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Review

Industry 4.0 and Marketing: Towards an Integrated Future Research Agenda

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Abstract: Industry 4.0, or the Fourth Industrial Revolution, is driven by innovative technologies that have profound effects on both production systems and business models. This revolution is characterized by the addition of disruptive technologies and methods. These aspects of Industry 4.0 have a significant impact on marketing, and have led to an evolution to ensure that marketing activities align with technological advancements and address consumers' current needs. The purpose of this paper is to formulate and discuss future research avenues for marketing considering the changes brought about by Industry 4.0. The approach taken in the paper is to review the relevant literature and focus on the key themes which are most important for future research on Industry 4.0 and marketing. Therefore, a Systematic Bibliometric Literature Review was conducted based on the SCOPUS indexing online database of scientific articles, the most important peer-reviewed journal database in the academic world. The paper finds that there are a number of research avenues for marketing researchers to conduct investigations in, but the most important areas are five marketing principles in Industry 4.0: cooperation, conversation, co-creation, cognitivity, and connectivity. Future research should focus on the quantitative study of these five principles.

Keywords: Industry 4.0; marketing; technologies; connectivity

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1. Introduction

In recent years, the world has been experiencing a new digital industrial revolution known as Industry 4.0, characterized by the complete digitalization of manufacturing processes. This revolution is a development from the other previous three major industrial revolutions, including Industries 1.0, 2.0, and 3.0. Industry 1.0 involved the discovery of steam machines and increased production activities, while Industry 2.0 was associated with the transition to mass production and electrical energy in the 20th century [1]. Industry 3.0 involved the transition from analog to digital production systems. Industry 4.0 is a further technological development allowing objects to interact and communicate over the internet. Some of the technologies driving the rise of Industry 4.0 include smart manufacturing technologies such as additive manufacturing and autonomous robots, cloud computing, augmented reality, Big Data, and the Internet of Things (IoT) [2]. Sterev [3] explained that Industry 4.0 combines innovations, human capital, and a new entrepreneurial mindset that forms a contemporary business culture. As a result, Industry 4.0 has led to greater flexibility of production processes and focus on customer needs and demands in order to overcome market complexity. Mehdiabadi et al. [4] add that technologies from Industry 4.0 created a more customized and personalized offer for each customer.

The primary goal of Industry 4.0 is to change economic rules with a primary focus on the manufacturing sector. Unlike the previous industrial revolutions, Industry 4.0 is more complex, as it aims to integrate machines, humans, and objects to create a more networked value chain [5]. Consequently, companies adopt three types of integration—vertical, horizontal, and end-to-end integration—to maximize customization and enhance

the efficiency of the production processes [2]. Major changes associated with Industry 4.0 are the increasing role of customers in the production process and the significance of social networking through internet technologies [6]. The emerging communication technologies have contributed to the spread of information, increasing consumer empowerment and controlling consumption decisions. Thus, Industry 4.0 is the integration and advancement of developments from the previous industrial revolutions.

Industry 4.0 promises a future based on smart customer management systems, open innovations, and additive manufacturing. Consequently, the final results of the new industrial revolution are innovative businesses based on new entrepreneurial approaches that leverage emerging technologies, changing business models, and operational excellence [7]. These aspects of Industry 4.0 have a significant impact on marketing, and have led to evolution to ensure that marketing activities align with technological advancements and address consumers' current needs [1]. For example, unlike in traditional marketing, in which consumers passively receive marketing information, contemporary internet-based communication allows them to share feedback and opinions on a product or a brand. Thus, marketers must account for such consumer information when developing and implementing marketing messages and campaigns. Ungerman and Dědková [8] explained that combining machine and artificial intelligence strengthens customer interaction by enhancing human-to-human interactions. Besides this, marketing under Industry 4.0 integrates offline and online consumer–company interactions to create strong relationships that improve business and social life. These findings indicate that there are several research avenues within the topic of Industry 4.0 and marketing, which is the basis for this research essay. Thus, there is an urgency to understand what significant changes Industry 4.0 can bring to the marketing field. We have developed a Systematic Bibliometric Literature Review to identify the research avenues that researchers should study in order to gain knowledge about how these disruptive technologies from Industry 4.0 can improve marketing functions to accommodate the rapid changes in markets and consumer needs.

2. Theoretical Framework

2.1. Definitions of Key Concepts

2.1.1. Industry 4.0

The German association "Industrie 4.0" coined the term 'Industry 4.0′ in 2011 to signal a shift in production from mass to personalized practices using emerging, advanced technologies. The association comprised scholars, policymakers, and executives, who identified a fourth industrial revolution based on the rapid digitization of organizational processes [9]. The main underlying idea of Industry 4.0 was that businesses in the current global markets are running using digital technologies that connect machinery, customers, supply chains, production facilities, and final products to obtain and share real-time operational and market data [10]. The German government was the first to adopt the "Industry 4.0" concept, which was integrated in the "High-Tech Strategy 2020 for Germany". Other countries such as the UK, USA, France, Italy, and the Netherlands launched Industry 4.0 initiatives to support digital technologies in the manufacturing sector. Over the years, these government initiatives have played a critical role in ensuring the rapid growth of Industry 4.0. For example, the French "Industrie du Futur", the American "Manufacturing USA", and the Dutch "Smart Industry" initiatives offered tax credits and fiscal benefits to companies that employed industrial approaches in line with Industry 4.0 goals [11]. These strategies boosted digitization and promoted the vertical and horizontal integration of organizational processes.

Scholars and practitioners have considered four major industrial revolutions throughout history. The first industrial revolution, Industry 1.0, occurred between 1760 and 1840, and focused on the steam machine, while Industry 2.0 occurred in the 19th century and involved utilizing electricity in industrial processes [11]. The third industrial revolution, Industry 3.0, started in the 1960s, and involved using Information Communication Technologies (ICT) and industrial automation [10]. This developmental period was followed by

the ongoing Industry 4.0, which involves building smart factories by integrating digital technologies with physical objects. The primary element characterizing this industrial phase includes the progressive changes in manufacturing systems connectivity facilitated by the combination of the IoT, ICT, and machines in cyber-physical systems (CPS) [12]. Consequently, Industry 4.0 can be defined as the diffusion and adoption of technologies leading to the digitization of companies.

