

Received September 14, 2021, accepted October 5, 2021, date of publication October 8, 2021, date of current version October 19, 2021.

Digital Object Identifier 10.1109/ACCESS.2021.3118988

Top Management Support in the Implementation of Industry 4.0 and Business Digitization: The Case of Companies in the Main European Stock Indices

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ABSTRACT Top management support is one of the key aspects in the implementation of Industry 4.0 and business digitization, whereas communication is essential to aligning and driving an organization in this task. However, to date, no research has addressed this support from this perspective. To fill this gap, we take a sample of companies ($N = 159$) listed on the 5 main stock indices in the European Union, and we qualitatively examine the letters issued by chief executive officers and other top managers in their annual reports. We assess whether, to which extent and under which motivations and barriers, the senior management of these companies are supporting this implementation through their discourse. Among other relevant findings, our results show that barely half of the managers make explicit their strong support for this implementation, as a kind of widespread spatial myopia that serves as a meta-barrier in this implementation. In addition, the support given by top executives is mostly driven by business and customer motivations; in turn, they generally fail to present sustainability within their main motivations. Overall, this paper offers a series of relevant contributions and insights with managerial implications taken from a novel approach in this field.

INDEX TERMS Industry 4.0, business digitization, motivations, barriers, sustainability, top management support, top management communication.

I. INTRODUCTION

The terms ‘Industry 4.0’ (I4.0) and ‘digitization’ embody a budding paradigm shift that is already taking place with different rates of implementation depending on the area and context and represent a milestone in the transformation of our world and our lives. This transformation will be indeed decisive not only for business prospects [1], but also to tackle the multiple social, environmental and health challenges faced by our society. I4.0 facilitates more efficient, flexible, and sustainable manufacturing processes [2], with better tailored and customized products [3]. I4.0 encompasses concepts such as smart products, smart cities, smart grids, smart transportation, smart homes or smart buildings, and extends beyond the

simple scope of a factory [4]. For example, I4.0 allows logistics optimization and emissions reduction through the concept of smart transportation [5], and can transform our towns into more efficient, practical and sustainable smart cities, thereby improving our quality of life [6]. In sum, I4.0 offers through its transformative capacity multiple opportunities as a competitive lever, as a creator of social value and as an enabler for sustainability [5], [7]–[9].

Although they are experiencing an ongoing development and enhancement, the required technologies for the implementation of I4.0 are already available, and many specialized providers are offering and implementing I4.0 solutions [10] in diverse ambits. One of the biggest challenges is to extend and customize their effective incorporation to the entire business fabric, across industries and geographical areas, the private and public sectors, our towns, our mobility and other aspects

The associate editor coordinating the review of this manuscript and approving it for publication was Daniela Cristina Momete¹.

of our daily lives, to get the most out of their potential and spread their benefits in all areas.

In particular, when addressing the drivers for implementation of I4.0 or digitization within a company, the support of top management is one of the essential aspects for success [11], [12]. Thus, managers should be aware of their leverage in this task and actively promote it. In this respect, communication is a key lever used for aligning the organization towards their goals [13]. In addition, within this communication, the introductory letters in the annual reports of companies, generally issued by the chief executive officer (CEO) either alone or together with the chairperson or other members of the managing board, comprise one of the most read sections [14], and represent a unique tool for top executives to convey their message, thereby drawing more or less attention and relevance to certain topics [15], [16]. Thus, these letters represent a precious channel for these individuals to provide explicit support for this implementation and share their comments about it.

Nonetheless, despite the importance of I4.0 and business digitization (BD) in the prospects of companies and society, as well as the leverage of the top management support and its communication as one of the key aspects in its implementation, we could not find any research investigating the communication of top managers in relation to their support to I4.0 and BD. In addition, the degree of development of I4.0 and digitization in Europe has been underexplored [17]. This paper aims to fill this gap by assessing and comparing whether or not, to which extent and under which motivations and barriers or difficulties, senior management of top companies in various European countries and industries are reasoning and fostering the implementation of I4.0 and BD through their discourse. To this end, we take a sample of companies listed on some of the main stock indices in the European Union, and qualitatively examine the letters issued by CEOs and other top managers in their annual reports.

The remainder of the article is structured as follows. Section II provides a theoretical background of I4.0 and the potential motivations and barriers for companies in regard to its implementation by delving into the role of top management in the strategy of their companies and the importance of top management support and communication in this task. In addition, the central role of the CEO and other top executives is appraised, as well as the relevance of their discourse in their letters that are included in the annual reports of their companies, as a source of great value for the assessment. In section III, the sample is defined, and the methodology is explained, while in section IV the findings from the assessment are presented and discussed. Finally, the last sections gather the conclusions, implications and limitations and future research venues.

For the main contributions and managerial implications, this paper provides a first perspective on how the senior management of some of the top companies in Europe are supporting I4.0 and BD through their discourse. The results show that barely half of the managers make explicit their

strong support for this implementation, which represents a kind of widespread spatial myopia and a meta-barrier to this implementation, thereby wasting a precious chance to line up their companies, staff and stakeholders in this transformation. Moreover, the support given by top executives for this implementation is mostly driven by business and customer motivations. In turn, they generally fail to present sustainability within their main motivations, except for the oil and energy sector; furthermore, they rarely address barriers. In addition, the current paper opens promising future research lines. To our knowledge, this approach is novel in this field and provides further insights to one of the key aspects for the future development of I4.0 and BD in a range of industries and countries from a new perspective.

This research also intends to contribute to increasing the self-awareness of top management, companies and stakeholders on this topic for their own benefit and a shared benefit with society, and call the attention of the scientific community towards the utility of exploring the communication of top management in this field, because these managers and their top companies may represent benchmarks or referents for their peers and small and medium size enterprises (SMEs), and can thus help establish the conditions and infrastructures that will help smaller companies to access these new technologies.

II. THEORETICAL BACKGROUND

A. INDUSTRY 4.0 AND BUSINESS DIGITIZATION. POTENTIAL MOTIVATIONS AND BARRIERS TO ITS IMPLEMENTATION

The I4.0 concept, also referred to as the digital industry, the smart industry or the fourth industrial revolution, is based on the effective incorporation of the latest technological and digital tools, with intelligent cyber-physical systems that combine the physical part with the virtual part, thus communicating and interacting with each other and with their environment. These systems collect, store, exchange, and manage a massive amount of data autonomously. At the same time, they are capable of improving automation processes, with decentralized control and advanced hyperconnectivity, to achieve real-time monitoring, analysis and decision-making for processes optimization [18]. The Internet of Things (IoT), big data, non-invasive smart sensors, cloud computing, artificial intelligence, advanced robotics, augmented reality and virtual simulation, blockchain, 5G, additive manufacturing, 3D printing, cybersecurity, drones, and Nanotechnology are some of the key ingredients in the puzzle that makes up I4.0. In all, digitization, information and communication technology, data collection and management, hyperconnectivity, artificial intelligence, automation, interoperability, integration at different levels and optimization are key concepts in this revolution [4].

