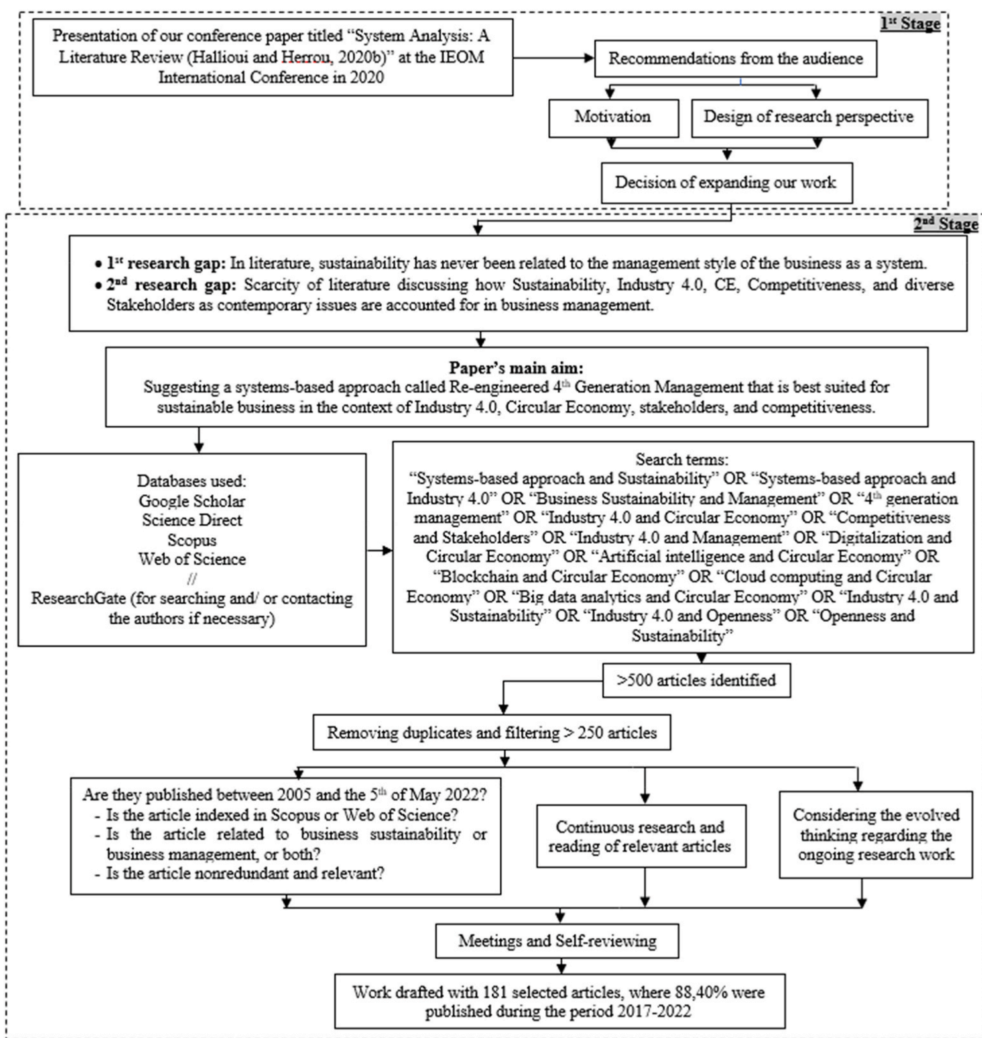

Fig. 2. Diagram of research methodology.

approaches to business management exist, the 4th Generation Management approach tends to take the lead by making the business customer-oriented through Joiner's triangle (Fig. 3). It revolves around quality and involves considering stakeholders, a scientific approach to rapid learning, and creating team-spirited relationships both within and beyond our organizations. However, since contemporary organizations operate under the landscape of VUCA designed by Industry 4.0 digitalization technologies, Circular Economy, competitiveness, and Stakeholders, business management approaches need to account for more contemporary issues such as Sustainability, Industry 4.0, Circular Economy, and Competitiveness beyond Stakeholders. However, there remains a scarcity of literature discussing how those contemporary issues are accounted for in business management to enable businesses to be more contemporary, competitive, and most of all sustainable while being driven toward sustainability and customer within their current context requiring more openness of businesses to their internal and external environments. Therefore, after highlighting the current context of businesses, the main aim of this study is to present a re-engineered 4th generation management as a systems-based model based on a tool called Hallioui's triangle (Fig. 4), suggested for managing contemporary businesses. All the study process is in measure to allow businesses a sustainability orientation and perspective within their current context. Section 2 presents the research methodology. Section 3 discusses the proposed systems-based approach to contemporary business management (i.e., the re-engineered 4th generation management) and the current context of businesses. This article concludes with Section 4, where propositions to businesses for more sustainability through the re-engineered 4th generation management, research implications, and future research directions are provided.

2. Materials and methods

Research design has been described as building a structure. An architect may work with many different general types of structures (e.g., single-family homes, multifamily homes, nonresidential buildings, etc. (Leavy, 2017). A research methodology of two stages is designed for this work (Fig. 2). The 1st stage was a step in light of which we studied the systems-based approach (i.e., systems approach, systemic approach, systemic, or system approach) and its related concepts in general; furthermore, we knew the need and orientation of research regarding the systems-based approach and its most needed applications in the current context of businesses and their management, including the need for a systems-based approach to managing businesses in a more contemporary landscape, which we confirm through Table 1; otherwise, the 1st stage resulted in a preliminary research work that leads to a set of results and advice (from the audience) that are crucial as bases for the target research work to be launched from the 2nd stage of research, that is for being open to the opinions and suggestions of the attending experts

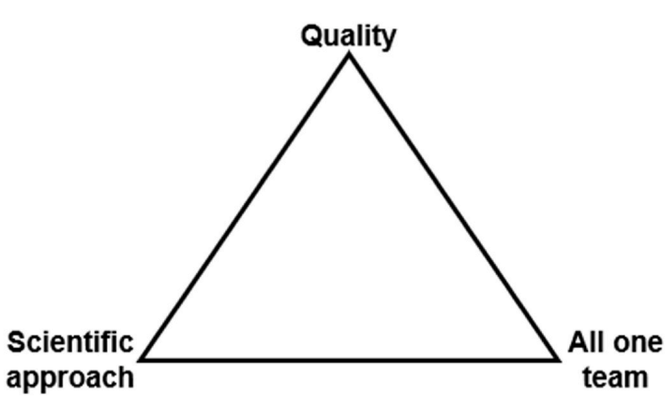

Fig. 3. Joiner's triangle as a basis for the 4th generation management (Joiner, 1994).

and audience of the international conference. The 2nd stage presents the core research process of this critical review paper. It is a road map to understanding how the main aim of this work is achieved through a literature review and dealing with the following research gaps: (i) In literature, sustainability has never been related to the management style of the business as a system—existing systems-based approach to managing businesses based on Joiner's triangle (Fig. 3) (i.e., the 4th Generation Management) is making them only customer-oriented (not sustainability-oriented) and therefore no more capable of adapting to their current context characterized more particularly by its two new components (i.e., Industry 4.0 and the Circular Economy); (ii) Scarcity of literature (almost no work) discussing how Sustainability, Industry 4.0, Circular Economy, Competitiveness, and diverse Stakeholders as contemporary issues are accounted for in business management (Table 1). This increased our motivation as pioneers to address those significant research gaps and to be creative by suggesting a systems-based approach called Re-engineered 4th Generation Management based on a tool we called Hallioui's triangle that is best suited for sustainable business in the context of Industry 4.0 digitalization technologies (e.g., Artificial intelligence, Blockchain, Cloud computing, and Big data analytics), Circular Economy, Stakeholders, and Competitiveness. It is suggested to make businesses more contemporary (i.e., more open and sustainable) while being oriented toward sustainability and customer in their current context.

According to Snyder (2019), a literature review is generally an excellent way of synthesizing research findings to show evidence on a meta-level and uncover areas in which more research is needed, which is a critical component of creating theoretical frameworks and building conceptual models. In this study, once the target research topic was identified, databases including Scopus, Web of Science, Science Direct, etc., are used to search for peer-reviewed papers as secondary data sources necessary for this work. This process involved removing duplicates and selecting papers relevant to the topic. The required relevant articles (i.e., selected articles) have titles, abstracts, or keywords containing at least one of these key terms: Systems-based approach, Sustainability, Industry 4.0 (or Artificial intelligence, Blockchain, Cloud computing, or Big data analytics), Circular Economy, Competitiveness, Stakeholders, Openness, or Management. Moreover, as inclusion criteria, the document is regarded relevant if it is a nonredundant conference or journal paper published between 2005 and the May 5, 2022, indexed in Scopus or Web of Science, combining at least two of those key terms, and addressing business sustainability or business management or both. This research strategy allowed us to select 103 papers from more than 500 papers identified and scanned in their titles, abstracts, and keywords (Fig. 2).

Through qualitative data analysis, we found that 80% of relevant papers are journal articles and 20% are conference papers. All were published between 2005 and the May 5, 2022, while 88,40% were published during 2017–2022; the journals with at least four relevant articles are *Journal of Cleaner Production* with 33 articles; *Technological Forecasting and Social Change* with 16 articles; *Resources, Conservation and Recycling* with nine articles; *Computers in industry* had seven articles, *Sustainable Production and Consumption* had six articles, the journals *International Journal of Production Research*, *International Journal of Production Economics,* and *Computers & Industrial Engineering* had five articles each, then *Sustainability (Switzerland)* had four articles. Table 1 provides the number and categories of relevant papers in the literature according to the search terms used. It helps to reflect on the suggested framework based on literature by formulating propositions to businesses for more sustainability through the re-engineered 4th generation management (Subsection 4.1).

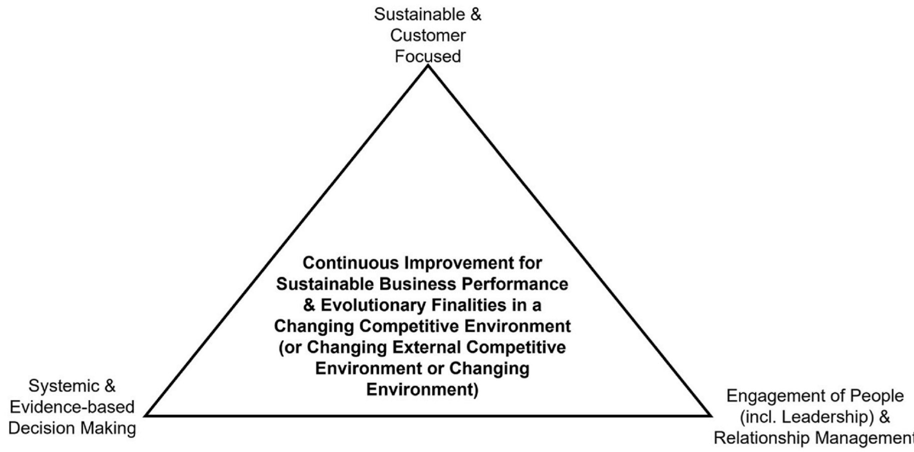

Fig. 4. Hallioui's triangle suggested as a basis for the re-engineered 4th generation management.

3. A systems-based approach to contemporary business management

3.1. The Re-engineered 4th generation management (system-based management style)

We speak about the system defined according to the systems approach (Section 1)—in principle, a system without an aim is not a system (Joiner, 1994). Fig. 1 is a model as a set of functions in dynamic interaction, organized according to its goals predefined over time. It presents the business as an open system to its external environment. Its openness to the outside world is parallel to its openness to its internal environment. It does not seem easy to be imagined.

Quite simply, the openness of the business as a system of processes and interactions to its changing external and internal environments can be translated by its holistic managerial behavior (Fig. 1), which can be explained by management oriented toward the outside, i.e., dependent on the competitive external environment of the business (Fig. 5), while thinking of all horizons, the short, medium, and long term. At this point, we designate the operational management (for the short and medium-term) and the strategic one (for the long-term) that must be open and externally oriented to assure the business's development and sustainability by ensuring its adaptation to its environment (external environment) of increasing competitiveness.