Industry 4.0 is a collective term for concepts and technologies associated with the changes in the manufacturing sector. It indicates the shift from the mass to the personalized production of goods and services based on online and offline data [13]. Chen [14] suggests that Industry 4.0 includes intelligent digital networking; rule-based, autonomous decision-making; and performance management in companies across the various value-creation stages. Buestán et al. [15] further emphasize that Industry 4.0 integrates social, economic, and technological innovations to exploit data gathered online and offline, thus maximizing value creation. Digital networking connects objects, humans, and machines to create a networked value chain that facilitates efficient information flow [16]. Besides this, the revolution combines optimized industrial manufacturing features and internet technologies, resulting in greater flexibility throughout the production process [11]. It also provides methods of satisfying the individual needs of every customer and other stakeholders. Therefore, Industry 4.0 has created new and improved opportunities for businesses to increase their competitiveness and align their product and system developments with the current, emerging changes.

Multiple technologies are needed in order to achieve the goals and optimize the opportunities provided by Industry 4.0. These technologies offer solutions to diverse problems such as costs and time in production, and should ensure interoperability between IT systems [11]. These technologies include Big Data analytics, cloud computing, augmented reality, cyber security, and additive manufacturing. Ungerman and Dědková [8] identified other Industry 4.0 innovations, including the Internet of Things (IoT), information communication technologies (ICT), cyber-physical systems (CPS), enterprise integration (EI), enterprise architecture (EA), and the use of cybernetic systems. These innovations play different but connected roles in Industry 4.0, and provide varying opportunities to enhance business practices in the current development phase. For example, innovations such as mobile devices and sensors are associated with industrial IoT solutions, while Big Data analytics facilitates customer profiling [17]. In addition, cyber security solutions are needed in order to enhance the safety of the information shared throughout the networked value chain. Despite the differences, these innovations are interconnected and mutually influencing, thereby improving performance and efficiency.

2.1.2. Marketing

Marketing is an organizational function that involves creating, communicating, and delivering value to consumers. In addition, marketing is used to manage customer relationships to benefit the company and all of its stakeholders. Kotler and Keller [18] define marketing as the process of identifying and satisfying consumer human and social needs while maintaining the company's profitability. Marketers create, communicate, deliver, and exchange offerings that provide customers, partners, and society with value based on their specific needs [19]. From these explanations, marketing management can be defined as "the art and science of choosing target markets and getting, keeping, and growing customers through creating, delivering, and communicating superior customer value" [18] (p. 26). However, the rapid technological advancements have continuously increased the complexity of customers' tastes and preferences. As a result, marketing and marketing management functions are frequently adjusted to accommodate these changes, as they are necessary for value proposition and delivery. Therefore, marketing involves flexible processes and activities that are frequently modified to accommodate technological changes and market performances.

Marketing is a dynamic and changing business activity. It is influenced by multiple issues, including technological changes, economic recessions, conflicts and war, inflation, and energy shortages. The digitization of business practices and the global adoption of the internet has been a major driving force in the marketing industry. For instance, Bala and Verma [20] indicated that the internet has significantly contributed to the transition towards market-driven marketing approaches that involve formalized techniques of acquiring accurate and timely information regarding customers, the market, products, and the general business environment. The internet allows marketers to utilize electronic commerce (e-commerce) to sell and market products and services online [21]. The history of internet-based marketing dates back to 1990, when people began using websites to provide customers with product information. Companies such as YouTube, Google, Yahoo, Alibaba, and Amazon have revolutionized digital marketing by allowing trading and increasing access to product information, advertising space, stock trading, and software programs.

In Industry 4.0, marketing experts and companies use various digital technologies to achieve marketing objectives. Bala and Verma [20] defined digital marketing as the application of digital technologies in marketing activities to align them with consumer needs. Industry 4.0-enabling technologies such as Big Data analytics allow the collection and analysis of consumer and market information for improved decision-making and marketing planning. For companies to succeed in the current business environment, they have to integrate digital and traditional marketing strategies in order to ensure that customers' needs are precisely addressed [22]. These companies manage to build their brands and drive traffic that boosts their success through online advertising. Thus, digital marketing provides a more effective way to reach a wider audience and expand the customer base by engaging existing and potential customers.

3. Materials and Methods

A Systematic Bibliometric Literature Review methodology (LRSB) was conducted in order to provide a comprehensive overview and discussion of the extant academic contributions to the fields of Industry 4.0 and marketing, and to establish a structure for further research. In this sense, this methodology contributes to the summary, synthesis and analysis of existing research to develop new theories, test specific hypotheses, identify research gaps, or explore a specific research topic [23–25]. Thomé et al. [26] defined it as the "methodology that locates existing studies, selects and evaluates contributions, analyses and synthesizes data, and reports the evidence in such a way that allows reasonably clear conclusions to be reached about what is and is not known" (p. 408). Based on these definitions, the methodology will help collect, analyze, and synthesize existing literature on Industry 4.0 and marketing in order to understand what is known and unknown about their correlation. The methodological approach was selected considering the indications of Kraus et al. [27], who claimed to use a more transparent approach in the collection and synthesis of data that increases the replicability and objectivity of the study. In addition, the LRSB involves a rigorous and well-defined research process that the quality of the synthesized results.

Therefore, the LRSB involves the screening and selection of information sources to ensure the validity and accuracy of the data presented, in a process consisting of 3 phases and 6 steps [24,25,28–30] (Table 1).

The methodology's approach began with a literature search on the SCOPUS indexing online database of scientific articles, the most important peer-reviewed journal database in the academic world. The use of Scopus alone is due to the fact that it is the main article base for academic journals/magazines, covering around 19,500 titles from more than 5000 international publishers, including coverage of 16,500 peer-reviewed journals in the fields scientific, technical, and medical and social sciences. It therefore provides a very real view of the researched subjects with scientific and/or academic relevance. However, we assume that the study has the limitation of considering only the SCOPUS database, excluding the other academic databases.

Table 1. Process of systematic LRSB.

Fase	Step	Description
Exploration	Step 1	formulating the research problem
	Step 2	searching for appropriate literature
	Step 3	critical appraisal of the selected studies
	Step 4	data synthesis from individual sources
Interpretation	Step 5	reporting findings and recommendations
Communication	Step 6	Presentation of the LRSB report

The keyword "Industry 4.0" was used to identify potential sources; during the initial search, 19,888 documents were identified, with the keyword "marketing" being identified in 183 documents. Other inclusion criteria for the thematic area were Business, Management, and Accounting being included in documents for up to February 2022. This step reduced the number of documents summarized in the final report from 61 (Table 2).

Table 2. Screening Methodology.

Database Scopus	Screening	Publications
Meta-search	keyword: Industry 4.0	19,888
Inclusion Criteria	keyword: Industry 4.0, Marketing	183
	keyword: Industry 4.0, Marketing Subject area: Business, Management, and Accounting	61
Screening	Published until February 2022	

Source: Our own elaboration of the 61 scientific and/or academic documents: 38 are articles; 12 are conference papers; 7 are book chapters; 2 are reviews; 1 is a book; and 1 is a conference review.