Furthermore, the transition required for the implementation of I4.0 involves end-to-end digital integration, vertical integration to deliver end-to-end solutions and horizontal

integration. Such integration comprises not only production but also marketing and interaction with customers or logistics [19]. The I4.0 concept has indeed transcended from its origins in the smart factory to a much broader scope of business processes involving an overall digital transformation [20]. In this respect, the concept of BD has evolved from its primary meaning, originally associated with the transmission of analogic to digital record content, and it is currently often used interchangeably by academics and practitioners when referring to such digital transformation of business, which involves the adoption of digital technology to obtain a series of business objectives [21]. Overall, the I4.0 and BD concepts can be considered currently as part of the same package, as conceived in this research.

Regarding the motivations or driving forces towards the implementation of I4.0 and BD, which are understood as the factors that may encourage companies in this transformation [22], the literature has appraised them as potential sources of opportunities for companies [1], to enhance competitiveness and provide added value [5], [23] and customer satisfaction [24] through more efficient, flexible and sustainable processes [2], [25], thereby easing reduced costs and lead times, as well as better quality, better adapted or customized and more sustainable solutions, products or services [3], [5], [9], [26] for the benefit of both customers and society. In particular, when addressing sustainability, I4.0 and BD may contribute specially to the environmental side, for example, by leading to better energy management, a more efficient and sustainable use of resources and a reduction in waste and pollution [27]–[29]. However, incorrect implementation can be counterproductive and jeopardize the future of businesses [1]. In sum, from the above cited works, three main potential blocks of motivations or drivers for companies can be discerned towards the implementation of I4.0:

- A focus on the customer by meeting the customer's needs and expectations; offering added value to them through a better quality of service or product, better prices and delivery times, and better customized solutions; facilitating connectivity, communication and relationship with customers; and enhancing their experience.

- A focus on the business itself to improve competitiveness, efficiency, productivity, flexibility, process and logistics enhancement, costs reduction, growth, revenues, profitability, control and monitoring to facilitate decision making or business model innovation, as a source of business opportunities and as a tool to face future challenges.

- A focus on making business more sustainable, with the pursuance of more sustainable products or services and operations within the principles of a circular economy and through the reduction of energy, resource consumption, emissions, pollution or waste, as well as through more durable, repairable, reusable and recyclable products, the improvement of working conditions and employee motivation, the reduction of social inequalities or the improvement of life quality.

In addition, these blocks are intrinsically interrelated. For example, as previously mentioned, a more efficient use of resources brings at the same time competitiveness and environmental enhancement, as well as cost reductions to offer a better price to customers or to make more profit. Additionally, customer-oriented business models with customized solutions bring about the possibility of leveraging competitiveness [30].

Moreover, although the adoption of technologies associated with I4.0 and BD can bring numerous benefits to companies, their implementation is not without difficulties and challenges given the complexity and side effects that this process entails [29], [31]–[33]. Various studies have focused their attention to a greater or lesser degree on the barriers that hinder such implementation (i.e., [22], [34]–[36] or [33]). Although it is a literature with a high degree of fragmentation, the most salient identified barriers are the lack of a skilled workforce and knowledge about I4.0, with the need to recruit, upgrade or train staff; conflicts between workers regarding resistance due to changing working environments and disruption to existing jobs; the lack of financial resources or the high amount of investments required; the lack of clarity regarding economic benefits; the lack of infrastructure (i.e., lack of Internet coverage and IT facilities); challenges related to organizational and process changes including value-chain integration, which is a very complex task; the low maturity level of the technology; further inequalities between developing and developed countries and younger and older generations; data quality and management; security issues; the lack of standards or regulations; the need to establish a code of conduct for an ethical use; and the lack of understanding of the strategic relevance of I4.0. As stated in different works (i.e., [22], [25] or [33]), research in relation to barriers that limit the implementation of technologies associated with I4.0 is in its initial state; thus, it is advisable to make a greater effort to investigate the obstacles and difficulties that stunt said implementation. In this vein, the perspective of the senior management of leading companies in the main European stock indices may provide additional clues to this nascent research field.

B. THE SUPPORT OF TOP MANAGEMENT AS ONE OF THE KEY ASPECTS IN THE IMPLEMENTATION OF INDUSTRY 4.0 AND BUSINESS DIGITIZATION

Since the 2011 Hannover Fair, where the concept of I4.0 was first introduced, academics have made significant progress towards determining the key aspects in its overall implementation. As an example, Sony and Naik [11] through a systematic analysis of the literature that integrated more than 80 related publications, identified a series of critical factors in this implementation; among them was the required implication of top management: ‘the top management shall support the I4.0 initiatives wholeheartedly’ [11:806].

There is indeed a large body of literature in which the support of senior management is emphasized as a key factor when implementing innovative projects in the organizational

context, i.e., projects that can be of diverse nature, such as the implementation of information systems [37]–[39], the development of new products [40], [41] or the implementation of environmental certifications [42]. Top management support refers to ‘providing the required support to an operating process and the role of providing explicit directions for the running of a business’ [43:579].

Along the same lines, from the approach of two of the most widely adopted technology adoption models, namely the technology acceptance model (TAM) and the technology-organization-environment (TOE) framework, scholars have identified top management support as one of the essential factors in diverse technology adoption contexts (i.e., [44]–[46]).

Moreover, research in this field has highlighted the importance of the support of senior management in the successful development of new projects through different channels. On the one hand, the relevance of this support has been emphasized through the commitment of funds (or any other resources) necessary for the correct development of the project [40], [47], [48]. The importance of the active involvement of senior management in coordinating the efforts that this project could entail for the different members of the organization has also been highlighted [49].