Generally, strategic management determines the operational one. So, it is imperative to highlight this concept. Ginter et al. (2002) suggested that strategic management is the essential process for coping with external change; it is the central philosophy guiding the management of all types of contemporary organizations (Table 3 and Fig. 6) and is an externally oriented philosophy of managing an organization that links strategic thinking and analysis to organizational action. According to Jasper and Crossan (2012), strategic management is a relatively new concept within the management literature, having developed in the 1960s out of studies on the economic organization, bureaucracy, science of work, and roles of managers, to name but a few (Nag et al., 2007; Ketchen et al., 2007; Furrer et al., 2008, Nerur et al., 2008). That's why it is crucial to underline the concepts of *(i) bureaucracy*, *(ii) the science of work*, and *(iii) the roles of managers*. First, it is well known that the strategic management of any contemporary business is based on the following main functions: planning, organization, staffing, motivation, and control. But the management style of the business has a direct impact on its strategic decisions. According to Pyzdek and Keller (2013), the management styles are often viewed from a psychological perspective through deep research in the literature.

Starting with the roles of managers, we cannot continue the present discourse about the new manager role within the contemporary business (Fig. 6) as a system (Figs. 1 and 5) without referring to the American school of management (or quality) represented in this context by the professor William Edwards Deming. Through recapitulating what was said by Pyzdek and Keller (2013) regarding this issue, Deming (1993) offered this perspective: A manager understands and conveys to his people the meaning of a system (Figs. 1 and 5). He explains the aims of the system. He understands a stable system. He understands the interaction between people and the circumstances they work in. He understands that the performance of anyone that can learn a skill will come to a stable state—upon which further lessons will not improve performance. A manager of people knows that in this stable state, it is distracting to tell the worker about a mistake; He has three sources of power, which are the office's authority (1st), knowledge (2nd), and personality and persuasive power (3rd). A successful people manager develops the 2nd and 3rd; he does not rely on its 1st source of power. Nevertheless, he must use the 1st, as this source of power enables him to change the process equipment, materials, and methods to improve, such as reducing variation in output. He is in authority, but lacking knowledge or personality must depend on his formal power (i.e., the 1st). He unconsciously fills a void in his qualifications by making it clear to everybody that he is in a position of authority. His well is done; He will study results to improve his performance as a people manager; He will try to discover who, if anybody outside the system, needs special help. He creates trust and an environment that encourages freedom and innovation; He does not expect perfection; He listens and learns without passing judgment on him that he listens to; He will hold an informal, unharried conversation with every one of his people at least once a year, not for judgment, merely to listen. The purpose would be to develop the understanding of his people, their aims, hopes, and fears. The meeting will be spontaneous, not planned.

That is why Kohn (1986) said before W.E. Demine that "through the new view of managers role, people understand the benefits of cooperation and the losses from competition between them and between groups." By recapitulating, the manager role within the contemporary business (before Industry 4.0 advent: Table 3; after Industry 4.0 advent: Fig. 6) is one of the main matters of any systems-based approach, such as the 4th Generation Management during the 1st era of the contemporary business (see Table 3 and Subsection 3.4), it was based on Joiner's triangle (Fig. 3) in his book entitled "Fourth Generation Management: The New Business Consciousness," which is among its criticizing works of the traditional organization (Table 3).

Joiner (1994) described how the evolution of management and the revolution in quality are converging and what it means for the business and the nation. Mainly, he defined four generations of management styles: *1st generation management – management by doing*; *2nd generation management– management by directing (micromanagement)*; *3rd generation management – management by results*; and *4th generation management – systems-based approach*. He treated the management styles in the quality

Table 1
The number and categories of relevant papers according to the search terms used in Scopus, Web of Science, and Science Direct.

Search terms	Number of relevant papers	Relevant papers
(Industry 4.0 & Circular Economy) or (Artificial intelligence & Circular Economy) or (Blockchain & Circular Economy) or (Cloud computing & Circular Economy) or (Big data analytics & Circular Economy) or (Digitalization & Circular Economy)	103	Abdul-Hamid et al. (2020); Alcayaga et al. (2019); Antikainen et al. (2018); Awan et al. (2021b); Bonciu (2014); Bressanelli et al. (2018); Culot et al. (2020); Ć wiklicki and Wojnarowska (2020); Dev et al. (2020); Fatimah et al. (2020); Franciosi et al. (2018); Frank et al. (2019); Gupta et al. (2021); Hermann et al. (2016); Kang et al. (2016); Kristoffersen et al. (2020); Lin (2018); Lu (2017); Machado et al. (2019); Man and Strandhagen (2017); Marjamaa et al. (2021); Masi et al. (2018); Merli et al. (2018); Miranda et al. (2017); Nogueira et al. (2019); Pagoropoulos et al. (2017); Pan et al. (2015); Piscitelli et al. (2020); Rajput and Singh (2019); Rajput and Singh (2020); Sarc et al. (2019); Tao et al. (2016); Tseng et al. (2018); Turner et al. (2020); Uçar et al. (2020); Waibel et al. (2017); Yadav et al. (2020b); Zhou et al. (2020); Chauhan et al. (2022); Mon and del Giorgio (2022); Castro et al. (2022); Manavalan and Jayakrishna (2019); di Maria et al. (2022); Silva and Sehnem (2022); Fosso Wamba et al. (2021); Ghoreishi and Happonen (2020a); Ghoreishi and Happonen (2020b); M. Chen et al. (2020); Wang and Zhang (2020); Alavi et al. (2021); Acerbi et al. (2021); Nañez Alonso et al. (2021); Upadhyay et al. (2021); Kouhizadeh et al. (2019); Bag et al. (2021); Esmaeilian et al. (2020); Nandi et al. (2021); Narayan and Tidström (2020); Böckel et al. (2021); Rejeb et al. (2022); Demestichas and Daskalakis (2020); Modgil et al. (2021); Awan et al. (2021a); Chen and Storey (2012); Gupta et al. (2019); Chiappetta Jabbour et al. (2020b); Chauhan et al. (2019); Nazareth (2019); García-Muiña et al. (2021); Ranta et al. (2021); De Souza et al. (2021); Kristoffersen et al. (2021); Ajwani-Ramchandani et al. (2021); Shojaei et al. (2021); P. Kumar et al. (2021); Einabadi et al. (2019); Lu et al. (2019); Llopis-Albert et al. (2021); Lees and Johnstone (2021); Bag et al. (2021b); S. Kumar et al. (2021); Abdul-Hamid et al. (2021); Shayganmehr et al. (2021); Ahmad et al. (2022); Laskurain-Iturbe et al. (2021); Spaltini et al. (2021); Chiappetta Jabbour et al. (2020a); Bag et al. (2020b); Dantas et al. (2021); Bag et al. (2020a); Ozkan-Ozen et al. (2020); Pizzi et al. (2021); Dahmani et al. (2021); Kamble et al. (2021); Cui et al. (2021) ;Centobelli et al. (2021); López-Guajardo et al. (2021); Yildizbasi (2021); Khayyam et al. (2021); Aivaliotis et al. (2021); Xu et al. (2021); Blömeke et al. (2020); Huang et al. (2022)
Industry 4.0 & Management	28	Piccarozzi et al. (2018); Shrouf et al. (2014); Chauhan and Singh (2019); J. Chen et al. (2019); García and García (2019); Garrido-Hidalgo et al. (2019); Abdirad and Krishnan (2020); Silvestri et al. (2020); Öztürk and Yildizbaşi (2020); Zonta et al. (2020); Caiado et al. (2021); Jasiulewicz-Kaczmarek et al. (2022); Alarcón et al. (2021); Tortorella et al. (2021); Cao et al. (2022); Hien et al. (2022); Velmurugan et al. (2022); Birkel and Müller (2021); Mastos et al. (2021); Shao et al. (2021); Mehta et al. (2021); Forcina and Falcone (2021); Wang (2021); Oliveira-Dias et al. (2022); García-Reyes et al. (2022); Ivanov et al. (2022); Gažová et al. (2022); Guo et al. (2022)
Industry 4.0 & Sustainability	27	Buer et al. (2018); Burritt and Christ (2016); Ciano et al. (2020); Ejsmont (2021); Bai et al. (2020); Ghobakhloo (2020); Kunkel et al. (2022); Mubarik et al. (2021); Mastos et al. (2020); Toktaş-Palut (2022); Piccarozzi et al. (2022); Matthess et al. (2022); Satyro et al. (2022); Gadekar et al. (2022); Yadav et al. (2020a); Onu and Mbohwa (2021); Pourmehdi et al. (2022); R. Kumar et al. (2020); Verma et al. (2022); Belaud et al. (2019); Miranda et al. (2019); Zhao et al. (2019); Rose et al. (2021); Khan et al. (2021); Figueiredo et al. (2022); Favi et al. (2022); Hidayatno et al. (2019)
Openness & Sustainability	7	Kimpimäki et al. (2022); Öberg and Alexander (2019); Othman Idrissia et al. (2012); Aslesen and Freel (2012); LAZZAROTTI and MANZINI (2009); Kratzer et al. (2017); Wu et al. (2013)
Competitiveness & Stakeholders	5	Anning-Dorson (2016); Anning-Dorson (2018); Chan et al. (2010); Derakhshan et al. (2019); Müller et al. (2016)
Business sustainability & Management	5	Bai et al. (2019); Bansal (2005); Matos and Silvestre (2013); Ramos et al. (2016); Stubbs and Cocklin (2008)
Systems-based approach & Sustainability	3	Hallioui and Herrou (2021); Hester and Adams (2013); Seiffert and Loch (2005)
Industry 4.0 & Openness	2	Bigliardi et al. (2022); Mubarak and Petraite (2020)
Systems-based approach & Industry 4.0	1	Valamede and Akkari (2020)

perimeter, given that the quality function is one of the management processes within the contemporary business as a set of interaction processes, organized according to the whole's finalities (Fig. 1). So, until today, the system-based management (i.e., systems-based approach) can be explained only based on three main elements of Joiner's triangle (Fig. 3) that describe the 4th generation management as the only

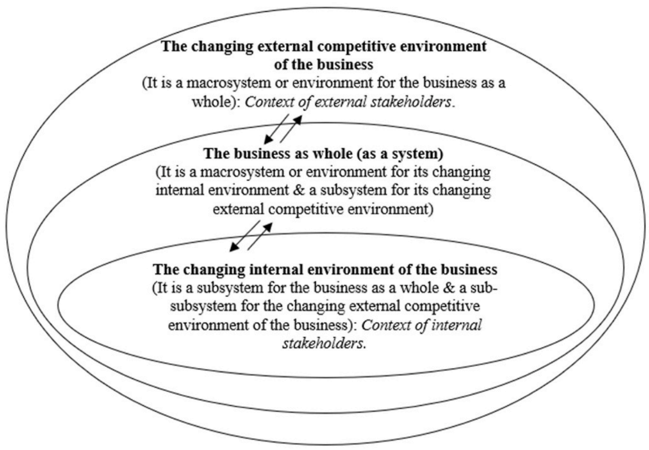

Fig. 5. The business as an interacting system (a whole) with its changing internal and external environments of stakeholders.

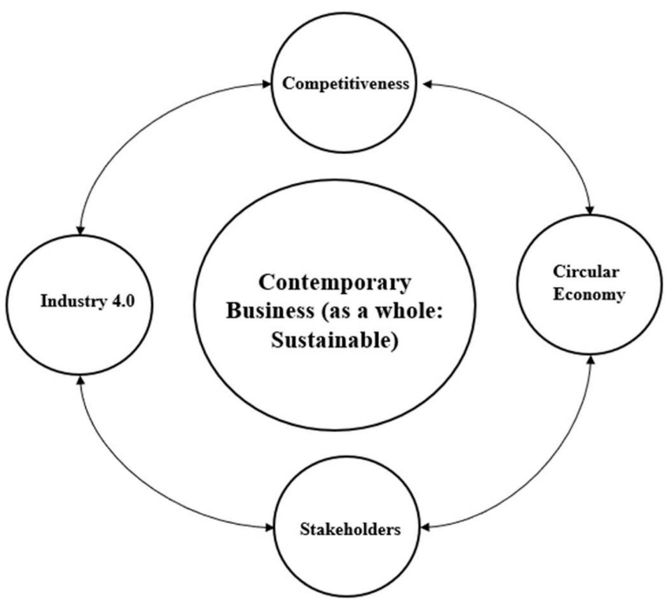

Fig. 6. The current context of the business as a system or the contemporary business and its context after the advent of Industry 4.0 and significant growth of the Circular Economy awareness in the business world.

existing systems-based approach to managing contemporary businesses in literature (Table 3). Before beginning this explanation, it is crucial to indicate that the International Organization for Standardization (2015b) has described and urged a comprehensive way to system-based management while defining the quality management principles for the business as a system that must be sustainable within its environment (Figs. 1, Fig. 5, and Fig. 10). Joiner's vision (Fig. 3) can be explained, re-engineered, and evolved through Hallioui's triangle (Fig. 4) as a basis for the re-engineered 4th generation management to support the transition toward a more contemporary business (Fig. 6).