4. Literature Analysis: Themes and Trends

Peer-reviewed documents on the topic for up to February 2022 were analyzed. The year 2020 was the year with the highest number of peer-reviewed documents on the subject of Industry 4.0 and Marketing, with 22 publications. Figure 1 analyzes peer-reviewed publications published through to February 2022.

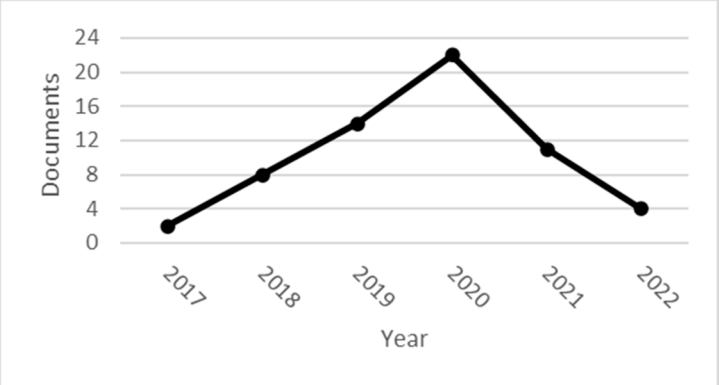

Figure 1. Documents by year. Source: Our own elaboration.

The publications were sorted as follows: Accounting, Finance, Sustainability, Governance and Fraud (3); Journal of Intellectual Capital (3); Proceedings of the International Conference on Industrial Engineering and Operations Management (3); Journal of Business and Industrial Marketing (2); Technological Forecasting and Social Change (2); and one remaining publication.

We can say that between 2017 and 2022, there has been an interest in research on Industry 4.0 and Marketing (Figure 1).

In Table 3, we analyze the Scimago Journal and Country Rank (SJR), the best quartile, and the H index by publication. Take for example The Administrative Sciences, with 15,100 (SJR), Q1 and H index 181.

Table 3. Scimago journal and country rank impact factor.

Title	SJR	Best Quartile	H Index
Administrative Sciences	15.100	Q1	181
International Journal Of Production Economics	2.410	Q1	185
Technological Forecasting And Social Change	2.230	Q1	117
Journal Of Business Research	2.050	Q1	195
International Journal Of Production Research	1.910	Q1	142
Journal Of Knowledge Management	1.840	Q1	113
Journal Of Manufacturing Technology Management	1.290	Q1	70
Journal Of Intellectual Capital	1.260	Q1	89
International Marketing Review	1.200	Q1	89
Journal Of Self Governance And Management Economics	0.850	Q1	10
Marketing Intelligence And Planning	0.750	Q2	70
Journal Of Business And Industrial Marketing	0.740	Q1	67
Journal Of Enterprise Information Management	0.740	Q1	61
International Journal Of Retail And Distribution Management	0.730	Q1	78
Operations Research Perspectives	0.700	Q1	16
Business Process Management Journal	0.670	Q1	81
Management Review Quarterly	0.650	Q1	17
International Journal Of Innovation Studies	0.560	Q2	8
Production Engineering Archives	0.540	Q2	33
TQM Journal	0.540	Q2	67
International Journal Of Construction Management	0.510	Q2	25
Journal Of Business Economics And Management	0.490	Q2	37
International Journal Of Technology	0.430	Q2	15
International Journal Of Event And Festival Management	0.420	Q2	26
Organizacija	0.400	Q2	8
Engineering Management In Production And Services	0.350	Q2	11
Polish Journal Of Management Studies	0.320	Q3	21
International Journal Of Enterprise Information Systems	0.280	Q3	21
Academy Of Entrepreneurship Journal	0.210	Q3	12
Applied Marketing Analytics	0.210	Q3	2
Quality Access To Success	0.210	Q3	21
Rivista Di Studi Sulla Sostenibilita	0.160	Q3	12
Logistics Journal	0.120	Q4	5
Proceedings 14th IEEE International Conference On E Business Engineering Icebe 2017 Including 13th Workshop On Service Oriented Applications Integration And Collaboration Soaic 207	0.200	*	6
Proceedings Of The International Conference On Industrial Engineering And Operations Management	0.130	*	9
Proceedings Of The 31st International Business Information Management Association Conference Ibima 2018 Innovation Management And Education Excellence Through Vision 2020	0.120	*	12
Proceedings Of The 33rd International Business Information Management Association Conference Ibima 2019 Education Excellence And Innovation Management Through Vision 2020	0.120	*	6

Table 3. *Cont.*

Title	SJR	Best Quartile	H Index
Proceedings Of The 14th European Conference On Management Leadership And Governance Ecmlg 2018	0.110	*	2
European Research Studies Journal	0	*	34
International Journal Of Recent Technology And Engineering	0	*	20
International Journal Of Supply Chain Management	0	*	17
Contributions To Management Science	0	*	14
Progress In International Business Research	0	*	9
Advances In Transdisciplinary Engineering	0	*	5
Accounting Finance Sustainability Governance And Fraud	0	*	*
2018 IEEE International Conference On Technology Management Operations And Decisions Ictmod 2018	0	*	*
Global Challenges Of Digital Transformation Of Markets	0	*	*
Icitm 2020 2020 9th International Conference On Industrial Technology And Management	0	*	*
Innovation Technology And Market Ecosystems Managing Industrial Growth In Emerging Markets	0	*	*
Innovations And Challenges In Human Resource Management For Hr4 0	0	*	*
Proceedings 2021 21st Acis International Semi Virtual Winter Conference On Software Engineering Artificial Intelligence Networking And Parallel Distributed Computing Snpd Winter 2021	0	*	*
Proceedings Of 2021 International Conference On Information Management And Technology Icimtech 2021	0	*	*
Proceedings Of International Conference On Computation Automation And Knowledge Management Iccakm 2020	0	*	*

Note: * data not available. Source: Our own elaboration.

There are totals of 53 publications on Q1, 16 publications on Q2, 10 publications on Q3, and six publications on Q4. Publications from the best quartile Q1 represent 30% of the 53 publications titles; the best quartile of Q2 represents 19%, the best quartile of Q3 represents 11%, the best quartile of Q4 represents 2%, and data from 20 publications are not available.

As is evident from Table 3, the significant majority of articles on Industry 4.0 and marketing rank on the Q1 best quartile index.

The thematic areas covered by the 61 scientific and/or academic documents were: Business, Management and Accounting (61); Decision Sciences (21); Engineering (15); Economics, Econometrics and Finance (11); Computer Science (10); Social Sciences (six); Mathematics (three); Psychology (two); and one each for the remaining keywords (Arts and Humanities, Energy, Environmental Sciences, Medicine, and Physics and Astronomy).