On the other hand, the relevance of said support has been underlined insofar as it involves the public identification of the project as a priority for the organization [50]. This identification conveys, both outside and inside the company, a signal of the relevance of the project for the organization, thereby clarifying the objectives and eliminating possible uncertainties associated with its development. The message within the company is especially relevant. In this sense, to the extent that the members of the organization perceive greater support from senior management, they will be more likely to show greater interest in the project and approach its development with greater enthusiasm and commitment, thus assuming a greater degree of possible risks associated with it [40], [41]. The creation of a climate of support and trust is a key element in overcoming the obstacles that the development of innovative projects entails.

In all, this support must materialized not only through the adequate resource allocation but also by proactively leading the required changes at different levels, such as lining up the strategy, fostering the required innovation and transformation, aligning the organization and adapting its structures, updating the staff in the required knowledge, integrating upstream and downstream, ensuring a proper coordination and dealing with potential threats and conflicts, whereas in this task, top management communication is essential, as will be appraised in next section.

C. THE SUPPORT OF TOP MANAGEMENT THROUGH THEIR COMMUNICATION: CEO LETTERS AS A VALUABLE SOURCE

Top management support is vital in the success of any initiative [39], [51], and the proper communication of top executives, as a driver to inspire influence, is essential to

aligning and driving the entire organization towards strategic goals [13]. Thus, if the implementation of I4.0 and BD is part of the strategy and a main priority, then this should be properly transmitted and highlighted. In this implementation, which implies a deep transformation, the CEO and other top executives must first recognize the need for this transformation and behave as visionary leaders by presenting and giving relevance to the subject and communicating its aim and benefits in an inspiring way [52], i.e., with a meaningful and convincing vision [53].

The introductory letters of top executives such as the CEO, which are one of the most read sections in annual reports [14], represent a unique tool for CEOs to convey their vision and message to the entire company and external stakeholders. These letters are voluntary and not subject to any particular rules or constraints; in them, top executives draw attention to certain topics over others and address to them through their lenses [16]. In addition, according to Van Alstine and Barkemeyer [54], they offer information on the challenges and opportunities that top management has identified and intends to address. In the same line, Yadav and his associates [15] appraised various benefits of using these letters from several perspectives. As public documents, such letters require some objectivity and accountability. They represent not only a means of communicating with external audiences but also a potentially powerful tool for enrolling employees in the task of involving resources in activities that are vital to the firm’s prospects. The same authors claim that the letters offer a unique glimpse into the minds of CEOs and their limited attentional focus, which is difficult to obtain by other means, and they argue that the way CEOs drive their attention has significant implications for the firm innovation outcomes, thus affecting the adoption of new technologies. Hence, these letters appear as a valuable, unique, and quite universal source found in large corporations to examine the top management support, influence, and approach in relation to the implementation of I4.0 and BD.

III. DATA AND METHODOLOGY

For our purpose, the initial sample comprised the companies listed in the 5 major stock indices in the European Union, namely, DAX-30 (Germany), CAS-40 (France), FTSE MIB (Italy), IBEX-35 (Spain) and AEX-25 (The Netherlands), specifically those companies belonging to the top 5 economies in terms of GDP during years 2019 and 2020, as a rich representation of the main companies operating within the European Union. The data source consisted of the introductory messages of CEOs or other top managers in their absence, in form of letters, statements or interviews that were included in the latest available annual report, i.e., that issued during year 2020 and referring to the fiscal year 2019, which was downloaded from the respective company websites. After discarding 10 companies with no message from their top managers in their annual reports and one company repeated for France and Italy (STMicroelectronics), which was only considered once, the final sample consisted

of 159 companies, representing seven main industries in our classification: oil and energy, basic materials for industry and construction, consumer goods, consumer services, financial services, technology and telecommunications and real estate services. With the aim to unify the classification of industries for all countries, the classification from the Spanish stock index IBEX 35 in accordance with [55] was adopted for reference. The annex shows the list of companies by countries and industries finally included.

For our empirical analysis, two of the three authors together carried out a close reading analytical technique [16] on the introductory letters or statements using a qualitative and interpretive approach to identify any content related to I4.0 and digitization and assess its relevance and degree of emphasis. The assessment was applied in the form of three categories as per Table 1.

TABLE 1. Categorization of our assessment in terms of top management support.

Category name	Category code	Explanation
Strong support	YES+	Explicit relevance /emphasis /leverage on the topic
Weak support	YES-	Weak relevance /no emphasis /anecdotal mention
No support	NO	No mention at all

Source. Own elaboration.

In addition, some extracts illustrating cases under codes ‘YES+’ and ‘YES-’ are provided as follows:

Examples of categorization ‘YES+’:

... we’re linking together with other companies and educational institutes to make sure we have the capabilities and the talent to drive advances in digital and technology. . . We ramped up our digital strategy and organization and became more of an omnichannel company. . . I would also like to see us make a big leap forward in technology and digital, getting customers more connected to our company but also helping them. . .

AHOLD-DELHAIZE-THE NETHERLANDS. CEO letter in Annual Report 2019.

The digital transformation, also thanks to the exceptional incubator which is the Digital Factory, has become a distinctive feature of our company, that allows us to radical change the methods of network and process management, improving both service quality and operating efficiency improve, as well as the sustainability of our business, supporting on the energy transition.

ITALGAS-ITALY. CEO letter in Annual Report 2019.

A fact that we were able to verify during the COP 25. . . , in which an intense debate on the universal purpose of companies in the so-called fourth industrial revolution, a transformation in which today the Company is immersed

and identified as a key strategic pillar, with which to compete in this new decade and face the great global challenges. . .

MELIA-SPAIN. CEO letter in Annual Report 2019.

Examples of categorization ‘YES-’:

We are planning further growth in 2020 and believe we are well equipped to thrive in future markets and under the conditions of ongoing digitization.

DEUTSCHE BOERSE-GERMANY. CEO letter in Annual Report 2019.

Our solid results make Carrefour a more agile, more digital, more resolute company, fully committed to serving its customers in the best possible way.

CARREFOUR-FRANCE. CEO letter in Annual Report 2019.

We have done this with the tools that every modern company should have: emergency plans, worker health and safety, digital technologies, agile working, process innovation.

A2A-ITALY. Chairperson and CEO letter in Annual Report 2019.

Furthermore, the authors collected the stated motivations and barriers or difficulties related to the implementation of I4.0 and BD, and classified them into groups and subgroups, in line with the literature review. Three main groups of motivations or drivers were identified depending on the focus used to support the implementation of these new technologies; within each group were several subgroups that gathered the references made by top executives in their letters, which were established as follows:

Group M1-Customer focus

M1.1-Improving quality of service or product, meeting customer’s needs, offering added value to them.