First, by going back to Fig. 1, we can say that the re-engineered 4th generation management is the management style recommended by the International Organization for Standardization, especially given the International Organization for Standardization (2018) defines the business as a whole (Figs. 1 and 5), by stating that it is "a person or group of people that has its own functions with responsibilities, authorities, and relationships to achieve its objectives," in addition to saying that "the organization shall determine external and internal issues that are relevant to its purpose and that affect its ability to achieve the intended outcomes." This coincides with the business's vision as a system oriented toward its evolutionary finalities (e.g., objectives of continuous improvement of productivity, products quality, dependability, etc.) according to its competitive environment incessantly changing and impacting the business's sustainability (Fig. 1). This is the dynamic vision (i.e., holistic vision) recommended for managing the contemporary business that must be managed as an immersed and active part within its external environment (Figs. 6 and 10). Furthermore, the International Organization for Standardization (2018) recommends mastery of the external and internal contexts, in view that the business is a subsystem for its external environment and a macrosystem for its internal one (Fig. 5). As a remark, the International Organization for Standardization affirms what Pyzdek and Keller (2013) said about the management styles in general when they proclaimed that the business management styles are often viewed from a psychological perspective, which follows the definition provided by the International Organization for Standardization (2015a, 2018) to the business, by defining it as a person or group of people that has its functions with responsibilities, authorities, and relationships to achieve its finalities. This definition did not present any concept outside the lexical field of human capital.

As Fig. 5 illustrates, in the perimeter of management styles in general and the re-engineered 4th generation management (Fig. 4), it is essential to see the business from the angle of human capital, which is the link with the diverse stakeholders. That is why Pyzdek and Keller (2013) said that "the management styles are often viewed from a psychological perspective." When we speak regarding the business stakeholders, we must emphasize the business's internal and external contexts by considering it as a system of interacting processes and open to its macro-system or environment (Fig. 10). According to Hitt et al. (2006), stakeholders are the people who are affected by a firm's performance and who have claims about its performance. Furthermore, the business's internal and external stakeholders can be classified according to their kinds into three main families: the capital market stakeholders (e.g., shareholders, major suppliers of capital such as banks, etc.), product market stakeholders (e.g., customers, suppliers, etc.), and organizational stakeholders (e.g., employees, managers, nonmanagers, etc.). So, there are stakeholders from the external environment of the business and others making part of its internal one, in fact, from its interacting processes (Fig. 5). Although, theoretically, the importance of sustainable business models has become widely accepted in literature, little is known about how managers deal with practical issues such as differences in stakeholder interests (Matos and Silvestre, 2013). Previous studies have suggested that focusing on stakeholder relations is one of the critical components of a firm's strategic processes for sustainability (Bansal, 2005; Stubbs and Cocklin, 2008). By going back to Hallioui's triangle (Fig. 4) as a re-engineering of Joiner's triangle (Fig. 3), it is a tool that summarizes the recommendation for the re-engineered 4th generation management by the International Organization for Standardization (2015b, 2018).

According to Joiner (1994), the core elements of the 4th generation management are shown in Fig. 3: *The quality corner* of the triangle represents an obsession with customer-perceived quality. The organization seeks to delight its customers, not to satisfy them merely; *The scientific-approach corner* indicates learning to manage the business as a system (Figs. 1 and 5), developing process thinking, basing decisions on data, and understanding data; *All one team* means believing in people, i.e., treating everyone with dignity, trust, and respect, and working toward win-win for customers, employees, shareholders, suppliers, and the communities in which we live (Pyzdek and Keller, 2013). By reviewing Hallioui's triangle (Fig. 4), its three corners are based on: (i) the seven quality management principles set by the International Organization for Standardization (2015b), and that explains the three corners of Joiner's triangle (Fig. 3); (ii) the sustainability focus as matter creating the difference between the 4th generation management (Fig. 3) and the re-engineered 4th generation management (Fig. 4). The following table compares Joiner's triangle (Fig. 3) and Hallioui's triangle (Fig. 4) to describe the transition from the 4th generation management toward the re-engineered 4th generation management.

Firstly, as illustrated in Table 2, the most critical notice in this scope is that the *scientific approach* component of Joiner's triangle is a complementarity point between the systemic approach and analytical approach (Section 1). That confirms and rephrases what Rosnay (1975) said when he proclaimed that "the analytical thinking and the systemic one are more complementary than opposed." So, despite the systemic nature of the suggested system-based management style (i.e., the re-engineered 4th generation management), it integrates cartesian pragmatism. Furthermore, the re-engineered 4th generation management is the way towards the continuous improvement and adaptation of the business to its competitive external environment and, therefore, a path toward a sustainable, open, and up-to-date business (Fig. 10). Indeed, it is the contemporary business's management style (Fig. 6) with which the business's strategic management might be able to link the strategic thinking and analysis to the organizational action by taking into account the business' sustainability and changing environments (Figs. 1, Fig. 4, and Fig. 5), through a dynamic vision allowing the fact of believing in business's evolutionary resources and finalities over time, by other words, by believing in the creative evolution of the business due to its holistic behavior within its changing external context (Figs. 1, Fig. 5, and Fig. 10).

The re-engineered 4th generation management is indeed a participative management style that is sustainability and customer-oriented and leads to the business democracy in the frame of the significant openness allowed to the managed business (Fig. 10), in view that there are several research works attributed to academics from the fields of production engineering, management sciences, and organizational studies such as Ramos et al. (2016) that categorized all management styles in two types, one participative and other competitive: (i) the participative style is more democratic and focused on relationships (i.e., interactions) with the business's stakeholders (Fig. 5). The superior's attitude is based on consultation and consideration with the organizational goal and the members involved; (ii) the competitive style is more autocratic and task-oriented. The manager focuses on each corporate member and the completion of goals and aims to reduce communication and transmission of information. Moreover, besides the focus of the re-engineered 4th generation management on human capital as any holistic approach to managing the business as an open system (e.g., the 4th generation management), it focuses on Industry 4.0 digitalization technologies to make the business more open to its diverse stakeholders and sustainable (Subsection 4.1) to adapt it to its current context.

Table 2
A simple comparison between Joiner's triangle and Hallioui's triangle to explain the transition toward the re-engineered 4th generation management.

Joiner's triangle components (Bases for the 4th generation management)	Hallioui's triangle components (Bases for the Re-engineered 4th generation management)
Quality	Sustainability and Customer focus (i.e., Sustainability and Customer-driven business).
Scientific approach	Systemic approach. Evidence-based decision-making (pragmatism, which is from Cartesianism, is the evidence precept referring to classical or analytical thinking (Hallioui and Herrou, 2020b)).
All one team	Engagement of people (i.e., total involvement). Leadership. Relationship management (i.e., management of relationships with all business stakeholders).
Continuous improvement of sustainable business performances and evolutionary finalities within a changing competitive external environment.	

Table 3
Comparison between Traditional organization and Contemporary organization before the advent of Industry 4.0 and during a low awareness of the Circular Economy in the organization world (Edosomwan, 1993).

	Traditional organization (in general)	Contemporary organization (during its 1st era: before the advent of Industry 4.0 and during a low awareness of Circular Economy in the organization world)
Product and service planning	Short-term focus.	Long-term focus.
	Reactionary management.	Prevention-based management.
	Management by the objectives planning process.	Customer-driven strategies.
Measures of performance	Bottom-line financial results.	Customer satisfaction.
	Quick return on investment.	Market share.
		Long-term profitability. Quality orientation. Total productivity.
Attitudes toward customers	Customers are irrational and a pain.	The voice of the customer is essential.
	Customers are a bottleneck to profitability.	Professional treatment and attention to customers are required.
	Hostile and careless. Take it or leave it" attitude.	Courteous and responsive. Empathy and respectful attitude.
Quality of products and services	Provided according to organizational requirements.	Provided according to customer requirements and needs.
Marketing focus	Seller's market.	Increased market share and financial growth achieved.
	Careless about lost customers through customer satisfaction.	
Process management approach	Focus on error and defect detection.	Focus on error and defect prevention.
Product and service delivery attitude	It is OK for customers to wait for products and services.	It is the best to provide fast time-to-market products and services.
People orientation	People are the sources of problems and are burdens on the organization.	People are an organization's greatest resource.
Basis for decision-making	Product-driven.	Customer-driven.
	Management by opinion.	Management by data.
Improvement strategy	Crisis management.	Continuous process improvement.
	Management by fear and intimidation.	Total process management.
Mode of operation	Career-driven and independent work.	Management-supported improvement.
	Customers, suppliers, and process owners have nothing in common.	Teamwork between suppliers, process owners, and customers is practiced.

3.2. Overview of the current context of the business

In the contemporary business's perimeter (Fig. 6), after detailing the roles of managers in a frame of the re-engineered 4th generation management in Subsection 3.1, and by referring to two other causes of the appearance of the strategic management concept in the management literature, that are studies on the bureaucracy and others on the science of work. Firstly, this is the opportunity to open the interval toward the difference between the contemporary business allowed by the re-engineered 4th generation management (Figs. 4 and 6) and the traditional or classical organization (Table 3), enhancing the reductionism between its processes and based on the bureaucracy and Taylorism to anchor a "reductionist mentality" among the business departments. Secondly, regarding the science of work or Taylorism, according to Pyzdek and Keller (2013), throughout the 20th century, management thought was largely activity-oriented. In the early 1900s, Frederick Taylor's scientific management (Taylor, 1947) focused on dividing and subdividing work into discrete tasks or activities that could be closely monitored, measured, and tweaked to produce the most efficient performance from each activity. It is crucial to know that the contemporary business presented in Table 3 is enabled by the 4th generation management and differs from that making subject for the study (Fig. 6).

Today's business (Fig. 6) must be more open and active (Fig. 1) than any business in the past (Table 3) to be sustainable. Given the current competitive and emerging context, it needs a total adaptation. For instance, by speaking about the industrial business, which is the economic core of every country worldwide, Machado et al. (2019) proclaim that in the last years, industrial production systems have been transformed due to a higher level of digitalization, which leads to an intelligent, connected, and decentralized production. According to Hermann et al. (2016), this new level of organization is often called the 4th industrial revolution or Industry 4.0. Artificial Intelligence, Blockchain, Cloud computing, and Big data analytics are among its technologies. Besides the Industry 4.0 digitalization technologies and in the sphere of the re-engineered 4th generation management (Fig. 4), the new economic model with its systemic vision, which is called the Circular economy, in addition to Competitiveness and Stakeholders, are all the main components of the current context of the business as a system (Figs. 1, Fig. 5, and Fig. 6).

As illustrated in Fig. 6, there are two new components and two others considered normal for the current context of the business as a system. The new components are Industry 4.0 and the Circular Economy. The two others that have become normal are Stakeholders and Competitiveness. These last ones are becoming normal through the re-engineered 4th generation management (Fig. 4). In general, these four main components of the current environment of the business around the world are creating the difference between the contemporary businesses in the pre-Industry 4.0 era (Table 3) and those after the appearance of Industry 4.0 in 2011. As a note in this optic, it is essential to know that both types of contemporary businesses are based on management by systems approach (i.e., systems-based approach).