The most quoted article was "Towards Industry 4.0: Mapping digital technologies for supply chain management-marketing integration" from Ardito et al. with 150 quotes, published in the Business Strategy and the Environment, with 0.670 (SJR), the best quartile (Q1) and with H index (81). The study's innovative efforts were undertaken over time to develop the digital technologies for the management of the interface between supply chain management and marketing.

In Figure 2, we can analyze the evolution of citations of documents for up to February 2022. The number of citations shows positive net growth with an R2 of 36% for the period 2017–February 2022, with 2021 having a peak of 283 citations.

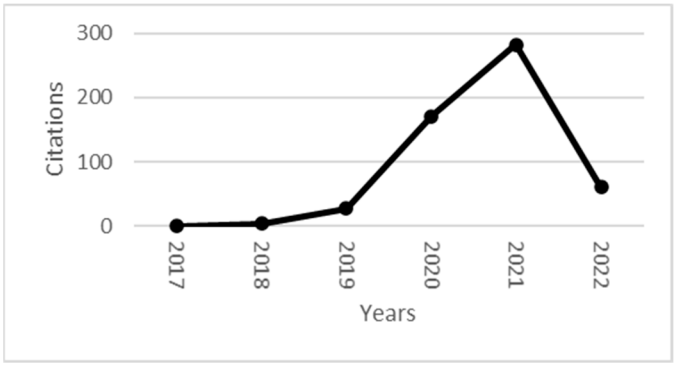

Figure 2. Evolution of citations between 2017 and February 2022. Source: Our own elaboration.

The h-index was used to ascertain the productivity and impact of the published work, based on the largest number of articles included that had at least the same number of citations. Of the documents considered for the h-index, nine had been cited at least nine times.

In Appendix A, Table A1, the citations of all scientific and/or academic documents up to February 2022 are analyzed; 21 documents were not cited in this period, giving a total of 545 citations. Appendix B, Table A2, analyzes the self-citation of documents for up to February 2022. Of the 61 articles, we found a total of 18 self-citations. The article "Human capital and AI in Industry 4.0. convergence and divergence in social entrepreneurship in Russia" was self-quoted 12 times.

In Figure 3, the bibliometric study is presented in order to investigate and identify indicators on the dynamics and evolution of scientific information. The study of the bibliometric results, using the scientific software VOS viewer, aims to identify the main search keywords in studies that integrate Industry 4.0 and the marketing research area.

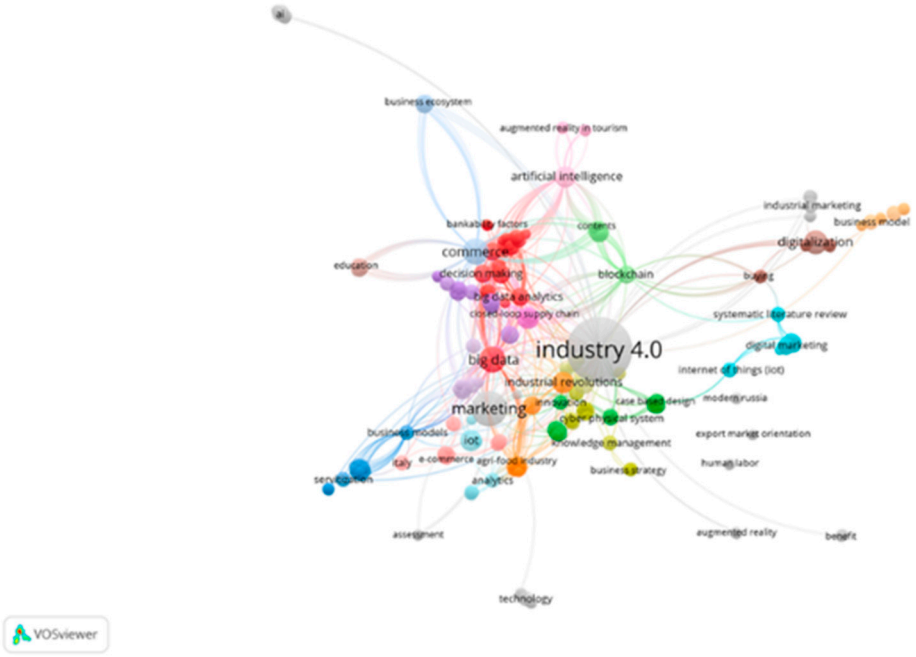

Figure 3. Network of all keywords.

The research was based on the articles analyzed on Industry 4.0 and Marketing. The associated keywords are shown in Figure 4, making clear the network of keywords that appear together/linked in each scientific article, allowing us to know the themes studied by the researchers and identify future research trends. In Figure 5, a profusion of bibliographic couplings with a cited reference analysis unit is presented.

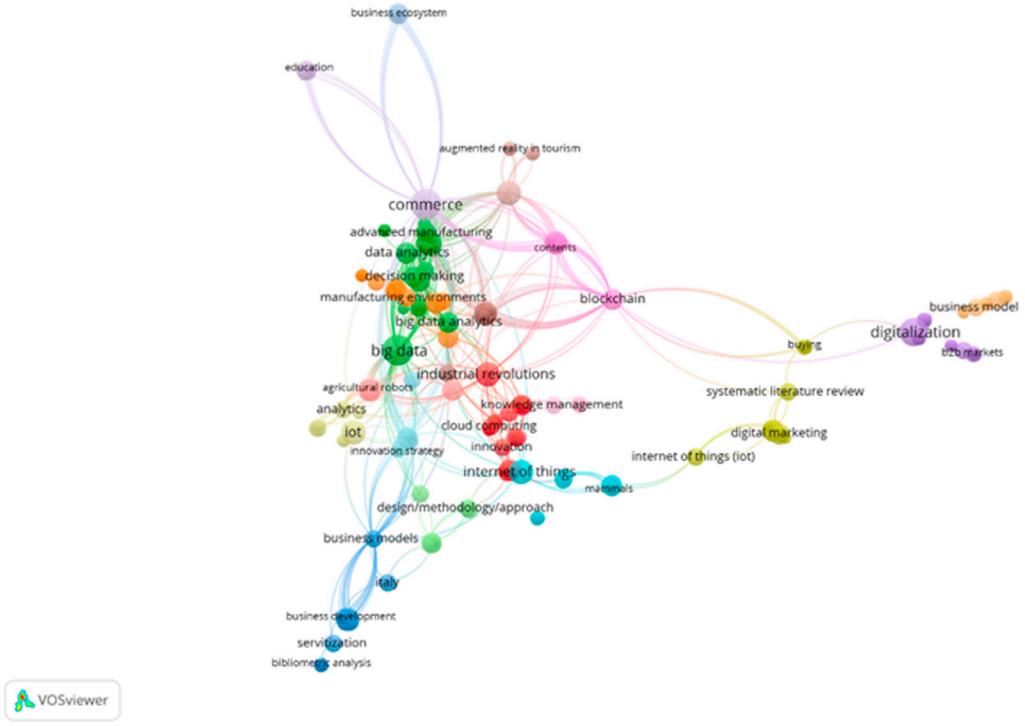

Figure 4. Network of linked keywords.