M1.2-Reaching customers, connecting with them.

M1.3-Enhancing the customer experience.

Group M2-Business focus

M2.1-Enhancing competitiveness, efficiency, or results.

M2.2-Business opportunity, tool to face future challenges.

Group M3-Sustainability focus

M3.1-Contributing to make business more sustainable.

Additionally, the authors found six types of barriers or difficulties noted by the top managers in regard to implementation, which are diverse in nature but generally much less referred to compared to the abovementioned motivations:

B1-High investments

B2-Complex task

B3-Recruiting/upgrading/training staff

B4-Security

B5-Code of conduct/ethical use

B6-Lack of regulation

In this way, from the close reading, it was determined whether top management leaders referred to each of these groups of motivations and barriers, as presented in the next

section. The multiple case study approach, not only in terms of companies but also comprising several countries and industries, allows the provision of better grounded and more generalizable results [56] and is appropriate when examining relatively novel, contemporary, and evolving events [57].

IV. RESULTS AND DISCUSSION

A. TOP MANAGEMENT SUPPORT TO INDUSTRY 4.0 AND BUSINESS DIGITIZATION

Remarkably, within the final sample of 159 companies belonging to the 5 major stock indexes within the European Union, more than half of the top managers did not show strong support (‘YES+’) for the implementation of I4.0 or BD through their letters or statements; more than one third of them do not even refer to such implementation (‘NO’). Figure 1 depicts these results:

These ‘YES–’ and ‘NO’ percentages are relatively high taking into account the relevance of the topic for the prospects of companies, the leverage of top management involvement in the implementation of I4.0 and that we are considering top companies within the European Union and global leaders in their industries worldwide. A mitigating factor could be that just ten years ago, the concept did not even exist; or it could even be interpreted that the topic is not present because it is something that is taken for granted or maybe already implemented and thus no longer within the focus of top managers regarding the performance or prospects of the company. However, even in that case, considering the relevance and the potential benefits, as well as the image projected, showing themselves to be at the forefront of a relatively new trend would be worth at least a mention in the letter.

Thus, we consider that it is more about a lack of background or a profile that is distant from new technologies, with some managers not yet well aware of the significance and potential benefits at all levels of digitization, which is worsened by the yet relatively incipient emergence of the concept. Whatever the case, regarding not only the importance of I4.0 and BD per se but also the uneven approach and relevance given between peers within same industry and context, the so-called spatial myopia [58] arises in part of the sample, which involves a lack of awareness of available technologies or their potential. Those companies are losing a great opportunity to appear as innovative or avant-garde, and their managers are wasting a precious marketing tool that could be used to transmit a positive image of the company [59] and a lever in their discourse to orientate the company towards results and success. According to Sony and Naik [11], the support of top management is one of the key aspects for I4.0 implementation; for this purpose, top management should envision and transmit it in a convincing way [13], [53]. This support, properly conveying both outside and inside the company the relevance and benefits of the project, contributes to the public identification of the project as a priority for the organization [50]. In addition, it helps to clarify goals and eliminate possible uncertainties, especially within the organization, as middle managers and staff per-

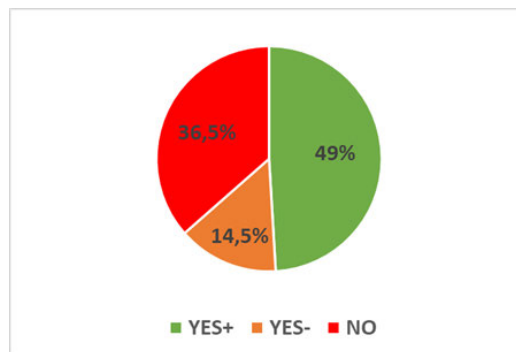


FIGURE 1. Top management support to Industry 4.0/business digitization.

ceive this support and are more likely to get involved, face obstacles and assume potential associated risks [40], [41]. Far from that, in many cases top managers are ignoring this strategic lever in their discourse.

Moreover, aside from the internal leverage, CEOs and other top managers, as public figures [60], may serve as role models and benchmarks for their peers across the industry fabric and contribute to foster the implementation of Industry 4.0.

1) MOTIVATIONS

Concerning the overall motivations when addressing I4.0 or BD, in general, top managers tend to refer to and reason in greater extent about the benefits of their implementation rather than about the difficulties faced due to it. Figure 2 illustrates the global percentages of each main group of motivations.

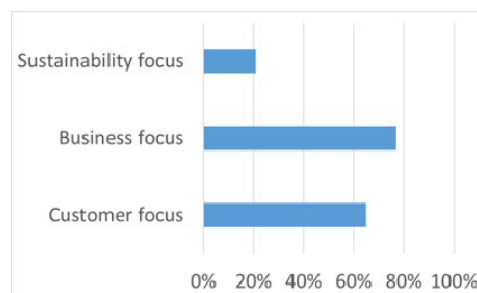


FIGURE 2. Main groups of motivations addressed by top managers.

The most recurrent motivation group is business focus; nearly 80% of managers show this motivation when referring to I4.0 and BD, followed by customer focus, in 65% of cases. In turn, the third motivation, sustainability focus, is just reflected in only 21% of the total cases and only in relation to its environmental side; furthermore, it is distributed quite unevenly among industries, as discussed later.

Within customer focus, the most present motivation is M1.1-Offering added value to customers (55% of cases), while M1.2-Reaching customers and M1.3-Enhancing customer experience are present in about a quarter of cases. Regarding Business focus, there is a more balanced distribution of the two subcategories M2.1-Competitiveness/efficiency/results and M2.2-Business opportunity, with 58% and 48% of the cases respectively.

Concerning the slight presence of sustainability as a motivation in our sample, this occurs despite the relevance and attention that sustainability has gained in recent years in the strategy of companies and being one of the critical factors identified by Sony and Naik [11] in the successful implementation of I4.0. Whereas the social dimension is not so clearly positively associated with I4.0 [29], the potential contribution of I4.0 to the environmental dimension is much more evident. As noted in the theoretical background section, apart from the direct strategic and economic benefits for a company, Industry 4.0 may lead to more sustainable processes [2], [25] and more sustainable solutions, products or services [26], for example with an improved energy management, a more efficient and sustainable use of resources and a reduction in waste and pollution [27], [28]. Hence, sustainability in its environmental aspect has a direct relationship with other more addressed motivations by the top managers in this research, such as M2.1-Enhancing competitiveness/efficiency, or M1.1-Offering added value. In addition, I4.0 facilitates the implementation of circular economy strategies [25], [61]. Thus, the widespread lack of emphasis on the motivation to become more sustainable regarding the environmental side is found as a clear weakness in the discourse of top managers when addressing to I4.0 and BD.