3.3. *Industry 4.0, circular economy, and the world's contributions*

At the dawn of the 21st century, the world is witnessing the fourth industrial revolution and the digital transformation of the business world commonly referred to as Industry 4.0 (Ghobakhloo, 2020). Industry 4.0 and sustainability are key to contemporary business management (Piccarozzi et al., 2022) but are not the only ones since the Circular Economy, competitiveness, and stakeholders are also components of the current context of contemporary business (Fig. 6). Currently, Industry 4.0 is the most popular concept relating to changes in the functioning of industrial enterprises (Ejsmont, 2021). It makes the business processes more autonomous, automated, and intelligent (Mubarik et al., 2021). Many research works have recently shown that Industry 4.0 can be implemented to manage various business operations and processes such as maintenance (e.g., J. Chen et al., 2019; García and García, 2019; Silvestri et al., 2020; Zonta et al., 2020; Alarcón et al., 2021; Tortorella et al., 2021; Jasiulewicz-Kaczmarek et al., 2022; Cao et al., 2022; Hien et al., 2022; Velmurugan et al., 2022), supply chain and logistics (e.g., Chauhan and Singh, 2019; Garrido-Hidalgo et al., 2019; Abdirad and Krishnan, 2020; Esmaeilian et al., 2020; Bag et al., 2020b; Öztürk and Yildizbaşi, 2020; Mastos et al., 2020; Caiado et al., 2021; Birkel and Müller, 2021; Mastos et al., 2021; Shao et al., 2021; Mehta et al., 2021; P. Kumar et al., 2021; Kunkel et al., 2022; Toktaş-Palut, 2022; Oliveira-Dias et al., 2022; García-Reyes et al., 2022; Ivanov et al., 2022; Pourmehdi et al., 2022; Huang et al., 2022), production (e.g., García and García, 2019; R. Kumar et al., 2020; Yadav et al., 2020a; Onu and Mbohwa, 2021; Satyro et al., 2022; Guo et al., 2022; Gadekar et al., 2022; Verma et al., 2022; Favi et al., 2022), safety and environment (e.g., Fatimah et al., 2020; Forcina and Falcone, 2021; Wang, 2021; Lees and Johnstone, 2021; Javaid et al., 2022), etc., in several sectors, such as the automotive industry (e.g., Einabadi et al., 2019; Yadav et al., 2020a; Yadav et al., 2020b; Turner et al., 2020; Llopis-Albert et al., 2021; Kamble et al., 2021; Gažová et al., 2022), oil and gas industry (e.g., Lu et al., 2019; Mehta et al., 2021; Ahmad et al., 2022), energy and electronics industry (e.g., Hidayatno et al., 2019; Matthess et al., 2022; Kunkel et al., 2022), agri-food industry (e.g., Belaud et al., 2019; Miranda et al., 2019; Zhao et al., 2019; Rose et al., 2021; S. Kumar et al., 2021), etc.

The concept of Industry 4.0 is very complex and comprehensive, and the literature does not provide a univocal definition (Buer et al., 2018; Piccarozzi et al., 2018; Culot et al., 2020; Ciano et al., 2020). According to Ciano et al. (2020), "Among the many, Pan et al. (2015) focused on the fact that Industry 4.0 represents the ability of industrial components and actors to communicate. The focus on the link between elements was highlighted by Kovács and Kot (2016). They argued that the core point of Industry 4.0 is the introduction of network-linked intelligent systems able to realize a self-regulating production. Burritt and Christ (2016), Lu (2017), Frank et al. (2019), Bai et al. (2019), and many other authors proposed a definition based on combining nature, considering Industry 4.0 as an umbrella term to describe a group of connected technological advances for increasing the digitization of the business." Furthermore, Industry 4.0 represents the end-to-end technological integration of each value chain, which extends from smart factories to the dizzying changes in mass consumption in different markets. The impact of this transformation imposes substantial technological changes in the multiple productive sectors since the competitiveness of companies goes through globalization, productivity, innovation, and the incorporation of technology as a pillar of development (Mon and del Giorgio, 2022). Hence, arguably, Industry 4.0 can enhance the holistic behavior of the business by making it more interconnected (Fig. 1).

During the last years, a growing interest in the academic and non-academic environment in the Circular Economy has been shown, perceived as a concept in continuous evolution, which adjusts and consolidates its definition, boundaries, principles, and associated practices (Merli et al., 2018). The Circular Economy is an umbrella concept for closing material loops toward enhanced environmental performance (Castro et al., 2022). It is an economic system that closes the material and energy loops in the production and consumption systems (Uçar et al., 2020). The essential characteristic of a Circular Economy, which distinguishes a Circular Economy from other attempts to reduce energy and material consumption, is a holistic approach with the creation of circular loops of material, energy, and waste flows encompassing all societal activities (Bonciu, 2014; Masi et al., 2018). So, in the last definition of the Circular Economy, the concept of the holistic approach is to be underlined because it highlights the concept of the systems approach (Section 1), which allows the consideration of the business's openness, indeed its openness to its changing environment (Figs. 5 and 10), by considering the holistic behavior of the business and maintaining its orientation toward its customer, achievement of its changing goals, and its sustainability within its environment or context (Figs. 4 and 1). Therefore, moving toward a sustainable business (Fig. 6) can only be achieved through the re-engineered 4th generation management (Fig. 4). Understanding the Circular Economy as a holistic approach was one of the reasons why Marjamaa et al. (2021) proclaim that the Circular Economy is a promising solution to the looming sustainability crisis.

Industry 4.0 has accelerated the process of overcoming barriers to achieving circularity, and digitalization has increasingly emerged as a facilitator for the design of cleaner production (Shrouf et al., 2014; Kang et al., 2016; Tao et al., 2016; Waibel et al., 2017; Bressanelli et al., 2018), then for a sustainable environment as a macrosystem of the sustainable ecological business as a whole and a sub-system (Fig. 5), in fact, as a more sustainable ecosystem (Fig. 10). According to Tseng et al. (2018), in times of industrial digitalization, the linkage between Industry 4.0 and the Circular Economy has clearly and persistently enabled the exploration of various ways to achieve ecological sustainability objectives. More clearly about this linkage, Ćwiklicki and Wojnarowska (2020) confirmed that "there is a one-way relationship, i.e., Industry 4.0 leads to a Circular Economy, and a two-way relationship, indicating the synergy between these concepts". Of course, for tending the business toward a contemporary value by adapting it to the current context (Figs. 6 and 10).

In general, research regarding the 4th Industrial Revolution and the Circular Economy has gained traction since 2014 (Table 1) (Awan et al., 2021b). Industry 4.0 and Circular Economy are new matters of the current environment of the business as a system (Fig. 6). Between 2017 and 2021, there were 75 published and indexed articles in Scopus/Science Direct/Web of Science that treated Industry 4.0 and the Circular Economy as new components of the current context of the business (Table 4).

The growing interest of researchers in Industry 4.0, the Circular Economy, and their relationship has become very striking in the last years. To confirm this fact, based on Table 4, Fig. 7 shows the growth of the number of contributions per year to research works on Industry 4.0 and the Circular Economy as new components of the current context of the business (Fig. 6) during the period 2017–2021.

Researchers from distinguished countries and universities carry out the selected papers (Table 4). The goal is to present the pioneer and advanced countries in contributing to the design, defining, and explaining the challenges of the new context of businesses around the world (Fig. 8); indeed, the context where Industry 4.0 and the Circular Economy are two essential matters leading to a contemporary business (Fig. 6) characterized by its great openness (i.e., internal and external openness) and sustainability (Fig. 10)—which can be led and enhanced through the re-engineered 4th generation management (Fig. 4). To give an idea about the contemporary business within its environment (Fig. 6), Miranda et al. (2017) summarized what is said in this paragraph, what was recently said in the present Subsection, and Fig. 6 in three features that are the 3S, by saying that the business must be Sensing, Smart, and Sustainable to face the global challenges related to local, national, and international market dynamics.

As a result, according to Fig. 8, speaking about the period 2017–2021, the research world is divided into five parts of pioneer and advanced countries in terms of contributions to research works, considering Industry 4.0 and the Circular Economy as new pillars of the context of today's business (Fig. 6). These five parts are the North American continent, where the USA had 11 contributions, Canada and Mexico had two contributions each, then Cuba had one contribution; the South American continent, where Brazil had three contributions, but Chile had one contribution; the European continent, where the UK had 14 contributions, France had 10 contributions, Italy had nine contributions, Finland had eight contributions, Germany had six contributions, Denmark, Norway, Greece, and Spain had three contributions each, Sweden and Austria had two contributions each, then Poland, the Czech Republic, and Portugal had one each; the Asian continent where India had 18 contributions as the most significant number in the world, China had five contributions, Taiwan and Turkey had three contributions each, Malaysia and Iran had two each, then Indonesia, Singapore, Philippines, Hong Kong, Bangladesh, Vietnam, and Saudi Arabia had one contribution each of them; the Australian continent where Australia and New Zealand had three contributions each; and the African continent where South Africa had four contributions, and Morocco had two contributions. However, the contributions from most African countries and even other North American, South American, Australian, Asian, and European countries and their universities are somehow unknown. This shows that the relationship between Industry 4.0 and the Circular Economy is not yet well known and studied by the entire research world. In other words, the current environment of businesses (Fig. 6) is not yet

Table 4
Contributions treating Industry 4.0 and the Circular Economy as new components of the current context of the business. All articles are peer-reviewed and indexed in Scopus/Science Direct/Web of Science during the period 2017–2021.

Source	Country/Area	Contribution
2021		
Dantas et al. (2021)	Brazil	Systematic literature review to identify how the Circular Economy-Industry 4.0 nexus, the combination of Circular Economy practices and Industry 4.0 technologies, could contribute to achieving the Sustainable Development Goals.
Khayyam et al. (2021)	Australia, Canada, the UK, and Singapore	Presenting a Circular Economy approach with machine learning to improve the energy efficiency of carbon fiber manufacturing through waste heat recovery.
Spaltini et al. (2021)	Italy	Studying Industry 4.0 and Circular Economy paradigms and their relationship to understand the link between the two topics and envisage a new framework focused on circularity among supply chains.
Laskurain-Iturbe et al. (2021)	Spain	Exploring the influence of Industry 4.0 technologies on the Circular Economy.
Shayganmehr et al. (2021)	Iran, UK, and Bangladesh	Proposing a framework to assess the importance of Industry 4.0 enablers for implementing Cleaner Production practices embedded in Circular Economy in the context of ethical societies and assessing an industry's readiness.
Abdul-Hamid et al. (2021)	Malaysia & Taiwan	Investigating the drivers of Industry 4.0 in the Circular Economy and the nexus between them from an ecological modernization theory perspective.
Khan et al. (2021)	Finland & Sweden	Mapping the broad field of sustainable development and investigating the key research areas which comprise the aforementioned perspectives under Industry 4.0 framework.
Kumar et al. (2021)	India & Italy	Identifying Industry 4.0 and Circular Economy adoption barriers in the agriculture supply chain in India.
Bag et al. (2021b)	South Africa & India	Develop a theoretical model linking key resources for Industry 4.0 adoption that are essential to driving technological progress and its effect on sustainable production and circular economy capabilities.
P. Kumar et al. (2021)	India, UK, and Vietnam	Analyzing the barriers in the era of Industry 4.0 and the Circular Economy to improve the sustainability of a supply chain.
Mastos et al. (2021)	Greece	Showing that redesigning supply chains for a circular economy using Industry 4.0 technologies can enable circular supply chain management.
Bag et al. (2021)	South Africa, France, and the UK	Statistical validation of a theoretical framework provides insight into the role of institutional pressures on resources and their effects on the adoption of big data analytics-powered Artificial Intelligence and how this affects sustainable

(continued on next page)

Table 4 (*continued*)

