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The Emperor's New Clothes or an Enduring IT Fashion? Analyzing the Lifecycle of Industry 4.0 through the Lens of Management Fashion Theory

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Abstract: This paper examines the recent hype around Industry 4.0 through the lens of management fashion theory to answer the question of how Industry 4.0 has emerged as a management fashion and to what extent it has diffused in organizational practice. Therefore, we conducted a comprehensive discourse lifecycle analysis based on 3920 academic and practical publications comprising a rhetoric and content analysis along with a diffusion lifecycle analysis involving selected diffusion indicators. The findings indicate that Industry 4.0 constitutes an enduring management fashion that has recently reached its peak, with the first signs for an upcoming downswing. The discourse around Industry 4.0 illustrates the concept as a panacea for business problems such as a lack of sustainability and intense global competition; however, the diffusion lifecycle analysis indicates hesitation among companies to adopt Industry 4.0 due to the ambiguity in the conceptual interpretation. The findings enable a more holistic understanding of the recent developments around Industry 4.0 and help to identify actions for the involved political, practical and academic actors. To actively shape the Industry 4.0 fashion development path, more institutional work is needed to help Industry 4.0 fashion users with their adoption engagements and hence achieve "professionalization" at an organizational level.

Keywords: Industry 4.0; management fashion theory; discourse lifecycle analysis; diffusion lifecycle analysis; content analysis

1. Introduction

Since its introduction in 2011, Industry 4.0 has attracted widespread attention in the press and media as well as research and practice, even outside of Germany [1]. In recent years, numerous publications from across diverse disciplines, published by consultancy firms, professional associations, business gurus and academics, have highlighted Industry 4.0 as a panacea that can help organizations to increase their productivity and competitiveness. Based on the three core principles (1) horizontal integration, (2) digital consistency of engineering across value chains and (3) networked production systems, fully automated "Smart Factories" are to overcome the challenges of highly customized products, intense global competition and societal problems such as a lack of sustainability and demographic change [2]. Given the growing global population and the associated increased demand for capital and consumer goods, Industry 4.0 is expected to be a key enabler for a sustainable future of work and society by "ensuring a sustainable evolvement of human existence in its social, environmental and economic dimensions" [3]. Thus, Industry 4.0 can contribute to an enhanced sustainability not only from an environmental perspective, but also from economic and social perspectives. Other countries across the globe have launched similar digitization initiatives to address the Industry 4.0 idea, such as the "Industrie du Future" initiative from France [4], the "Industrial Internet Consortium" from the US [5] and the "Industrial Value Chain" initiative from Japan [6] (p. 35).

Critical voices are emerging amid the astronomical rise of Industry 4.0, questioning whether Industry 4.0 indeed signifies an innovative concept or simply represents a transitory management fashion [7,8]. The inflationary use of the term "Industry 4.0" in the business press and media, as well as the fact that Industry 4.0 only merges existing technologies and concepts into something new, indicate that Industry 4.0 is indeed a management fashion [7,8]. Management fashions are essentially described as cultural phenomena that are shaped by norms of reality and progress [9]. Although management fashion theory originally aims to explain fashions from the management area, in recent years an increasing number of publications have applied it to analyze the emergence of new information systems (IS) and information technologies (IT) such as social media [10], big data [11,12] and mobile banking [13], to name a few. However, an attempt has yet to be made to systematically examine the nature and lifecycle of Industry 4.0 through the lens of management fashion theory to empirically validate this "fashion claim".

Similar to Baskerville and Myers [14], who argue that innovations in information technology (IT) have triggered IS fashions, we adopt an analogous perspective to investigate the recent hype around Industry 4.0. Therefore, we hypothesize that Industry 4.0 signifies a fashion wave comparable to well-known management fashions such as business process reengineering, e-commerce or enterprise resource planning. Drawing on the principles of management fashion theory [15–17], the primary focus of our study is to answer the following research questions (RQs):

RQ1 Who are the major participants of the fashion arena and how do they use rhetoric to shape the recent fashion discourse?

RQ2 What are the main focuses and developments of the Industry 4.0 fashion discourse?

RQ2 Does the recent hype around Industry 4.0 constitute a serious and enduring management fashion that will soon be institutionalized, or is it merely a short-lived fashion?