2) BARRIERS

As for difficulties or barriers, top managers barely refer to them in their discourse, and when so, they do it often in an implicit way; in general, such issues do not seem to be among their main concerns. A possible explanation could be related to the extent of resources and capabilities of their companies, considering they are top players worldwide; in line with Horváth and Szabó [22], top players tend to have more opportunities and face less barriers in the implementation of I4.0. Overall, the barriers with a certain presence are high investments (13%), recruiting/upgrading/training of staff (11%), security issues (8%) and complex tasks (5%). Figure 3 depicts these results.

All of these barriers are coincident with previous works (i.e., [22] or [33]), whereas other barriers identified in the literature such as the disruption to existing jobs, the lack of clarity regarding economic benefits, the lack of understanding of its strategic leverage, the lack of infrastructure, the low maturity level of the technology, further inequalities between developing and developed countries and the young and old generations, data quality and management, or resistance to change are not addressed by top managers in our sample.

B. ASSESSMENT BY COUNTRY

When looking at differences between countries, and excluding real estate service companies, since they are only present in German and Spanish indices, France, Italy and Spain show very similar results; approximately 45% of top managers strongly support the implementation of Industry 4.0 and BD. In the case of Germany, the percentage rises to 58%, and it is 67% for the Netherlands (Figure 4).

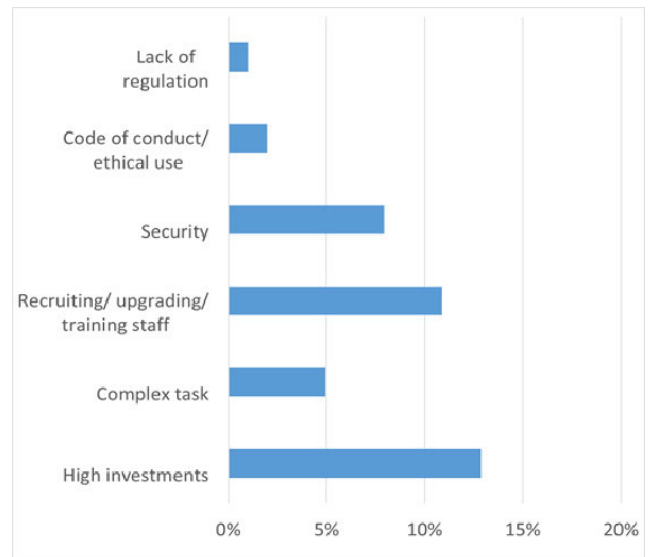


FIGURE 3. Main barriers addressed by top managers.

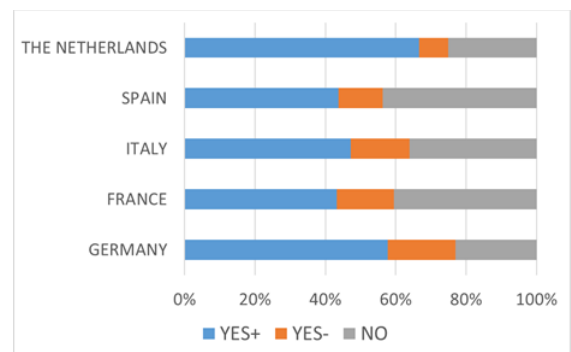


FIGURE 4. Top management support by country.

In terms of motivations (Figure 5), the Netherlands is in first place in the customer focus group, followed by France and Spain, with Germany at the bottom of the list. Moreover, Spain is the country where top managers more widely emphasize motivations within the business focus dimension, followed by France, Germany, the Netherlands, and Italy. For sustainability focus, this dimension is more often reflected by Italian and Spanish top executives, followed by France and Germany, while it is not present in our sample from the Netherlands. Overall, and considering each aggregated subgroup, the top managers of Dutch companies are the ones more frequently noting their motivations in their discourse when referring to I4.0 or BD, followed by Spain and France.

Regarding the difficulties or barriers (Figure 6), we notice that the need for qualified staff by the top managers of German firms does not appear as a concern, while it is more present in countries such as France or Italy. The same happens with Dutch companies in relation to high investments, which is not present as a barrier, while this barrier has a certain weight in the rest of countries. This lack of mention of these

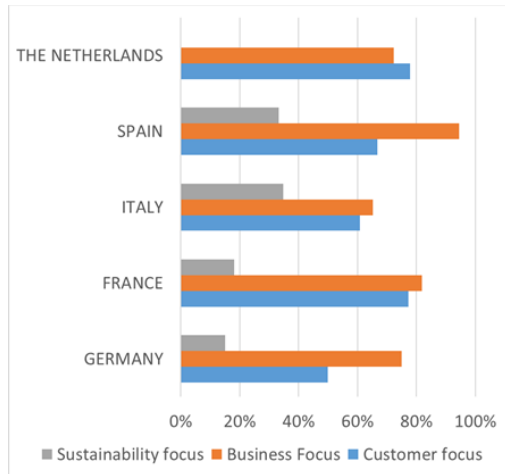


FIGURE 5. Main groups of motivations by country.

investments could correspond to a higher degree of implementation of new technologies where most of the investments have already been made, which is also in line with the more widespread weight of digitization in their letters compared to other countries. Furthermore, in the case of Netherlands, security is the difficulty that is mentioned the most, which is probably caused by a major background issue or development.

In any case, these results point at certain trends, but a deep and conclusive interpretation of these differences by country is constrained by the composition of each index and the relatively small number of companies of each industry by country; the focus of our research when dissecting the results is more on the assembly of top European companies and by industries and not so much on the country, which would require a much larger sample representing the business fabric in each country.

C. ASSESSMENT BY INDUSTRY

From the above results, we carry out an analysis by industry, seeking for common trends and specificities. Figure 7 depicts the results of our assessment in terms of top management support to the implementation of I4.0 and BD by industry. The consumer services industry stands out for the generalized strong support of its management, with 80% of cases, whereas the oil and energy and the consumer goods industries show less than 40% of cases. This outcome is quite striking considering the potential of I4.0 and BD in the industrial and sales related processes associated with these companies. The real estate services industry includes only four companies in our sample, but a little overall support is also in sight. However, probably the most striking finding is that 40% of top managers in the technology and telecommunications industry do not show a strong support for the implementation of I4.0 or BD, considering that their companies are key actors in the digital transformation.