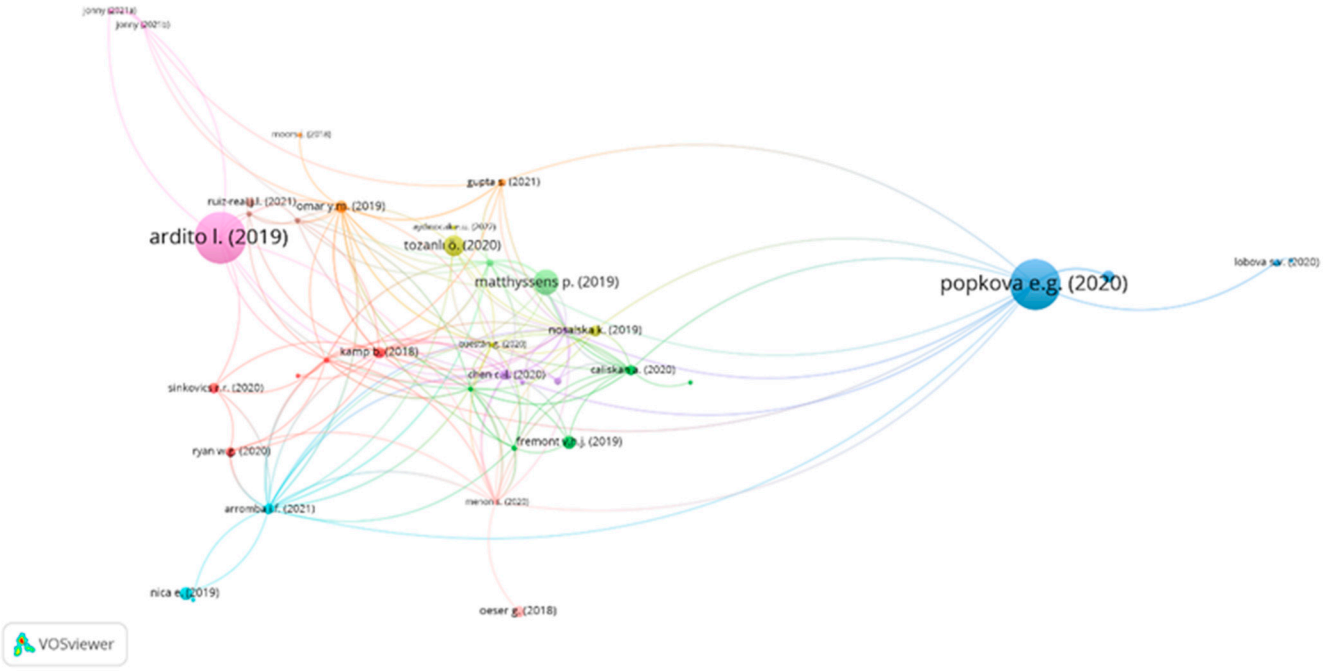

Figure 5. Networks bibliographic coupling.

These figures show the keywords which are most addressed in the articles indexed in SCOPUS, and therefore reflect the main themes related to the impact of Industry 4.0 on marketing practices.

5. Theoretical Perspectives

In the current times of globalization, companies face challenges associated with rapid changes in markets and consumer needs. As a result, companies understand the need to develop new technologies and products to attract and maintain customers, and to achieve competitiveness and higher performance [31]. Therefore, Industry 4.0 innovations are vital developments that provide solutions for the challenges in the current globalized markets [32]. One central innovation driven by Industry 4.0's development that will be explored in this research is innovative marketing that involves creating new products and services to address consumers' new needs [14]. The emerging technologies under Industry 4.0, such as Big Data, have increased marketers' ability to gather and analyze market information for improved decision-making and marketing plans [10]. Thus, the existing research highlights a significant relationship between Industry 4.0 and marketing. The primary aim of this section is to illustrate how the industrial revolution, Industry 4.0, has contributed to innovative marketing in the current business environment.

5.1. Core Enabling Technologies of Industry 4.0 in Marketing

Emerging technologies provide companies with opportunities to transform their practices and match them with customer demands and expectations. Thus, with new technologies under Industry 4.0, companies can achieve the sustainable competitive advantage needed for better positioning in the market and performance [33]. For example, Industry 4.0 materializes through a network of digital factories based on cyber-physical systems. The cyber-physical systems can make autonomous decisions, as the systems communicate and work with each other, humans, and other smart factories to exchange data [34]. The smart products created can also react to real-time changes occurring in their surroundings. Such advanced technologies can be used to develop and implement marketing approaches and campaigns that address customers' real-time issues [35]. Marketing is concerned with technologies that focus on information processing, such as Industrial IoT, cloud computing, Big Data analytics, customer profiling, and Artificial Intelligence (AI).

5.1.1. Internet of Things (IoT)

In contemporary society, disruptive technologies are emerging rapidly, and people are becoming instantly connected. As a result, the Internet of Things (IoT) has become more common as companies adopt these technologies to improve customer experiences and build better relationships. Aydınocak [36] defined the IoT as a global system of IP-connected devices, systems, and services that use an existing internet infrastructure to facilitate autonomous communication. These interconnected technologies will enable business leaders and managers to infuse intelligence into their systems and processes in order to explore new opportunities to improve customer satisfaction [37]. The IoT in marketing is used as an innovative communication strategy in which digital communication objects and appropriate protocols are interconnected in order to facilitate information flow [38]. Besides this, IoT technologies are used to collect enormous amounts of data from users due to their integration in a wide range of devices, including smartphones, monitoring sensors, surveillance cameras, and home appliances [39]. Marketers can use this as an opportunity to gather strategic information from target customers.

Additionally, the IoT can be used to enhance marketers' understanding and prediction of consumer behaviors. Using IoT technologies, physical devices are connected and data is exchanged over the internet, allowing companies access to communications and critical data [40]. This interconnection creates an opportunity for marketers to expand their communications, and improves companies' capability to effectively and efficiently respond to customers' feedback, questions, or complaints. As a result, the IoT enables companies to be

more proactive in issues related to customer service, thereby boosting satisfaction and building beneficial relationships. The IoT can aid relationship marketing. The IoT will, therefore, allow unprecedented access to customers, through which marketers can understand and predict consumer behaviours, and, consequently, improve customer experiences.