The theoretical lens of management fashion theory is employed to methodologically guide the research process and explain the research results that emerge from the collected data. In doing so, our aim is not to empirically test the theory but rather to enable a more holistic understanding of the recent developments around Industry 4.0.

To study the fashion around Industry 4.0, the remainder of this paper is structured as follows. First, the theoretical background is outlined by briefly introducing the main principles of management fashion theory, which serve as an analytical framework for this research as well as previous studies on former management and IT fashions. Furthermore, the Industry 4.0 concept and its basic characteristics are illustrated. Afterwards, we describe the research methods that are applied to answer the research questions. A discourse lifecycle analysis is conducted by means of a content and rhetoric analysis based on a sample of 3920 practical and academic publications, whereas the diffusion lifecycle analysis is based on the meta-analysis of two statistical indicators. For the discourse analysis, we additionally relied on publications that examine related concepts to Industry 4.0 to receive a more holistic understanding of the global view on policy-driven digitization initiatives of manufacturing environments. Therefore, we decided to include the most common concepts related to Industry 4.0 that have also been established outside of Germany into the analysis such as the "Industrial Internet" term coined by the American Industrial Internet Consortium or the Chinese initiative "Internet Plus" [18,19]. The main findings are subsequently synthesized, interpreted and explained with reference to the mechanism proposed by management fashion theory. In the discussion section, the results of this study, its limitations as well as implications for research and practice are discussed. Finally, concluding remarks are provided.

Overall, the findings of this study indicate that Industry 4.0 constitutes an enduring management fashion that has recently reached its peak in terms of the discourse and diffusion lifecycle, with the first signs for an upcoming downswing. To actively shape the Industry 4.0 fashion development path, more institutional work is needed to help Industry 4.0 fashion users with their adoption engagements and hence achieve "professionalization" at an organizational level. These findings contribute to

the ongoing discourse on Industry 4.0 by analyzing this phenomenon through the lens of management fashion theory and thus enable a more holistic understanding of the recent developments around Industry 4.0. This enhanced understanding, in turn, helps us to assess the possible development paths of this fashion and identify possible actions for the involved political, practical and academic actors.

2. Theoretical Background

2.1. Principles of Management Fashion Theory

Originating from the management discipline, management fashion theory has been developed to explain the diffusion of administrative technology fads such as quality circles, job enrichment, total quality management and business process reengineering [17]. Informed by neo-institutional theory and theories of innovation and diffusion [14,20], management fashion theory posits that the diffusion of particular innovations tends to be a cultural phenomenon rather than the result of rational decision making [21]. According to Abrahamson [9], the management fashion-setting process consists of the following stages:

- **Creation:** during the fashion creation stage, fashion setters attempt to construct the collective belief that the new fashion is an innovative improvement compared to the current state.
- **Selection:** the selection of a management fashion is affected by external and techno-economic forces. As a response, fashion setters set out to propose management techniques that are expected to satiate the created demand.
- **Processing:** after selection, fashion setters actively promote these management fashion techniques, inter alia through rhetoric, to convince fashion followers of the associated advantages.
- **Dissemination:** the use of mass media is one major opportunity to widely disseminate management fashions. However, rhetoric may be disseminated in several ways. Academics, consultants and practitioners focus on publishing papers in academic and practice-oriented journals, whereas management gurus and educators tend to disseminate their rhetoric in books or academic journals. For the dissemination of corporate culture rhetoric, popular management journals are the most appropriate.

Following these principles, the definition of a management fashion proposed by Abrahamson [9] posits that a management fashion represents *"a relatively transitory collective belief, disseminated by management fashion setters, that a management technique leads rational management progress"*. Since its introduction in 1991 [16] (p. 257), management fashion theory has attracted considerable interest across research disciplines. Although management fashion theory originally aims to explain and analyze fashions from the management area, a growing number of publications have applied management fashion theory to IT and IS in recent years.