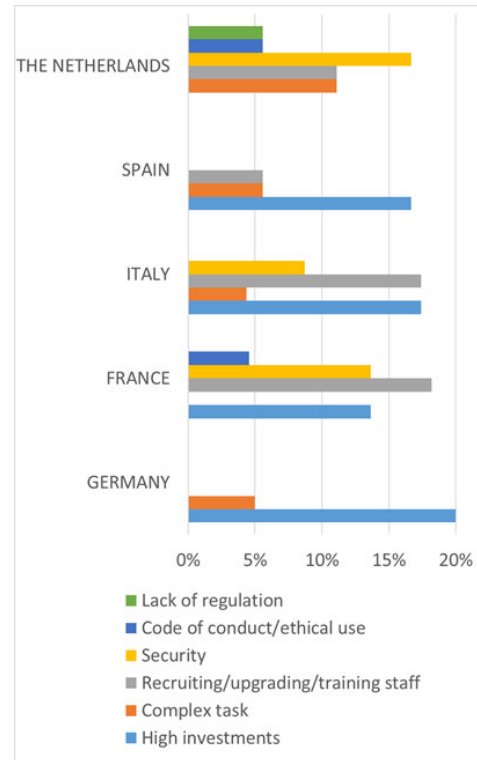


FIGURE 6. Barriers by country.

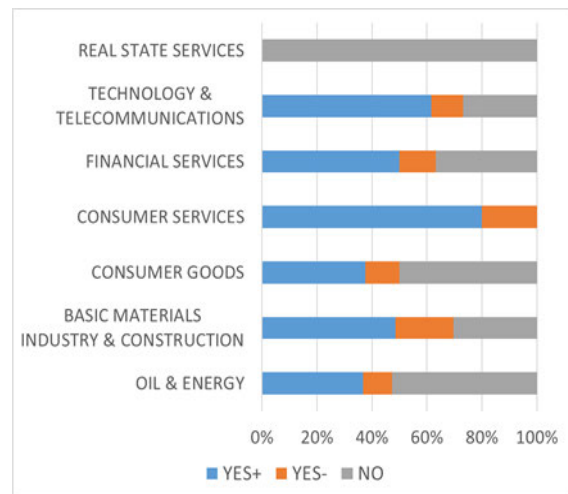


FIGURE 7. Top management support by industry.

Moreover, Figure 8 shows the presence in percentage of the main groups of motivations for each industry. In general, business focus and consumer focus are the dominant motivations, with variable but significant weights across industries. In contrast, sustainability, apart from being the least recurrent motivation group, it is the one showing greater differences between industries. The oil and energy industry is by far the one where the contribution to sustainability is more frequently stressed as one of the benefits of digitization, which is present in 67% of the cases. This can be related to the sector's relative more controversial nature [62], especially in terms of environmental concerns, and thus it being more active in this

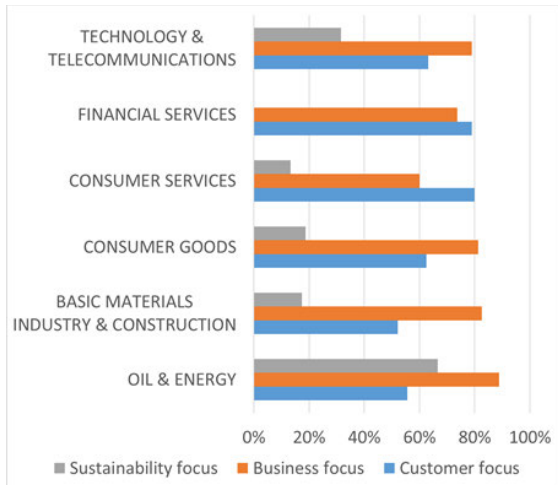


FIGURE 8. Main groups of motivations by industry.

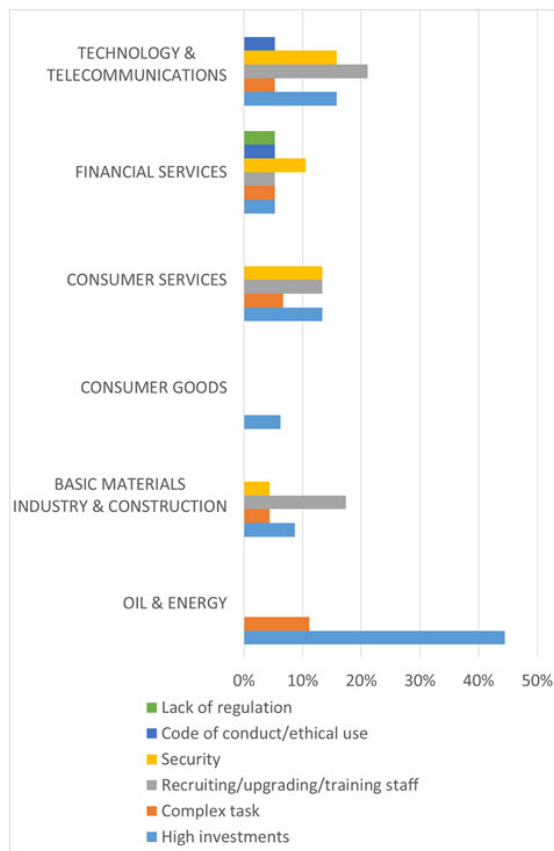


FIGURE 9. Main barriers by industry.

communication [63] as though it is seeking a social license to operate [64]. At the opposite end of the spectrum, none of the top managers in the financial services industry are even referring to sustainability associated with I4.0 or digitization, whereas the other industries hardly raise the issue of such motivation with some more presence in the technology and telecommunications industry than in the rest of the industries. This failure to link I4.0 and sustainability is particularly evident, for example, in the case of the consumer goods industry,

considering the utility of I4.0 and its intelligent production of goods to promote sustainability that is widely recognized in the literature [5], [7]–[9].

Regarding barriers by industry (Figure 9), the most relevant outcome apart from the slight general mention of them across industries, is the relative high number of references to high investments in the oil and energy industry, which is the only case where a barrier has such a significant weight, thus serving as a sign of its specific relevance within this industry.