5.1.2. Cloud Computing

Cloud computing is an emerging technology based on a wide-bandwidth internet connection with low latency. Before its emergence, companies were required to invest in software, hardware, networking, and storage in order to be compatible with digital technologies [41]. However, cloud computing currently eliminates these costs without compromising organizational profitability by providing computing resources such as data storage and configuration [42]. Cloud computing services are accessible from anywhere at low costs with existing computing hardware in order to provide data storage, analytics, architecture, and design [13]. Consequently, cloud computing contributes to the development of the critical digital infrastructure needed for effective marketing. For instance, digital marketers have remote access to data in various file formats. On the contrary, the previous storage technique of owning servers meant that the terminals were physically hooked to the servers, and were thus accessible locally [43]. Therefore, managing and maintaining efficient workflow in marketing led to the loss of time and resources.

Cloud computing eliminates these issues and allows digital marketers to access critical data anytime and from anywhere. In addition, cloud computing allows digital marketers to create a safe and secure environment in which customers can provide real-time feedback on products, services, or the entire brand [44]. This information can be integrated into marketing campaigns, messages, and approaches to ensure that the company's marketing initiatives match customer needs and demands in order to increase satisfaction and build relationships [45]. While this access to customer feedback is a critical opportunity for business growth, marketers' inability to interpret the vast amount of data gathered through disruptive technologies can be a significant hindrance [46]. Thus, access to cloud-based analytical tools provides potential solutions to such problems, increasing digital marketers' capabilities to optimize Industry 4.0 tools and technologies. Furthermore, marketing data can now be accessed quickly and easily by organizations of all sizes, allowing them to operate more effectively and increasing their productivity.

5.1.3. Big Data Analytics and Customer Profiling

Big Data marketing is related to database marketing, which involves collecting, aggregating, and commercializing personal data and information. The increased popularity of social networking platforms such as Facebook, Twitter, and Instagram, and e-commerce platforms such as Amazon and Alibaba, have increased avenues of data collection for targeted advertisements [47]. Data companies—known as data brokers—collect, analyze, combine, and sell users' information, including personal data associated with online and offline behaviors [48]. This dramatic shift in the significance of data has led to the global popularity of the Big Data concept. Fan et al. [49] defined Big Data as "the amount of data just beyond technology's capability to store, manage and process efficiently" (p. 28). The data comes in large amounts because it is gathered from multiple interconnected devices and systems, making it hard to analyze and implement. Thus, Big Data analytics refers to the use of analytical tools to identify hidden patterns in these data and generate meaningful interpretations. This notion is supported in Erevelles et al.'s [50] definition of consumer Big Data analytics: "the extraction of hidden insight about consumer behavior from Big Data and the exploitation of that insight through advantageous interpretation" (p. 897). Big Data analytics enable marketers to know how their customers view and interact with the brand in marketing. Big Data analytics provides the business intelligence needed to transform marketing approaches by bringing about positive changes to improve product or service quality.

Marketing in Industry 4.0 is data-driven. Thus, it leverages Big Data to increase brand awareness and boost customer acquisition. Big Data analytics provides marketers with a 360-degree view of customer behaviors and patterns, enabling them to design and implement customer-specific content to enhance online and in-store brand recognition and recall [47]. Besides this, Big Data allows marketers to leverage the cloud to gather and analyze consistent and personalized data from multiple sources, including mobile applications, emails, and the web [51]. Big Data can help marketers leverage real-time marketing data to optimize performance and reduce costs [52]. Therefore, Big Data analytics provides marketers with opportunities to understand target customers and markets in order to implement strategies that match current needs and demands.

5.1.4. Artificial Intelligence (AI)

Artificial intelligence (AI) in marketing is rapidly gaining popularity due to increasing computing power, access to Big Data, reduced costs of computing, and the availability of advanced machine learning models and algorithms. Whilst traditionally AI has been defined as machines that learn to act like humans, current definitions have expanded to 'computational agents' that use robust data to act intelligently [53]. AI combines robust datasets and computer science to facilitate problem-solving, while at the same time utilizing machine learning and deep learning algorithms to create expert systems that predict or classify information based on input data. Vlačić et al. [54] define marketing AI as creating artificial agents that use data about customers, focal companies, and competitors to take or suggest marketing actions in order to attain the best results. AI marketing involves leveraging intelligence technologies to gather and analyze customer data to gain critical insights, anticipate their behaviors and activities, and make automated decisions about marketing initiatives and progress.

AI marketing has multiple benefits and opportunities that can be optimized in order to enhance marketing performance. For instance, AI technologies facilitate real-time personalization and build better customer relationships [53]. Marketers can use the customer data and insights gathered through AI technologies to create custom-tailored messages or services [55]. For example, making push notifications can increase marketing initiatives' success, as each customer receives customized messages based on their search or online activities [56]. Hence, AI can improve the customer journey. In addition, AI can be used to automate marketing activities and reduce errors. Marketing automation enables marketers to translate data into meaningful information and decisions in order to enhance interactions that result in positive business outcomes [54]. This automation reduces human intervention, minimizing human errors. Therefore, marketers should learn more about the application of AI in marketing in order to optimize the opportunities and benefits it creates.

5.2. Design Principles of Industry 4.0 in the Context of Marketing

Disruptive technologies have become standard for individuals and businesses. While these technologies have supported the digitization process, the ineffective implementation of new technologies can limit the organizational capability to deliver the Industry 4.0 vision [57]. Thus, the successful integration of new technologies requires the development of well-designed systems that consider how the latest innovations will optimize departments within an organization [58]. Researchers identified design principles of Industry 4.0 that can be used to realize the benefits and integration of the technologies in the systems. The design principles related to marketing identified by Nosalska and Mazurek [7] include interconnection, information transparency, and the decentralization of decisions.

5.2.1. Interconnection

The interconnection of the digital technologies within the digital ecosystem is the essence of Industry 4.0. People, products, devices, and machines are interconnected to create a network of shared goals supported by the free flow of information and cooperation. Nosalska and Mazurek [7] identified the interconnection within Industry 4.0 as

the "Internet of Everything" (IoE), which is characterized by three types of collaboration; human–machine, machine–machine, and human–human. The primary goal of Industry 4.0 is to digitize and integrate production–business relationships in order to ensure that the entire production chain has access to the necessary data [59]. This is because Industry 4.0 is based on the underlying understanding that different departments across the production chain are mutually influencing and interconnected [60]. However, designers should maintain the ecosystem's interoperability in order to ensure that the computer systems or software can exchange data effectively. Interoperability is a primary Industry 4.0 principle which ensures that cyber-physical systems, people, and all smart factory elements can communicate via the Internet of Things and Services [61]. This interconnection and communication increase the organizational capability to adjust to market changes and meet the individual needs of existing and potential customers. Besides this, the modular nature of these interconnected systems increases the organizational capacity to create a product configuration tool that enhances the ability to customize products and services.