The main focus of previous studies on IT fashions has been directed toward the investigation of IT and IS innovations that have evolved or are about to evolve as new fashion waves. For example, Baskerville and Myers [14] examine the discourse lifecycle of four different IT fashions: office automation (OA), computer-aided software engineering (CASE), business process reengineering (BPR) and e-commerce (E-COM) to prove the suitability of management fashion theory for the study of IT fashions, while calling for the more proactive engagement of IS academics within the fashion-setting process. Hirschheim et al., [22] compare the fashion discourse of business process reengineering (BPR), enterprise resource planning (ERP) and service-oriented architecture (SOA) to analyze the differences between the reasonability of the argumentation employed within the discourse lifecycle. Extant research on former IT and IS fashions also includes studies on customer relationship management (CRM) [23–25], social media [10], big data [11,12], mobile banking [13], agile development [26] or enterprise architecture (EA) [27] as single concepts.

Some fashions have managed to diffuse in organizational practice, such as enterprise resource planning [22], customer relationship management [25] and mobile banking [13], whereas others have

not. For example, this case is true for the fashion around big data, as a "deployment gap" and a "limbo stage" exist, in which companies keep experimenting but do not proceed to deployment due to the intent to adopt big data [11]. With regard to the findings offered by previous studies, management fashion theory is deemed to enable the systematic investigation of management or IT fashions by drawing a comprehensive portrait of the fashion and thus analyzing whether the fashion exhibits the potential to widely diffuse in business practice.

To date, one single attempt was made by extant research to examine Industry 4.0 through the lens of management fashion theory [28], but with an only selected view on single aspects of the fashion setting process rather than a holistic understanding of the development path. Furthermore, this prior work lacks a systematic and structured research approach that could provide a more representative and validated view on Industry 4.0 as a management fashion.

2.2. Industry 4.0: Another Management Fashion?

Over the past few decades, the emergence of "transformational IT" has resulted in the pervasive digitization of manufacturing and business environments across industries, which has produced changes in business models, company organizations and work processes. The term "transformational IT" describes technologies that have the potential to shape and reshape the economy by altering processes, creating new organizations or enabling market entries, changing social relationships and user experiences and gaining new customers [29]. At first sight, these transformational characteristics also apparently apply to the Industry 4.0 concept, which is expected to radically shape manufacturing environments and processes across industries.

Introduced in 2011, the Industry 4.0 concept was a major part of the German government's high-tech strategy for boosting efficiency and productivity and strengthening Germany's competitiveness [30–32]. The transformational nature of Industry 4.0 has been promoted under the impressive term "Fourth Industrial Revolution", which underlines its huge technological potential, comparable to the first three industrial revolutions: (1) the field of mechanization, (2) the use of electricity and (3) the beginning of digitization [32]. The Industry 4.0 concept is technically based on three key characteristics [2,33]:

- Horizontal integration through value networks: IT systems, processes and data flows between different organizations (e.g., customers, suppliers and other stakeholders) are integrated for an improved collaboration across company borders;
- End-to-end digital integration of engineering across the entire value chain (e.g., through the use of cyber-physical systems) for enabling highly customized products and achieving cost reduction;
- Vertical integration and networked manufacturing systems: IT systems, processes and data flows within the company are integrated (e.g., product development, manufacturing, logistics and sales) for an improved cross-functional collaboration (smart manufacturing environment).

According to this definition, Industry 4.0 manufacturing and business environments are fully integrated, smart, autonomous and digitized. To attain this characterization, Industry 4.0 combines several key technologies such as cyber-physical systems (CPS), internet of things (IoT), big data, 3D printing, radio-frequency identification (RFID) technology and cloud computing [33], to name a few. Thus, Industry 4.0 is more a bundle of different technologies rather than a single concept.

Meanwhile, critical voices are emerging amid the rise in popularity of Industry 4.0, questioning whether Industry 4.0 indeed constitutes an innovative concept or simply represents a transitory management fashion [7,8]. The inflationary use of the term "Industry 4.0" in the business press and media, as well as the fact that Industry 4.0 only merges existing technologies and concepts into something new, indicate that Industry 4.0 is indeed a management fashion [7,8]. Similar to the emperor's invisible clothes as told in Hans Christian Andersen's tale "The Emperor's New Clothes" [34], the ensuing impression is that Industry 4.0 might be a fashion that everyone pretends to believe in, although in reality there is nothing to see. Thus, the recent discourse in which Industry 4.0 has been praised as a panacea should be observed from a more critical and reasoned perspective.