Source	Country/Area	Contribution
		manufacturing and Circular Economy capabilities under the moderating effects of organizational flexibility and industry dynamism.
Pizzi et al. (2021)	Italy, Portugal, and the UK	Analysis and discussion of case studies linking Fintech application Circular Economy in diverse industries and contexts.
Dahmani et al. (2021)	France, Morocco, and India	Exploring the relationship between lean eco-design and Industry 4.0 strategies for designing eco-efficient products based on a literature review.
Kamble et al. (2021)	France, Morocco, USA, India, Denmark	Using a large group decision-making technique to identify and rank the best big data-driven circular economy (BDDCE) practices in the auto-component industry.
Cui et al. (2021)	China, India, and Saudi Arabia	Identifying the important barriers to adopting the Internet of Things in the Circular Economy in the manufacturing sector.
López-Guajardo et al. (2021)	Mexico, USA, and India	Highlighting and discussing the emerging framework of the integration between Circular Chemistry, Industry 4.0, and Process Intensification and how the data obtained from this integration is at the core of the next generation of Process Intensification strategies.
Xu et al. (2021)	New Zealand, Germany, and Sweden	Presenting the inception, conception, and perception of Industry 4.0 and Industry 5.0.
Yildizbasi (2021)	Turkey	Discussing to eliminate the problems experienced in the energy grid management process, the blockchain concept, and its integration with renewable energy systems.
Aivaliotis et al. (2021)	Greece	Presenting the concept of an intelligent waste management system (based on Cloud computing) for the efficient collection and recycling of industrial wastes, focusing on the metalwork-copper industry.
Centobelli et al. (2021)	Italy	Designing a circular blockchain platform in a supply chain, including manufacturer, reverse logistics service provider, selection center, recycling center, and landfill.
Alavi et al. (2021)	Iran, USA, and Germany	Suggesting an artificial intelligence-based customizable decision support system to select the most suitable suppliers based on circularity criteria.
Acerbi et al. (2021)	Italy	Highlighting the significance of the Circular Economy's potential enhanced by Artificial intelligence for making regenerate resources.
Nañez Alonso et al. (2021)	Spain	Applying Artificial Intelligence in the Efficient Self-Management of Waste to suggest one of the essential solutions enabled by Digitalization to the Circular Economy and business sustainability.
Upadhyay et al. (2021)	UK & Turkey	Demonstrating that Blockchain technology can contribute to the Circular Economy and support businesses' sustainability.
Nandi et al. (2021)	USA	Showing how Blockchain-enabled Circular Economy practices can support supply chain LAD efforts.
Böckel et al. (2021)	Germany	Underlining the importance of Blockchain as an Industry 4.0 digitalization technology for the Circular Economy.
Modgil et al. (2021)	India, France, and the UK	Carrying out a landscape for a big data-enabled Circular Economy that involves stakeholders as essential decision-makers.
Awan et al. (2021a)	Finland, the UK, and the Czech Republic	An empirical investigation of the association of big data analytics capability with the Circular Economy performance and examining the mediating role of data-driven insights in the relationship between big data analytics capability and business decision-making.
García-Muiña et al. (2021)	Spain & Italy	Demonstrating that the digitization of production processes enables the assessment of environmental impact and can also play a key role in knowing the social performance of a manufacturing organization and identifying the hidden social dimension in the circular economy.
Ranta et al. (2021)	Finland	Conducting multiple case studies with interviews and document data from four Northern Europe-based forerunner firms with circular economy business models enabled by digital technologies.
De Souza et al. (2021)	Brazil & France	Demonstrating how digital technologies can help supermarkets' marketing departments drive corporate sustainability while benefiting both consumers and societal well-being.
Kristoffersen et al. (2021)	Norway & Germany	Developing a deeper understanding of the importance of taking a holistic approach to business analytics when leveraging data and analytics towards a more efficient and effective digital-enabled circular economy, the smart circular economy.
Ajwani-Ramchandani et al. (2021)	India & Australia	Advancing the theory in the Circular Economy by enhancing it with Digitalization and new technologies such as Blockchain and Artificial intelligence.
Shojaei et al. (2021)	USA	Enabling a Circular Economy in the built environment sector through blockchain technology.
Awan et al. (2021b)	Finland, USA, and China	Allowing practitioners and researchers to understand the literature and critical elements of the transition toward a more circular economy through Industry 4.0.
2020		
Blömeke et al. (2020)	Germany	Identifying smart manufacturing technologies and solutions that

(*continued on next page*)

Table 4 (*continued*)

Source	Country/Area	Contribution
		support the Circular Economy and map them to remanufacturing and recycling operations to derive a Recycling 4.0 framework.
Ozkan-Ozen et al. (2020)	Turkey & the UK	Contribution to the existing literature by presenting synchronized barriers that integrate circular supply chain and Industry 4.0 barriers.
Bag et al. (2020a)	South Africa, New Zealand, the UK, and India	Identifying how Procurement 4.0 and digital transformations are related and how digital transformation impacts the intention to optimize the procurement process in the Circular Economy.
Bag et al. (2020b)	South Africa, India, New Zealand, and Australia	Investigating how Industry 4.0 resources impact smart logistics and further influence dynamic remanufacturing and green manufacturing capability and the final effect on business logistics sustainability.
Chiappetta Jabbour et al. (2020a)	France, Brazil, Hong Kong, and Canada	Unveiling the drivers, challenges, and opportunities for the sharing economy based on original evidence gathered from exemplary “first-mover” cases in the Brazilian manufacturing industry that use metallic natural resources.
Kumar et al. (2020)	India & UK	Analyzing the challenges in the application of Industry 4.0 technologies in SMEs for sustainable manufacturing operations.
Esmaeilian et al. (2020)	USA	Providing an overview of Blockchain technology and Industry 4.0 for advancing supply chains toward sustainability.
Ghoreishi and Happonen (2020a)	Finland	Suggesting a positive influence of implementing Artificial Intelligence techniques in Circular Economy solutions in manufacturing industries.
Ghoreishi and Happonen (2020b)	Finland	Presenting new promises, Artificial Intelligence brings into circular economy accelerated product design.
Wang and Zhang (2020)	China	Examining the statistical approach for power control based upon multiple costing frameworks using a machine learning model-based resource optimization process in the supply chain and the Circular Economy process.
Narayan and Tidström (2020)	Finland	Tokenizing coopetition in a Blockchain for a transition to Circular Economy.
Demestichas and Daskalakis (2020)	Greece	Conducting an extensive academic literature review on prominent Information and Communication Technology solutions paving the way toward a Circular Economy.
Abdul-Hamid et al. (2020)	Malaysia/Palm oil industry	Identifying valid barriers and proposing a model to understand the challenges to Industry 4.0 in Circular Economy to obtain social, economic, and environmental benefits in practice.
Zhou et al. (2020)	China	Finding the most suitable path for technological progress and structural change to promote economic growth is the key to adopting Industry 4.0 technologies and successfully transforming into a Circular Economy. Thus, the key to China achieving sustainable development quickly.
Piscitelli et al. (2020)	Italy	Carrying out a literature review to examine the current state of the art of Circular Economy with Industry 4.0 perspective and highlighting its benefits from the point of view of sustainability within the industry.
Rajput and Singh (2020)	India	Proposing a mixed-integer linear programming (MILP) model for Industry 4.0 set-up to achieve a circular economy and cleaner production by optimizing products-machine allocation.
Fatimah et al. (2020)	Indonesia, China, and Denmark	Investigating the fundamental issues and opportunities and developing a sustainable and smart country-wide waste management system using Industry 4.0 technologies.
Dev et al. (2020)	India & UK	Proposing a roadmap to the excellence of operations for sustainable reverse supply chain/logistics by the joint implementation of principles of Industry 4.0 and the ReSOLVE model of Circular economy approaches.
Yadav et al. (2020b)	India & UK	A framework to overcome sustainable supply chain challenges through industry 4.0 and circular economy solutions.
Kristoffersen et al. (2020)	Norway & Germany	Proving that the Circular Economy and Digital Technologies are emerging fields, there exists little systematic guidance on how digital technologies can be applied to capture the full potential of circular strategies for improving resource efficiency and productivity.
Turner et al. (2020)	UK	Designing a Digital Maintenance Practice framework for Circular Production of automotive parts.
Uçar et al. (2020)	France	Evaluating the relationship between the Circular Economy and Digital Technologies by using Business Model Canvas to integrate R-principles such as Reuse, Remanufacture, and Recycle.
Ćwiklicki and Wojnarowska (2020)	Poland	Identifying the relationship between the Circular Economy and Industry 4.0. The findings showed a one-way relationship, i.e., Industry 4.0 leads to a Circular Economy, and a two-way relationship, indicating the synergy between these concepts.
2019		
Belaud et al. (2019)	France	Supporting the transformation of the agri-food industry toward an agri-food 4.0 by the valorization of agricultural waste.

(*continued on next page*)

Table 4 (*continued*)

Source	Country/Area	Contribution
Kouhizadeh et al. (2019)	USA	Presenting early evidence linking the Blockchain application to Circular Economy dimensions of regenerate, share, optimize, loop, virtualize, and exchange.
Gupta et al. (2019)	France, USA, India, and Chile	Building a case for utilizing big data analytics as a fundamental basis for informed and data-driven decision-making in supply chain networks supporting the Circular Economy.
Chauhan et al. (2019)	India	Suggesting that top managers are essential for integrating the use of Industry 4.0 to achieve sustainability in the light of the Circular Economy.
Sarc et al. (2019)	Austria	Confirming that the general aim of the Circular economy is the most efficient and comprehensive use of resources. Industry 4.0 technologies and approaches improve business sustainability through improved waste management.
Rajput and Singh (2019)	India	Understanding the hidden connection between the Circular Economy and Industry 4.0 in the supply chain context. Indeed, there is an Industry 4.0 and Circular Economy-based sustainable supply chain.
Nogueira et al. (2019)	USA	Developing a systems thinking framework using eight capitals by adding human, social, political, cultural, and digital capital to natural, manufactured, and financial ones to avoid limiting efforts in creating the circular economy.
Alcayaga et al. (2019)	Austria	Elaborating a new understanding of smart-circular (product-service) systems by articulating the base strategy of smart use and extending the following circular strategies (or technical loops): maintenance, reuse, remanufacturing, and recycling.
2018		
Tseng et al. (2018)	Taiwan & Philippines	Perspective on the big data-driven industrial symbiosis.
Lin (2018)	Taiwan	User experience-based product design for smart production to empower Industry 4.0 in the glass recycling Circular Economy.
Bressanelli et al. (2018)	Italy	Overcoming the Circular Economy challenges through Digital Technologies.
Antikainen et al. (2018)	Finland	Presenting Digitalization as an enabler of Circular Economy.
Franciosi et al. (2018)	Italy & France	Maintenance for Sustainability in the Industry 4.0 Context: an analysis shedding light on the increasing interest in the last years on "Maintenance and Sustainability" and the big potentiality of enabling technologies 4.0 in this frame and motivating future research for developing Sustainable Maintenance Methodologies/Policies, with a focus on Industry 4.0 context.
2017		
Miranda et al. (2017)	Mexico, Cuba, and the USA	Providing a reference framework that presents a systematic process for developing Sensing, Smart, and Sustainable products. Businesses must be Sensing (monitoring), Smart (with connectivity and Cyber-Physical systems), and Sustainable (managed by a system-based management style and implementing Industry 4.0 with a Circular economy, see Fig. 4) to face global challenges related to local, national, and international market dynamics (Fig. 6).
Pagoropoulos et al. (2017)	Denmark	Identifying how digital technologies can support the transition to Circular Economy.
Man and Strandhagen (2017)	Norway	Discussing potential sustainable business scenarios and proposing an agenda for research into how Industry 4.0 can be used to create sustainable business models.

mastered by all companies and their countries. Through a dynamic vision, this issue is a real challenge for the world market as a system, which is a world that obliges businesses to be contemporary and adapted to their evolved context (Fig. 6), which can be achieved under the re-engineered 4th generation management (Fig. 4).

3.4. Overview of competitiveness, external stakeholders, and eras of the contemporary business

To specify, there are two eras when the contemporary business made a great discussion among the world's researchers; the 1st was before the advent of Industry 4.0 in 2011 and during the low awareness of the world of businesses about the Circular Economy (Table 3), whereas the 2nd is the current era, in fact, the age after 2011 and where the business is called contemporary or even more contemporary or today's business (Fig. 6), in addition to the significant growth of the business awareness in terms of the Circular Economy. Competitiveness and External stakeholders are essential components for any contemporary business over its two eras (Table 3 and Fig. 6). These concepts were called in Subsection 3.2 "normal components of the context of today's business" (Fig. 6).