5.2.2. Information Transparency

Information transparency is essential in an interconnected digital ecosystem. Transparency is an integral characteristic of effective data exchange between key players in business practice, including marketing, and is a critical feature in the integration of production and supply chains. For example, in AI marketing, digital technologies are expected to make intelligent decisions or take actions based on the data input [62]. In this case, limited information can lead to misleading decisions or solutions that further undermine organizational performance. Nosalska and Mazurek [7] explained that reasonable conclusions and decisions require data from the sensors to be connected with other contextual data regarding the products, production processes, and device conditions. This data should then be interpreted and analyzed accordingly, in order to ensure accuracy and applicability [61]. Consequently, organizations optimizing Industry 4.0 technologies should have a high-speed, reliable, and safe communication infrastructure, such that all of the necessary information about products and systems is transferred among machines and devices throughout the production process [63]. Information transparency throughout the digital ecosystem ensures that all stakeholders can actively participate in critical activities and decision-making based on their access to real-time information.

5.2.3. Decentralization of Decisions

The principles of information transparency and the interconnection of people and objects influence the decentralization of decisions. For instance, when systems are interconnected and all participants have access to critical information, it becomes easier for the company to use local and international data to facilitate effective decision-making [64]. Decentralization, as a fundamental principle of Industry 4.0, involves autonomous decision-making and control, which is aligned with individual subsystems [65]. One major disruptive technology supporting this design principle is cloud computing, as storing and transferring data in the cloud redistributes functions from the central location. In the case of digital marketing, marketers can use these technologies to access general marketing data on the ecosystem without necessarily accessing the main computer [66]. Such a design approach increases the system's flexibility and enables unlimited scalability, leading to more-positive outcomes. According to Nosalska and Mazurek [7], trust is a significant issue hindering progress in Industry 4.0. In the marketing context, the decentralization of decisions builds mutually trusting relationships between marketers and their senior leaders, as they have the autonomy to use critical insights from digital technologies to make real-time, appropriate decisions based on specific current needs and conditions [67]. Besides this, trust and decentralized decisions influence a company's capability to design smart products with the ability to make autonomous decisions and respond to real-time stimuli in the environment. Thus, companies in Industry 4.0 should adjust their orga-

nizational structure to accommodate the increased flexibility and autonomy needed in designing Industry 4.0 systems.

5.3. Principles for Marketing in Industry 4.0

Other than the design principles of Industry 4.0, marketing throughout the new industrial revolution has been associated with redefined marketing principles based on connectivity, communication, and cooperation within the digital ecosystem. Unlike traditional marketing, in which marketers and organizations are in control, Industry 4.0 requires that all stakeholders—including customers, business partners, and suppliers—be treated the same way within the digital ecosystem [68]. Thus, Nosalska and Mazurek [7] identified five marketing principles in Industry 4.0: cooperation, conversation, co-creation, cognitivity, and connectivity.

These five principles create an innovative approach to the marketing mix under the new conditions of Industry 4.0. Due to the interconnectivity and data exchange, the product creation process is based on co-creation, while mutual communication characterizes the promotion processes. Similarly, the cooperation among all stakeholders within the ecosystem facilitates distribution, while the data gathered from cognitive processes analyzing real-time customer behaviors are used to determine product prices [7]. These four marketing principles in Industry 4.0 become practical when the principle of connectivity is employed, as it involves connecting digital technologies over the internet. These marketing principles reflect the mutual influence and interconnection of components within the Industry 4.0 ecosystem.

5.3.1. Cooperation

In recent years, companies no longer see their market share only in terms of competition with other brands but also take the opportunity to work with them and take advantage of their best skills. Integration into a larger ecosystem helps companies maintain strong ties of cooperation with other market participants.

5.3.2. Conversation

Maintaining a dialogue with its customers has been one of the fundamental strategies for companies to focus on solving their needs and desires. The application of smart algorithm solutions and modern Big Data technologies leads to the development of new communication tools such as chatbots, virtual assistants, and even marketing automation solutions that encourage the customer to dialogue with a company through the provision of useful content that matches their unique current needs.

5.3.3. Co-Creation

Now, we can refer to the client as a co-designer, co-marketing, co-brander and co-producer. Products are co-created by customers through their active involvement in the value creation process, for example by selecting the custom parameters of a product through an online configuration tool, or through the impact of customer voices and opinions shared on social media on brands and products.

5.3.4. Cognitivity

The Internet and the use of new technologies allow companies to dynamically adjust their prices to current demand and customer profiles, in real time. Uber uses this strategy heavily by applying a variety of rates, which vary depending on the time of day and the volume of orders at a given time and in a given location. Airline companies, for example, take advantage of the possibility of tracing the profile of customers based on the analysis of the history of their activity on the Internet to adapt their fares to the profiles of their customers. Given the sheer volume of data companies have access to, more opportunities will arise in the future to use variables found in price selection algorithms.

5.3.5. Connectivity

These four principles would not have become practicable if it weren't for the Internet. All digital technologies reach their real value when this connectivity is employed.

6. Conclusions

The objectives of this paper were to provide a comprehensive overview and discussion of extant academic contributions to the field of marketing considering the changes brought by Industry 4.0, and to establish a structure for further research in the field. In order to do so, academic literature on marketing and Industry 4.0 was reviewed. Based on the identified current state of the literature and the developed tentative theoretical framework, an integrated future research agenda was proposed.

The fourth industrial revolution, Industry 4.0, is characterized by the increased digitalization of manufacturing processes. It involves various disruptive technologies, such as additive manufacturing and autonomous robots, cloud computing, augmented reality, Big Data, and the Internet of Things (IoT), that have caused enormous changes in the business environment. For example, Industry 4.0 technologies connect people, machines, and objects to create an interconnected value chain. One major development resulting from this integration is the changing role of the customer in the production and marketing processes. Unlike traditional marketing, when customers were passive recipients of marketing information, Industry 4.0 marketing approaches require their treatment as active stakeholders within the digital ecosystem. New communication infrastructures such as Big Data analytics allow marketers to gather, analyze, and interpret consumer feedback, opinions, and viewpoints regarding the brand or its associated processes. Therefore, the new business models in this industrial revolution are customer-centered and involve meeting their needs; the offerings are—now more than ever—customized and personalized to each customer.