V. CONCLUSION

This paper has appraised the importance of I4.0 and BD for the prospects of companies and society, the potential motivations and barriers in their implementation, and the support of senior management as one of the key aspects of success in this task, whereas a relevant gap in the literature has been noted in regard to directly addressing this issue. In this sense, the paper has assessed the involvement and reasoning of the top management through their discourse by examining the CEO letters included in the annual reports of 159 companies listed in the five main stock indices of the European Union. In the qualitative assessment, the authors categorized the degree of relevance given to the topic, as well as the motivations and barriers mentioned by top managers, and classified the results by industries and countries for a subsequent analysis. The outcome offers a series of relevant contributions that complement and offer additional hints to the existing research from a novel approach in this field.

First, barely half of the managers in the sample included I4.0 of BD within their main themes in their letters. Considering that the support of senior management is one of the key factors in such implementation [11], this extended lack of emphasis in the sample can be interpreted as a lack of awareness of the strategic leverage of the issue and the importance of its communication. Those top managers who are ignoring the new technologies that are at their fingertips and the related strategic leverage in their narrative, as a kind of spatial myopia [58], are wasting a precious opportunity to line up their companies in this transformation through their discourse [13], as well as to project a positive image of the company to stakeholders and society [59]; furthermore, as public figures [60], they are failing to serve as role models and benchmarks for peers and the entire business fabric. Thus, the identification of such widespread spatial myopia in the implementation of I4.0 and BD across senior management of top corporations represents one of the main contributions of this paper.

Second, in terms of motivations, the business focus as a combination of performance-related aspects and as an opportunity or tool to face future challenges is found in most cases to be the most recurrent motivation, followed by the customer focus. In addition, we find some relevant differences between industries, especially in the case of the oil and energy sector, where sustainability focus, but only its environmental side, has a high presence compared to the rest of the industries, which is probably related to the sector’s more controversial

nature in terms of environmental concerns. In the rest of industries, although sustainability is another critical factor identified by Sony and Naik [11] in the successful implementation of I4.0, senior management ignores this added benefit in their letters and fails, for example, to link the widely addressed greater efficiency in the use of resources and processes with enhanced environmental sustainability, even when this link is quite evident as reflected in the literature (i.e., [27], [29]). Furthermore, no social benefits are stated by any of the industries; in this case, it is probably because such benefits are not so evident [29] and thus not easy to present or defend.

Third, in relation to the barriers or difficulties in the implementation of I4.0 and BD, this research aimed to bring additional insights from the perspective of senior management. The findings show that these barriers are barely present in the discourse of the top managers in our sample, which may be interpreted as these issues not being within their main concern, probably because they do not actually see them as difficult obstacles to overcome, due to the resources and capabilities available to them. It would be worth for future research to compare these results with SMEs from the same countries and with companies from developing countries with fewer resources or less infrastructure and probably in earlier stages of implementation.

The six blocks of barriers collected from our assessment coincide with some of the previous barriers identified in the literature. Furthermore, as an added contribution, the underlined top management lack of awareness of the strategic leverage of promoting I4.0 and BD can indeed be considered the seventh barrier, as a ‘meta-barrier’ underlying this research, which is obviously not mentioned by top managers in their letters. Other barriers identified in previous works such as the challenge in value-chain integration, the low maturity level of the technology, further inequalities between developing and developed countries and the younger and older generations, the data quality or management, or resistance to change [33] are not addressed at all in our sample.

As an exception to the general weak mention of barriers, within the oil and energy sector, more than half of the CEOs addressing to I4.0 and digitization referred to the high amount of investments required, which was also the only barrier addressed. In fact, this is the only industry where a barrier displayed such a significant weight in the discourse of senior management, which gives one an idea about its relative relevance in this context.

As an overall practical contribution, this paper provides a first perspective on whether, to what degree, and under which motivations and barriers, the senior managers of the top companies in the main European stock indices are supporting I4.0 and BD in their discourse. All in all, this research identifies certain weaknesses such as the lack of relevance or attention given to the subject in many letters and the prominent insufficient amount of attention given to sustainability, along with the lack of full awareness of the set of potential benefits of all their dimensions and their interrelations, as motivators

or drivers to address this transformation. These factors should be further considered, addressed, and leveraged by senior management for a more effective implementation of I4.0 and BD and the benefit and prospects of businesses and society.

VI. MANAGERIAL IMPLICATIONS

From above findings and conclusions, three main managerial implications may be inferred.

First, top executives should acknowledge how some of their peers are taking advantage of their communication to convey their support for the implementation of I4.0 and BD and the benefits of such implementation. Senior management may establish sound strategic plans and allocate a good deal of resources, but at the same time they should not ignore this precious communication tool at their disposal to align and involve employees and external stakeholders.

Second, top executives should realize the importance of appraising and highlighting the benefits offered by the implementation of I4.0 and BD. In particular, they should further ponder the potential environmental and social benefits to better support and foster this implementation, even more considering the growing relevance of sustainability in our society.

Last, in relation to the general lack of mentioning of barriers by top managers, we argue that considering such barriers and reasoning how their companies identify, face, and overcome them would be a way for leaders to show their command and ability to handle this transformation.

Figure 10 graphically represents the scheme leading to such managerial implications:

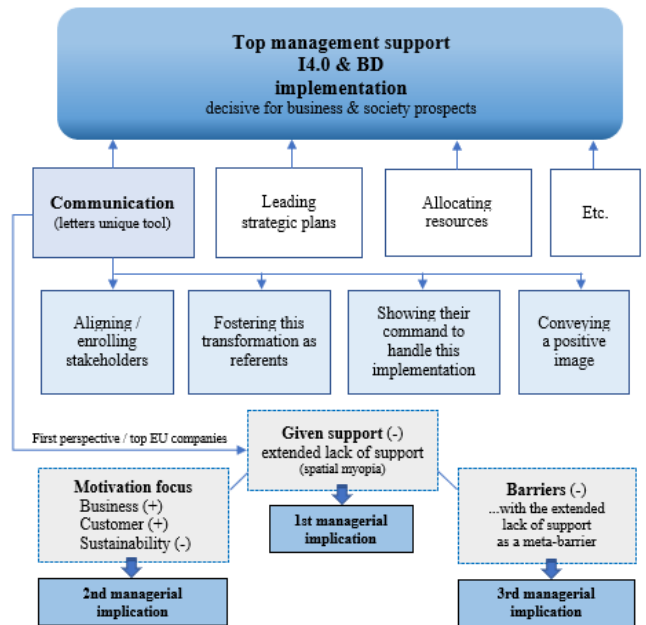


FIGURE 10. Scheme leading to managerial implications.