What is more important regarding Competitiveness and External Stakeholders is their relationship. It is evident that these two concepts influence each other. From a systemic point of view, today (Fig. 6), the involvement furthermore the management of External Stakeholders leads to the enrichment of the competitiveness of the business as an active and immersed part within its external context (Figs. 1 and 5). First, for managing External stakeholders, we cannot disregard the concept of project governance. The management literature showed that this latter leads to the business value creation by mastering its interactions as a system with its External Stakeholders (Figs. 5 and 10). De Santis (2021) clearly said that "the notion of project governance covers a management and organization style within a business. It allows to identify the roles and responsibilities of each stakeholder". In one of the earliest definitions, governance was described as the engagement of two actors in an economic transaction that requires them to monitor and control the transaction, protect the interests of each party, and reach the most efficient share of values (Williamson, 1979). Governance is defined as a multi-level phenomenon within the project context and encompasses the governance of the parent business, any contractors or suppliers, and the project (Turner and Müller, 2017). Similarly, Müller et al. (2016) define project governance as the interactions between project

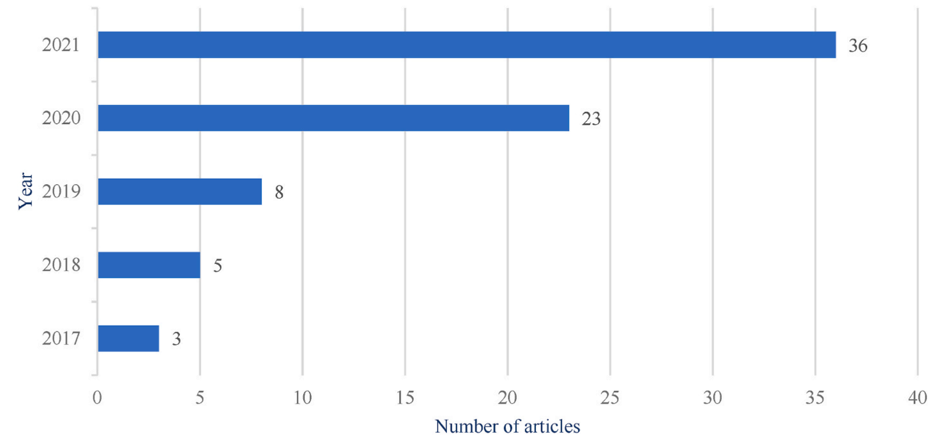

Fig. 7. Bar graph of the number of research contributions treating Industry 4.0 and the Circular Economy as new components of the current context of the business during the period 2017–2021.

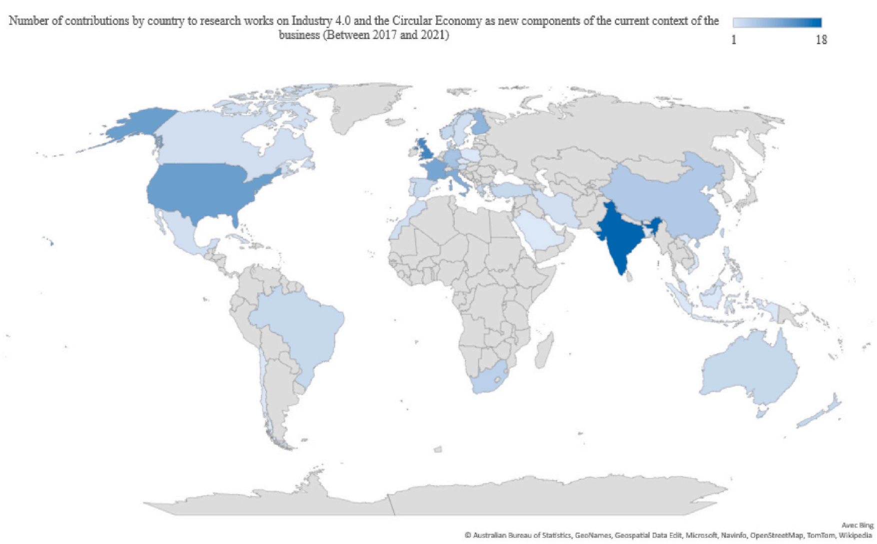

Fig. 8. Choropleth map of the number of contributions by country to research works on Industry 4.0 and the Circular Economy as new components of the current context of the business. All selected papers (Table 4) are peer-reviewed and indexed in Scopus/Science Direct/Web of Science between 2017 and 2021.

participants and the mechanisms adopted that can heavily influence the stakeholders' engagement and trust in the project. These definitions shed light on the vital link between governance and stakeholders (Derakhshan et al., 2019). All this is in brackets because this Subsection aims to discuss the relationship between the contemporary business and its context in general (Fig. 6) and the openness of the business to its External Stakeholders by involving them and considering their ideas for making decisions, innovating, and improving its Competitiveness as a sustainable organization more particularly, in addition to highlighting the relationship between these normal components of the current context of the business. Everything is in a framework of the suggested systems-based approach to managing contemporary businesses (i.e., the re-engineered 4th generation management) (Fig. 4).

Furthermore, today's business (Fig. 6) is focused on sustainability and customer (Table 2 and Fig. 4), so the latter is its major external stakeholder. But its involvement in the different business perspectives (e.g., sustainability, high quality, reducing costs, etc.) must not be formalized and is more special than that of any other external stakeholder for the business. Prahalad and Ramaswamy (2000) state that a customer's involvement is one of the key characteristics of any service and has been recognized as the new frontier of competitive advantage. Chan et al. (2010) proclaimed that businesses that can develop their customer involvement capabilities could increase and benefit from customer participation, which improves the performance of the business. That is why Anning-Dorson (2016) has recently described customer involvement as the ability of the business to generate an environment for the customer to have direct interaction and be engaged in the production and delivery process; because the importance of involvement capability is that it facilitates the customer's engagement in the service processes to co-design and co-produce solution (Anning-Dorson, 2018). For more openness of the business to external stakeholders, among many solutions (Subsection 4.1.2), there is the creation of a climate of freedom and lack of formalization in its relationships with them (Herzog, 2008; Aslesen and Freel, 2012) to benefit from their collaborations, contributions, potentials, and ideas as an essential element in the decision-making and innovation processes in general, and for better sustainability more particularly.

4. Propositions, research implications, and future directions

4.1. Propositions for more sustainability through the Re-engineered 4th generation management

Considering the business orientation toward the customer (i.e., quality), an intrinsic and evident feature in today's businesses management through the ISO9000 project and in the framework of the re-engineered 4th generation management suggested for businesses to be more contemporary (i.e., more open and sustainable) (Fig. 4), businesses could be driven in the light of two propositions that aim at explaining how they might adapt to their current context (Subsection 3.2), which is a complex of two new components (i.e., Industry 4.0 and Circular Economy) and two normal ones (i.e., Stakeholders and Competitiveness) (Fig. 6). Before presenting those propositions, it is crucial to bring to the managers' knowledge that: (i) The Circular Economy supports the business's sustainability. Still, it requires the involvement of stakeholders as critical decision-makers and cooperative members (Chiappetta Jabbour et al., 2020b). Moreover, the Circular Economy as a holistic approach with the creation of circular loops of material, energy, and waste flows (Bonciu, 2014; Masi et al., 2018) cannot be implemented unless a systems-based approach is adopted for managing the business as a whole; (ii) Industry 4.0 technologies can enhance the businesses' holistic behavior to make them more open to their diverse stakeholders (Fig. 1); and (iii) the re-engineered 4th generation management as a systems-based approach (i.e., holistic approach) best suited in a complex landscape, focuses on Industry 4.0 technologies in enhancing the Circular Economy and improving the businesses' openness to diverse Stakeholders for enhancing the Competitiveness of businesses and improving their sustainability.

In this optic and given the seven quality management principles as bases for the re-engineered 4th generation management and any other holistic approach (e.g., 4th generation management) (Subsection 3.1) are respected by almost all today's businesses, our most essential propositions to businesses are: *(P1) Incorporating digitalization technologies of Industry 4.0 into the Circular Economy; (P2) Using Industry 4.0 technologies to enhance the business's openness to stakeholders.*

4.1.1. Proposition 1: Incorporating digitalization technologies of Industry 4.0 into CE

As marked in Subsection 3.3, regarding the linkage between Industry 4.0 and the Circular Economy, there is a one-way relationship, i.e., Industry 4.0 leads to a Circular Economy, and a two-way relationship, indicating the synergy between these concepts (Ćwiklicki and Wojnarowska, 2020). According to di Maria et al. (2022), there is a great expectation that Industry 4.0 technologies will enable better Circular Economy results for businesses. The Circular Economy has the potential to capitalize upon emerging digital technologies, such as big data, artificial intelligence, blockchain, and the internet of things, amongst others (Chauhan et al., 2022). The ABDC (i.e., artificial intelligence, blockchain, cloud computing, and big data analytics) are key enabling technologies for implementing the Circular Economy.

The Circular Economy literature has long recognized the importance of digitalization as the key enabler (Chauhan et al., 2019, 2022; Kristoffersen et al., 2020; Nazareth, 2019). Here are some solutions enabled by digitalization technologies of Industry 4.0 (i.e., the ABCD) to allow a Circular Economy and empower the businesses' sustainability; the solutions are supported by the studies of Silva and Sehnem (2022), Chauhan et al. (2022), and Rejeb et al. (2022):

- *Artificial intelligence (A)* comprises the set of technologies that include machine learning and natural language processing, which enable machines to feel, understand, act, and learn (Manavalan and Jayakrishna, 2019). It can be defined as a framework potentially transforming the relationship between people and technologies (Fosso Wamba et al., 2021). The Circular Economy's potential in making regenerate resources is even more significant if supported by technologies, and artificial intelligence is gaining momentum in this regard (Acerbi et al., 2021). Artificial intelligence and machine learning provide various benefits such as cutting costs, identifying hidden patterns, improving quality, and enhancing responsiveness (Bag et al., 2021). Implementing artificial intelligence enhances productivity via improved optimization, real-time data analysis, and enhanced design, which all help to enable circularity (Ghoreishi and Happonen, 2020a, 2020b). It can effectively support managerial decision-making through the identification of hidden patterns. The decision tree algorithm of artificial intelligence has been used to design environmental cost control systems for manufacturing companies (M. Chen et al., 2020; Wang and Zhang, 2020). Alavi et al. (2021) suggest an artificial intelligence-based customizable decision support system to select the most suitable suppliers based on circularity criteria. Nañez Alonso et al. (2021) applied artificial intelligence in the efficient self-management of waste by developing an application of artificial intelligence-based systems using a small set of images to classify each of the diverse materials with a 90% reliability rate, which allowed effective automatic recycling of materials such as paper, plastic, glass, and organic materials. So, artificial intelligence-based solutions can strengthen productivity and minimize resource consumption and waste to enable a Circular Economy and business sustainability. To prove that, Khayyam et al. (2021) present a machine learning-based Circular Economy in the form of an innovative approach for process design and analysis of a new waste heat recovery system for carbon fiber manufacturing; they used two machine learning approaches with limited data, that are Artificial Neural Network (ANN) and Non-Linear Regression (NLR) to simulate and predict the stabilization energy consumption, and introduce a new conceptual design model for a waste heat recovery system and make the carbon fiber manufacturing more energy efficient; their results suggested that using the recovery system utilizing a heat exchanger, can yield over 62.7 kW recovery, corresponding to 64% of total exhausting energy from the entire process; the electric energy consumption was reduced from 73.3 kW to 10.2 kW, corresponding to an 86% improvement in the total energy efficiency; The model also confirmed that, by preheating the make-up air with the recovered energy, the energy performance index of the thermal stabilization could be increased from 0.08 to 0.44, along with a reduction in the process carbon footprint by 28.5 t/y.
- *Blockchain (B)* has been defined as distributed digital ledgers that keep records and transactions as encrypted timestamped chains (Swan, 2015). It has widely been discussed in the literature, especially in the finance area; for other sectors, the application of this technology is still immature and has developed mainly at the theoretical level, lacking practical applications (Figueiredo et al., 2022). In other words, blockchain technology has emerged in recent years and is not yet fully implemented (Yildizbasi, 2021; Öztürk and Yildizbaşi, 2020). Of all technological advancements, the innovative contribution of blockchain is its ability to operate independently, without the need for central entities—such as banks, to confirm the credibility of transactions. Instead of central authorities and intermediaries, network participants can audit and verify transactions before adding them to the ledgers (Kouhizadeh et al., 2019). As a revolutionary new protocol for sharing and updating information by linking ledgers or databases in a decentralized, peer-to-peer, open-access network—it can contribute to the Circular Economy by helping to reduce transaction costs, enhance performance and communication along the supply chain, ensure human rights protection, enhance healthcare patient confidentiality and welfare, and reduce carbon footprint (Upadhyay et al., 2021). Blockchain can facilitate the design of incentive mechanisms to encourage green consumer behavior, increase visibility, enhance efficiency, and support performance monitoring and reporting (Esmaeilian et al., 2020). Kouhizadeh et al. (2019) suggest blockchain as an emerging technology that can support the Circular Economy paradigm by presenting early evidence linking the blockchain application to Circular Economy dimensions of Regenerate, Share, Optimize, Loop, Virtualize, and Exchange (ReSOLVE model). According to Böckel et al. (2021), blockchain technology can provide a shared information infrastructure that enables the circular sourcing of renewable inputs and supports resource efficiency, besides its ability to aid the recovery of the materials, in particular refurbishing and recycling from