Although all of the Industry 4.0 technologies have made significant contributions to the global industrial transformation, only the information processing innovations directly influence marketing. Examples of these technologies include the IoT, cloud computing, Big Data analytics, customer profiling, and Artificial Intelligence (AI). These technologies allow organizations to collect, analyze, interpret, and implement customer data related to offline and online activities. While they play different roles in achieving the Industry 4.0 vision, these technologies are mutually influential and connected. Thus, companies must observe various design principles, including interconnection, information transparency, and decentralized decisions. The digital technologies must be appropriately interconnected over the internet in order to ensure that all the stakeholders have access to the critical data and tools to ensure the success of projects. In addition, data transparency aims at building mutually trusting relationships among stakeholders through effective data exchange. The decentralization of decisions promotes autonomous decision-making and control within subsystems, redistributing management from the central location. Furthermore, other principles—such as co-creation, cooperation, conversation, cognitivity, and connectivity—create an innovative approach to the marketing mix under the new conditions of Industry 4.0. Due to the interconnectivity and data exchange, the product creation process is based on co-creation, while mutual communication characterizes the promotion processes. Similarly, the cooperation among all of the stakeholders within the ecosystem facilitates distribution, while data gathered from cognitive processes analyzing real-time customer behaviors are used to determine product prices. These four marketing principles in Industry 4.0 become practical when the principle of connectivity is employed, as it involves connecting digital technologies over the internet.

These aspects help overcome the challenge of trust undermining the success of Industry 4.0 ideologies in most companies worldwide. However, the practical application of these disruptive technologies has increased the flexibility of marketing functions to accommodate the rapid changes in markets and consumer needs. To continue this work, we suggest carrying out quantitative studies regarding the five marketing principles in Industry 4.0: cooperation, conversation, co-creation, cognitivity, and connectivity.

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Appendix A

Table A1. Overview of the document citation period of 2017 to 2022.

Documents		2017	2018	2019	2020	2021	2022	Total
Long-term research on technology innovation in the form of n ...	2021						1	1
Big data and firm marketing performance: Findings from knowl ...	2021					1	3	4
Prior knowledge, industry 4.0, and digital servitization. An ...	2021					1	3	4
lndustry 4.0 in the product development process: benefits, d ...	2021					5	2	7
Enterprises' strategies transformation in the real sector of ...	2021					11		11
Artificial intelligence in business and economics research: ...	2021					5		5
Post-COVID marketing 2019: Launching a new cycle of digital ...	2021						1	1
Structured analysis of ICT adoption in the Europ ...	2021					3		3
Trade-in-to-upgrade as a marketing strategy in dis ...	2020				6	15	4	25
Cross-disciplinary innovations by Taiwanese manuf ...	2020					5	1	6
Digital Transformation and Eco no mie Contrib ...	2020					1	1	2
The lmpact oflndustry4.0 on Export Market Orient ...	2020					2		2
Research in business service purchasing: current status and ...	2020				1	1		2
Online wine purchasing: a comparison between South Afr ...	2020				1	1	1	3
The Internet and international marketing—from trigger tech ...	2020				1	5		6
Deprecated in policy, abundant in market? The fr ...	2020				1	2	1	4
The model of distribution ofhuman and machine lab ...	2020					4	5	9
Labor division and advantages and limits of participation in ...	2020				1	2	1	4
Human capital and AI in industry 4.0. Conv ...	2020				57	83	5	145
Recognizing events 4.0: the digital maturity of events	2020				1	3	1	5
Agriculture 4.0: How Use Traceability Data to Tell F ...	2020				2	4		7
A closer look at the consumer conformity in industry 4.0: P ...	2020					1		1
Digital transformation of traditional marketing bus ...	2020					6	1	7
How to leverage interne! ofthings data to generate benefits ...	2020				1	1		2
Digitalization of Business Functions under lndustry 4.0	2020					1		1
Reconceptualizing value innovation for lndustry 4.0 ...	2019			4	12	20	1	37
Hr marketing as a supporting toai of new managerial st ...	2019				1	2		3
Marketing principies for lndustry4.0—a conc ...	2019				3	5		8
Towards lndustry 4.0: Mapping digital technolog ...	2019			13	49	67	21	150
lnteraction through boundary objects: controversy and fricti ...	2019				4	4	2	10
lndustry 4.0: Food supply chain, sustainability and servitiz ...	2019					2		2
Cyber-physical production networks and adv ...	2019				7	3	1	11

Table A1. *Cont.*

Documents		2017	2018	2019	2020	2021	2022	Total
Typology of knowledge-intensive services for the purp …	2019					1		1
Business analytics in manufacturing: Current tre …	2019				3	5	1	9
Digitalization and leap frogging strategy among the supp …	2019			1	7	1	1	10
lmplications of the ageing population for the food dem …	2018			2	2	4		8
Expanding international business via smart services: lnsight …	2018			4		3	1	8
Mapping of PSS research: A bibliometric analysis	2018		2					2
Risk audit of marketing communication	2018		1	2	5	3		11
Accelerating retail-innovation design for smart services via …	2017		1	1	6			8
	Total		4	27	171	283	60	545

Appendix B

Table A2. Overview of the document self-citation period of 2017 to 2022.

Documents		2017	2018	2019	2020	2021	2022	Total
Big data and firm marketing performance: Findings from knowl …	2021						3	3
Trade-in-to-upgrade as a marketing strategy in dis …	2020					2		2
Cross-disciplinary innovations by Taiwanese manuf …	2020						1	1
The Internet and international marketing—from trigger tech …	2020					2		2
The model of distribution ofhuman and machine lab …	2020					1	1	2
Human capital and AI in industry 4.0. Conv …	2020				7	4	1	12
Reconceptualizing value innovation for lndustry 4.0 …	2019				2	2		4
Marketing principies for lndustry 4.0—a conc …	2019					1		1
Towards lndustry 4.0: Mapping digital technolog …	2019			1		1		2
lnteraction through boundary objects: controversy and fricti …	2019				1			1
lndustry 4.0: Food supply chain, sustainability and servitiz …	2019					1		1
Business analytics in manufacturing: Current tre …	2019					1		1
Digitalization and leap frogging strategy among the supp …	2019			1	6			7
lmplications of the ageing population for the food dem …	2018			1		1		2
Expanding international business via smart services: lnsight …	2018				2			2
Mapping of PSS research: A bibliometric analysis	2018			2				2
Risk audit of marketing communication	2018				2	1		3
Accelerating retail-innovation design for smart services via …	2017			1	1	2		4
	Total			6	21	19	6	52

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