VII. LIMITATIONS AND FUTURE RESEARCH

One of the limitations of this research is the sole consideration of the top management’s letters in their communication. However, the literature highly appraises the

TABLE 2. List of companies

Industry	Country	Company
1.Oil & energy	GERMANY	E.ON
		RWE AG ST
		FRANCE
	VEOLIA	
	ENVIRONNEMENT	
	ITALY	A2A
		ENEL
		ENI
		HERA
		ITALGAS
		SAIPEM
		SNAM
		TERNA
	SPAIN	ENAGAS
		ENDESA
		IBERDROLA
		NATURGY
	THE NETHERLANDS	RED ELÉCTRICA
		REPSOL
		ROYAL DUTCH SHELL A
2.Basic materials, industry & construction	GERMANY	BASF
		CONTINENTAL
		COVESTRO
		HEIDELBERGCEMENT
		HENKEL VZO
	FRANCE	LINDE PLC
		AIR LIQUIDE
		AIRBUS
		ARCELORMITTAL (GLOBAL)
		BOUYGUES
	ITALY	LEGRAND PROM
		MICHELIN
		SAFRAN
		SAINT GOBAIN
		SCHNEIDER
	SPAIN	STMICROELECTR RG
		THALES
		VINCI
		BUZZI UNICEM
		INTERPUMP GROUP
THE NETHERLANDS	PIRELLI & C	
	TENARIS	
	ACCIONA	
	ACERINOX	
	ARCELORMITTAL	
GERMANY	ACS	
	CIE AUTOMOT.	
	FERROVIAL	
	SIEMENS GAMESA	
	AKZO NOBEL	
THE NETHERLANDS	ARCELORMITTAL	
	IMCD NV	
	KONINKLIJKE DSM	

TABLE 2. Continued. List of companies

3. Consumer goods	GERMANY	ADIDAS
		BAYER
		BEIERSDORF
		BMW
		DAIMLER
	FRANCE	MERCK
		VOLKSWAGEN VZO
		DANONE
		HERMES
		KERING
4. Consumer services	FRANCE	L'OREAL
		LVMH
		PERNOD RICARD
		RENAULT
		SANOFI
	ITALY	PSASTELLANTIS BR RG
		AMPLIFON
		CAMPARI
		CNH INDUSTRIAL
		DIASORIN
SPAIN	FERRARI	
	MONCLER	
	RECORDATI ORD	
	FCA	
	ALMIRALL	
THE NETHERLANDS	GRIFOLS	
	INDITEX	
	PHARMA MAR	
	VISCOFAN	
	HEINEKEN	
5. Financial services	GERMANY	SIGNIFY
		UNILEVER
		DEUTSCHE POST
		FRESENIUS SE
		MTU AERO
	FRANCE	CARREFOUR
		ESSILOR
		PUBLICIS
		ATLANTIA
		NEXI
THE NETHERLANDS	AENA	
	IAG	
	MELIA	
	AHOLD DELHAIZE	
	PHILIPS	
GERMANY	RANDSTAD	
	RELX	
	ALLIANZ	
	DEUTSCHE BANK	
	DEUTSCHE BOERSE	
FRANCE	MUNICH RE	
	AXA	
	BNP	
	CRÉDIT AGRICOLE	
	SOCIETE GENERALE	
		WORLDLINE

TABLE 2. Continued. List of companies

		AZIMUT HOLDING
		BANCA GENERALI
		BANCO BPM
		BPER BANCA
	ITALY	EXOR
		FINECOBANK
		GENERALI ASS
		INTESA SANPAOLO
		POSTE ITALIANE
		UNICREDIT
		B. SANTANDER
		B. SABADELL
	SPAIN	BANKIA
		BANKINTER
		BBVA
		CAIXABANK
		MAPFRE
		AEGON
	THE NETHERLANDS	ASR NEDERLAND
		ING GROEP
		NN GROUP NV
		DELIVERY HERO
	GERMANY	DEUTSCHE TELEKOM
		INFINEON
		SAP
		ATOS
		CAPGEMINI
	FRANCE	DASSAULT SYSTEMS
		ORANGE
		TELEPERFORMANCE
		VIVENDI UNIVERSAL
		INWIT
	ITALY	LEONARDO
		PRYSMIAN
		TELECOM ITALIA
6.Technology & telecommunications		AMADEUS
		CELLNEX
	SPAIN	INDRA
		TELEFONICA
		ADYEN
		ASM
		ASML HOLDING
	THE NETHERLANDS	BE SEMICONDUCTOR
		JUST EAT TAKEAWAY
		KONINKLIJKE KPN
		PROSUS
		WOLTERS KLUWER
	GERMANY	DEUTSCHE WOHNEN
		VONOBIA
7.Real estate services		I.COLONIAL
	SPAIN	MERLIN

relevance and usefulness of such communication; its use allows us to eliminate the bias of comparing other communication channels more unevenly used in time and formats, although further research may examine other sources such as

blogs, social media, press interviews, etc. to contrast these results.

A second limitation is the degree of subjectivity and bias of our qualitative assessment, which is lessened by the joint assessment by the authors. Nonetheless, since the aim was to identify trends, the methodology was found to be suitable for the purpose.

Moreover, although our sample is adequate for the main purpose of this research and to determine global trends of the top companies operating in the European Union, it is limited regarding the comparison of industries and countries, even when our results point to some clear differences such as the more extended support of top management in the Netherlands and in the consumer services industry, or the relevance of sustainability as a motivation or the high investments as a barrier within the oil and energy industry only. Therefore, to further validate our initial outcome and expand it at this level, future research may consider expanding the sample by industries for each country.

In addition, this work focuses on companies in the main European Union stock indices, but these companies operate globally and not only within the European Union, which provides us with the possibility of extrapolating our results at the global level. However, similar studies involving other countries and regions may enrich our findings. As noted in the conclusions section, it is of special interest to assess, using this novel approach, the differences in the narrative between the top managers of top corporations and those from SMEs or companies from developing countries in different contexts; such an approach is expected to highlight more difficulties [22].

Finally, a further topic of research is that of deepening in the interrelations between groups of motivations in the implementation of I4.0 and BD and its implications.

ANNEX.

See Table 2.

ACKNOWLEDGMENT

The author would like to thank the reviewers for sharing their valuable and constructive reflections and comments to help them improve this paper, as well as the journal for considering their work for publication and guiding them through the process.

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