manufacturers and consumers via tracking of material and resource flows through different supply chains and consumption steps. With blockchain technology, platforms such as those for shared leasing can be developed, and businesses can collaborate and redistribute their excess resources (Nandi et al., 2021). The transparency feature of blockchains would also strengthen internal and external communication (Narayan and Tidström, 2020) and support the development of plans for the Circular Economy (Chauhan et al. (2022), supporting the businesses' sustainability initiatives. Besides the transparency and traceability features that blockchain provides through its ledgers or databases, reliability and security are also essential features; indeed, blockchain ledgers incorporate encrypted and secure information; blockchain systems utilize cryptography and distributed consensus mechanisms that are called proof of work, which make information safe and reduce the risk of system failure and cyber-attacks (Kouhizadeh et al., 2019). Furthermore, with the utilization of a blockchain, each material and component's current state can be tracked, doing the proactive planning for their reusability a tangible reality (Shojaei et al., 2021). For instance—in the framework of a new technologies-driven Circular Economy for packaging waste, Ajwani-Ramchandani et al. (2021) confirm that through the four features of blockchain technology involving all stakeholders, it is possible to track the onward journey of the packaging waste right from the point of creation to the point of disposal, to ensure that it is disposed of suitably and not discarded in an unscientific manner, and therefore, enhancing the business sustainability; Regarding technology in that application, blockchain offers a disintermediation solution when all the intervenient will be able to be used in a traceable and transparent way; The data for each household will be updated in a database that can be mounted on a blockchain to prevent data tampering; The physical waste can be sold to waste dealers, and the details can be updated on the same database. Another ideal solution for a blockchain-based Circular Economy has recently been proposed by Centobelli et al. (2021); To bridge the three circular supply chain reverse processes (i.e., recycle, redistribute, and remanufacture) and the three factors affecting blockchain technologies which are their features (i.e., trust, traceability, and transparency), they highlight the role of blockchain as a technological capability for improving control in the movement of waste and product return management activities by designing a circular blockchain platform in a supply chain, including manufacturer, reverse logistics service provider, selection center, recycling center, and landfill.

- *Cloud computing (C)* is a technology that can improve the efficiency of production chains and the precision of production systems while positively impacting circularity indicators (Silva and Sehnem, 2022). According to Rejeb et al. (2022), cloud computing can enable the integration and optimization of manufacturing resources and capabilities at a large scale, as it can enable seamless information sharing and agile, service-oriented, green, and smart manufacturing and allow for fewer storage requirements, minimum carbon footprint, and paperless environments. The dematerialization possibilities offered by cloud computing are likely to enhance the Circular Economy (Demestichas and Daskalakis, 2020). Evidence from empirical studies on the Cloud computing-enabled Circular Economy is still scarce in the literature. In a recent study about a smart Circular Economy for manufacturing businesses, Kristoffersen et al. (2020) propose cloud computing along with other advanced digital technologies to theorize a correlation between increasing industrial automation and expanding systemic resource efficiency and productivity in a Circular Economy, allowing businesses to leverage self-sensing, self-adaptive, self-organizing, and self-deciding functions. For the metalwork-copper industry, Aivaliotis et al. (2021) suggest an approach that facilitates the optimization of resource management in the waste collection process by eliminating waste and minimizing the process variation while, along with waste monitoring, consists of steps towards the creation of Circular Economy ecosystems; Technologically, they proposed the adoption of a Cloud-based platform for receiving and storing waste data from production; moreover, the implementation of management and scheduling algorithms, as well as neural networks and machine vision systems were proposed to compare real-time received data with expected values and identifying abnormalities from pre-defined thresholds.
- *Big data analytics (D)* refers to the data sets and analytical techniques in applications that are so large and complex that they require advanced and unique storage, management, analysis, and visualization technologies (Chen and Storey, 2012). Indeed, it refers to the strategy of analyzing large volumes of data used when traditional data mining and handling techniques cannot uncover the insights and meaning of the underlying data (Bai et al., 2020). Its capabilities are increasingly becoming important for broader decision-making in the Circular Economy and are gaining significant attention from academicians and practitioners (Gupta et al., 2019). It is a revolutionary approach for sound decision-making in organizations that can lead to remarkable changes in transforming and supporting the Circular Economy (Awan et al., 2021a). According to Rejeb et al. (2022), big data analytics supports reuse and recycling to reduce consumption and enable the Circular Economy stakeholders to make well-informed decisions. For example, Modgil et al. (2021) establish a unique landscape for a big data-enabled Circular Economy that involves stakeholders as essential decision-makers. As a piece of empirical evidence on the support of big data technology to the Circular Economy to enhance sustainability in the industry, Kamble et al. (2021) used a large group decision-making technique to identify and rank the best big data-driven circular economy—BDDCE—practices in the automobile component manufacturing industry, which conducted their study to find that *minimization of the raw material consumption; plan for reuse; recycle; recovery of material; and reduction of the process waste at the design stage* are among the highly ranked BDDCE. Big data-driven industrial symbiosis is among the most vital industrial applications and examples to incorporate Industry 4.0 digitalization technologies into the Circular Economy (Tseng et al., 2018). In this regard, big data analytics can be used for a smart waste management system, involving all symbiosis units stakeholders—e.g., a sustainable and smart management system where the waste treatment values are considered in decision making, automated technology and systems are employed to achieve efficiency, waste data and information are integrated into big data centers using Internet of Things systems, workers are highly skilled, the community is naturally involved, insurance or other initiatives are available for health, hygiene, and safety occupations, the system's compliance style is founded on self-regulation, all information is available real-time, and all personnel is committed to a culture of environmental awareness (Fatimah et al., 2020). In the agri-food industry, big data analytics, as one of the 3S technologies (i.e., Sensing, Smart, and Sustainable technologies) (Miranda et al., 2019), can be an engine for the Circular Economy and sustainability; it supports the transformation toward an agri-food 4.0, which is confirmed by Belaud et al. (2019) by developing an approach that integrates big data to improve sustainability management in supply chain design in an agricultural system that meets together the different stakeholders, with the aim of valorizing agricultural waste. Today, big data is one of the core technologies of Oil and Gas 4.0 that is still in its infancy as a data-driven intelligence exploitation system based on high digitization and could witness several application scenarios—such as intelligent oilfield, intelligent pipeline, and intelligent refinery (Lu et al., 2019). Moreover, big data analytics can be a Circular Economy enabler for all operations (e.g., maintenance operations, supply chain operations, exploitation operations, etc.) and managerial levels in a framework of Oil and Gaz 4.0, starting from the

operational to strategic management for petroleum businesses, which can be projected on all businesses sectors.

4.1.2. Proposition 2: Using Industry 4.0 technologies to enhance the business's openness to stakeholders

The openness to diverse stakeholders (i.e., internal and external stakeholders) is a quality provided by holistic approach-based business management (i.e., systems-based approach-based business management) to the business; in other words, it is the quality of any business managed as an open system to its external and internal environments of stakeholders (Figs. 1 and 5). In literature, business openness to its stakeholders can be measured on many dimensions. Öberg and Alexander (2019) defined five dimensions of openness: *breadth:* the more the stakeholders' competencies are different, the more the business is open (Othman Idrissia et al., 2012); *depth:* the deeper stakeholders' knowledge, the more the business is open (Othman Idrissia et al., 2012); *freedom and lack of formalization:* the freer a stakeholder's collaboration, the less is formalized, the more the business is open (Herzog, 2008; Aslesen and Freel, 2012); *the number of phases:* The more phases the stakeholders are included in, the more the business is open (LAZZAROTTI and MANZINI, 2009); and *the number of actors:* the more stakeholders, the more the business is open (LAZZAROTTI and MANZINI, 2009).

Industry 4.0 digitalization technologies (e.g., blockchain) can broaden the five dimensions of openness of the business by offering extensive, flexible, and open arenas of decentralized data shared with different internal and external stakeholders (e.g., employees from all hierarchical classes, customers, external experts, scientists, external research laboratories, universities, suppliers, etc.) to involve them as principal collaborators in decision-making and continuous improvement and essential sources of innovation for achieving various goals, notably business sustainability. The concepts of openness and sustainability have both enjoyed increasing popularity in the recent scientific literature (Kimpimäki et al., 2022). They are features of contemporary business (i.e., today's business). A business's openness (i.e., internal and external) mainly encompasses innovation; furthermore, it influences innovation (Wu et al., 2013; Kratzer et al., 2017; Öberg and Alexander, 2019). According to Mubarak and Petraite (2020) and Bigliardi et al. (2022), Industry 4.0 has been recognized as offering a valuable opportunity for businesses to drive innovation.

In the sphere of the re-engineered 4th generation management and contemporary business (Figs. 4 and 6), we emphasize open innovation as one of the core pillars of sustainability, and that can be improved through Industry 4.0 digitalization technologies that can enable a total involvement of stakeholders and enhance the holistic behavior of the business by making it more interconnected (Fig. 1). In opposition to closed innovation, which is based only on interactions with internal stakeholders and characterizing the traditional business, the open innovation paradigm expects businesses to engage in external interactions for innovation (Kratzer et al., 2017). Moreover, it is a paradigm that believes businesses should use internal and external ideas (Wu et al., 2013). In this regard, businesses can, for instance, exploit Industry 4.0 digitalization technologies (e.g., big data analytics) to base their sustainability-related decision-making and continuous improvement on feedback from customers, employees, academics interested in research about sustainability, government, etc., as generators of innovative ideas.

4.2. Results and discussion

The only existing systems-based approach to managing businesses is based on Joiner's triangle (i.e., the 4th Generation Management) (Fig. 3), it is making them only customer-oriented (not sustainability-oriented) and therefore no more capable of adapting to their current context characterized more particularly by its two new components (i.e., Industry 4.0 and the Circular Economy). We confirmed that in the literature, no work discussed how Sustainability, Industry 4.0, Circular Economy, Competitiveness, and diverse Stakeholders as contemporary issues are accounted for in contemporary business management (Table 1). The main goal of this study was to suggest a re-engineered 4th generation management as a systems-based approach that is an evolved system-based management style based on a tool we called Hallioui's triangle (Fig. 4) for managing contemporary or today's businesses (Fig. 6). The study process was measured to allow businesses as open systems (Figs. 1 and 5) a sustainability perspective within their current landscape characterized by Industry 4.0, the Circular Economy, Competitiveness, and Stakeholders. We selected 181 relevant papers published between 2005 and the May 5, 2022 from Scopus, Web of Science, and Science Direct databases (Table 1). We found that 88,40% of relevant papers were published between 2017 and 2022, and 22,92% of relevant journal articles have been published in the *Journal of Cleaner Production* as a 1st ranked and most relevant journal to this article.

Through this work, the systems-based approach to managing contemporary businesses evolves from the 4th generation management that allows businesses to be customer-oriented only (Fig. 3) to a re-engineered 4th generation management (Fig. 4), enabling businesses to be more contemporary and adapted to their current context (Fig. 6), while being focused on sustainability and customer, which led from a traditional business (Fig. 9) to the 1st era of a contemporary business characterized by its customer orientation and unawareness in terms of the Circular Economy (Table 3), then to the 2nd era of the contemporary business characterized by its significant openness to its external and internal environments, furthermore, characterized by its sustainability and customer orientation within a context of Industry 4.0, Circular Economy, Competitiveness, and Stakeholders (Fig. 6). From an organizational point of view, Industry 4.0 has a key role in developing the holistic behavior of the business to make it more contemporary (i.e., more open and sustainable), which is to benefit through the re-engineered 4th generation management (Subsection 4.1).

The re-engineered 4th generation management as a contemporary management style could enable businesses to be more competitive within their current context (Figs. 4 and 6), given competitiveness is becoming based on globalization, productivity, innovation, and the incorporation of technology as a pillar of development (Mon and del Giorgio, 2022) while incorporating Industry 4.0 digitalization technologies into the Circular Economy and using them for boosting the businesses' internal and external openness (open innovation included in businesses' openness) to diverse stakeholders are two actions recommended by the recent industrial literature and that can be taken under the framework we are suggesting in this paper, are enablers of sustainability for businesses (Subsection 4.1.1 and Subsection 4.1.2), besides their importance to enhance their productivity and even encourage them in the path of globalization.

Regarding the current context of businesses (Fig. 6), the research outcomes show that the growing interest of researchers in Industry 4.0, the Circular Economy, and their relationship has become significant in the last years (Table 4 and Fig. 7). Research in the literature (Subsection 3.3) confirms that the relationship between Industry 4.0 and the Circular Economy is not yet well known and studied by the entire research world (Fig. 8). So, the current context of businesses (Fig. 6) is not yet mastered by all businesses and their countries worldwide. That may be referred to the lack of managerial frameworks allowing an understanding of the role of Industry 4.0 digitalization technologies such as artificial intelligence, blockchain, cloud computing, and big data analytics in supporting the Circular Economy and sustainability. The re-engineered 4th generation management can boost awareness regarding the relationship between Industry 4.0 and the Circular Economy among managers, engineers, academics, etc., and encourage the incorporation of Industry 4.0 technologies into the Circular Economy at a managerial level of the business structure.

From this work onwards, even businesses that are open to their stakeholders and that were regarded as contemporary in the literature while being managed by the 4th generation management (i.e., customer-

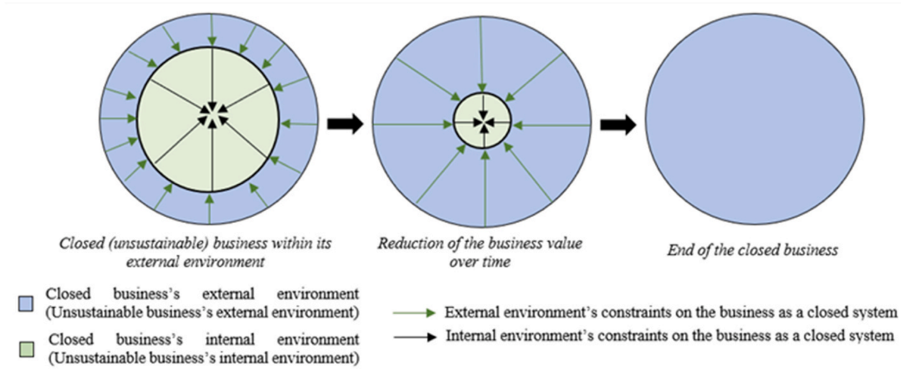

Fig. 9. Dimension of the unsustainable (traditional) business as a closed system over time.

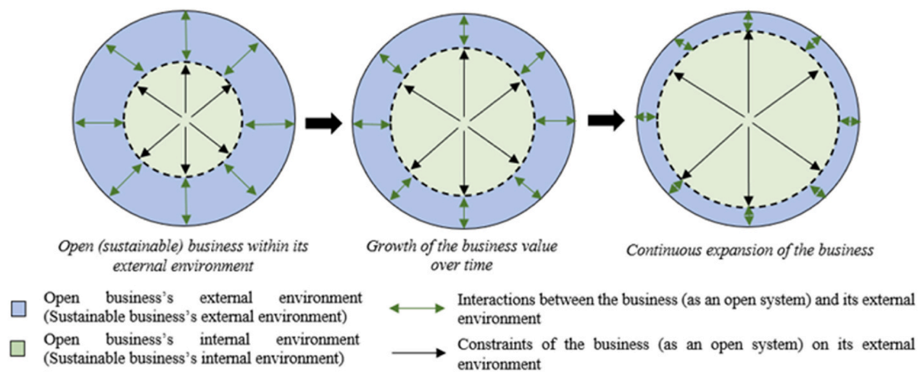

Fig. 10. Dimension of the business over time through the re-engineered 4th generation management (dimension or perspective of the contemporary business over time).

oriented) (Fig. 3) are to be considered traditional organizations (Fig. 9), given they are not sustainable within the current context (Fig. 6). Businesses are increasingly facing pressure (Fig. 9) to change production models from traditional (Table 3) to sustainable (Figs. 4, Fig. 6, and Fig. 10) which accordingly reinforces the need for assessing their performance on sustainability issues (Gupta et al., 2021). Concerning the temporal dimension and the perspective allowed by the re-engineered 4th generation management, the contemporary business (Fig. 6) is more open and sustainable and, therefore, more competitive, survives (i.e., interacts), and can grow and expand its value within its competitive environment and is more accepted by nature, like any system permanently able to adapt to its context or macro-system (Figs. 5 and 10). Whereas a traditional business organizationally behaves as a closed system to its internal and external stakeholders, is not sustainable and cannot be competitive and survive in the context of more contemporary competitors (i.e., businesses).

This study is the pioneer in incorporating sustainability into the business management style, which will serve as the first guide for managers and policymakers to change their vision of how to lead their businesses in a VUCA landscape requiring a sustainability orientation that can rely on Industry 4.0 digitalization technologies—such as artificial intelligence, blockchain, cloud computing, and big data analytics—, Circular Economy, and Stakeholders to make businesses more competitive. The proposed framework is a systems-based approach that saves the customer orientation for businesses based on the seven quality management principles since it is a Re-engineered 4th Generation Management (Fig. 4). Still, it is a new management key that will support the sustainable supply chain, sustainable maintenance, sustainable facility exploitation, etc.; It will help managers and policymakers to advance all business operations toward sustainability and build smart ecosystems while fostering the change of all business operations, functions, and even sectors to be sustainable and 4.0 (e.g., Supply chain 4.0, Maintenance 4.0, Safety 4.0, Procurement 4.0, Recycling 4.0, Agri-food 4.0, Oil and Gas 4.0, etc.), besides strengthening the open innovation and diverse green stakeholders. Moreover, top management should be engaged to make businesses more contemporary (i.e., more sustainable and open) by embracing the re-engineered 4th generation management to make them survive within their global market and countries under the obligation of respecting and developing the triple bottom line of sustainability (i.e., economic, social, and environmental) and realizing the 17 Sustainable Development Goals defined in the 2030 Agenda that has been announced in 2015 (Agenda for Sustainable Development, 2015). The recent literature (e.g., Dantas et al., 2021; Khan et al., 2021; Bai et al., 2020) highlighted the centric role of Industry 4.0 digitalization technologies, especially their combination with the Circular Economy in achieving the United Nations Sustainable Development Goals, so, a great backup of managers in (i) incorporating Industry 4.0 technologies into the Circular Economy and (ii) using Industry 4.0 technologies to enhance the business's openness to diverse stakeholders, will enable them to manage the business as a more open and sustainable system, which will help the business as a sub-system to support its country to achieve sustainable development goals, such as SDGoal 2—End hunger; SDGoal 3—Good health and well-being; SDGoal 6—Clean water and sanitation; SDGoal 7—Affordable and clean energy; SDGoal 8—Decent work and economic growth; SDGoal 9—Industry, innovation, and infrastructure; SDGoal 11— Sustainable cities and communities; SDGoal 12—Responsible consumption and production; SDGoal 13—Climate action; SDGoal 14—Life below water; SDGoal 15—Life on land; etc. Indeed, this study is a solid letter to managers and policymakers to lead the transformation of businesses toward a sustainable and customer-oriented generation to end the customer-oriented business generation launched by Joiner (1994) in the 1990s.

4.3. Limitations and future research lines

Complexity often means difficulty, the first limitation while performing this research work is its structure as a complex of two distinguished and related research parts. The coherence between the two stages of the research methodology designed and proceeded (Fig. 2) to carry out this work was always subject to our research and analysis. Furthermore, the duration between the participation in the International Conference to present the first part and the work on its extension to achieve the goals of the present work was dedicated to other independent research works. So, the research schedule significantly impacted and directly contributed to generating a factual limitation to this study. Despite the tremendous increasing research interest during the last years to investigate the relationship between Industry 4.0 and the Circular Economy as two new components of the current context of businesses, there is still a considerable scarcity of evidence from empirical studies to prove the efficiency of artificial intelligence, blockchain, cloud computing, and big data analytics as technology enablers of the Circular Economy and therefore sustainability, which created the second limitation to present more discussion on technology in this study.

There is a range of future research opportunities (Hossain, 2021). The first crossable research avenue is re-engineering the Total Productive Maintenance in a frame of the re-engineered 4th generation management (Fig. 4), which will lead to improving sustainability awareness and anchor its ideology among businesses worldwide for being the pioneers to design a Sustainable Total Productive Maintenance (Hallioui and Herrou, 2021) in the optic of considering the systems approach into the maintenance of production systems. Maintenance is a process between many interacting others within the business as an open system (Figs. 1, Fig. 5, and Fig. 10). To correctly implement the systems approach into the maintenance of production systems; it is crucial to understand and implement the re-engineered 4th generation management in the business as a contemporary organization (Fig. 10) and be highly adapted to the current context of the business (Fig. 6).

Another important issue that needs to be accounted for considering the systems approach in Total Productive Maintenance is incorporating risk analysis methods to detect and mitigate the risks involved in the production phase. An integration approach that seeks to provide value through risk analysis towards a more sustainable total product maintenance would be a future line of research to be accounted for since the detection and mitigation of risks, during the operational phase, fully integrated with the systems approach, would allow promoting sustainable development over the three known dimensions of sustainability, namely, Economics, Social, and Environmental. Several known and well-established approaches can be considered in this optic for such integration. An example of an existent and well-established method could be the Failure Mode and Effects Analysis (FMEA).

Besides Total Productive Maintenance, all lean manufacturing tools and production philosophies could be re-engineered to support business sustainability through the re-engineered 4th generation management. Other future line research could allow us to improve the adaptability degree of the Sustainable Total Productive Maintenance due to a change in the context, leading to a redesign of the systems approach—developed before. A way to prevent the influence of such changes in organizational performance should pass to incorporate artificial intelligence techniques, such as neuronal networks, to provide the systems-based approach with the ability to prevent the change and better adapt it.

Further work can also be carried out to emphasize the role of the re-engineered 4th generation management in creating smart ecosystems. We also suggest studying and conducting case studies to assess its effectiveness in the current context of businesses and even in the era of Industry 5.0 to help businesses contribute to achieving sustainable development goals (e.g., SDGoal 2—End hunger; SDGoal 3—Good health and well-being; SDGoal 6—Clean water and sanitation; SDGoal 7—Affordable and clean energy; SDGoal 8—Decent work and economic growth; SDGoal 9—Industry, innovation, and infrastructure; SDGoal 11— Sustainable cities and communities; SDGoal 12—Responsible consumption and production; SDGoal 13—Climate action; SDGoal 14—Life below water; SDGoal 15—Life on land; etc.) according to the UN 2030 Agenda for Sustainable Development.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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