3. Research Method

In the management fashion literature, two types of analyses are suggested for investigating the lifecycle of a management fashion. Abrahamson and Fairchild [17] (p. 716) recommend *"a mixture of analytical, historical and practical considerations"* as a guide to examine the discourse and diffusion lifecycle. We follow Abrahamson's recommendation by applying a multi-step research design as illustrated in Figure 1 for the analysis of the discourse lifecycle.

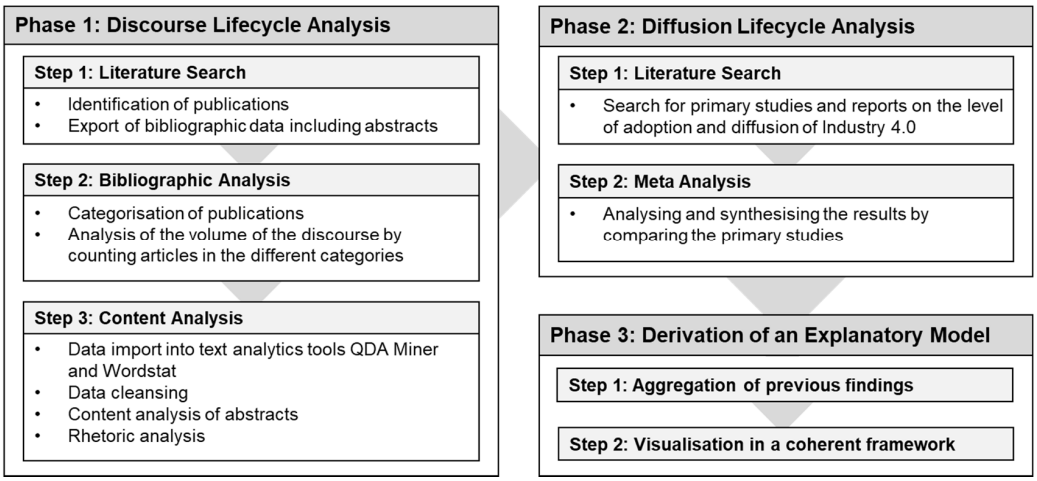

Figure 1. Research Design.

The discourse lifecycle analysis examines debates in the mass media about particular fashions within their lifecycles. This discourse is shaped by the volume and content of the fashion setter's rhetoric attempting to actively promote the dissemination of the particular management fashion [17]. Previous management fashion literature has suggested bibliographic analysis as an appropriate and reliable method for examining the lifecycles of management fashions in terms of article counting [14,17,35]. Hence, we initially examine whether the volume of the discourse on Industry 4.0 follows the typical pattern of a management fashion.

Therefore, we conduct a literature search by following the approach recommended by Webster and Watson [36] to search for relevant publications that address Industry 4.0 topics. Due to the interdisciplinary nature of the Industry 4.0 concept, the literature search is performed in the Scopus and EBSCOhost databases, which both offer a broad coverage of academic and practical journals, magazines, conference proceedings, notes and other types of publications. As Industry 4.0 is a popular topic in German academic and practical literature, we do not restrict our search to English publications but also seek for publications that are written in German. To be selected for the subsequent analysis, the publications must contain the term "Industry 4.0" or "Industrie 4.0" in their titles. As concepts related to Industry 4.0 have also been established outside of Germany, such as "Industrial Internet" coined by the American Industrial Internet Consortium or the Chinese initiative "Internet Plus" [18,19], we repeatedly applied the search procedure to these search terms. As listed in Table 1, this literature search generated 6459 hits, including potential duplicates.

Table 1. Results of the literature search.

Search Phrase (Search in Title)	Country	Database		Total	Relevant Hits
		Scopus	EbscoHost		
"Industr* 4.0"	Germany, global	3026	1940	4966	
"Industrial Internet"	US	598	724	1322	3920
"Internet Plus"	China	101	70	171	
Total		**3725**	**2734**	**6459**	**3920**

In a further step, we extract the bibliographic data of all the identified publications including their abstracts by using the export function offered by Scopus and EbscoHost. Although often applied to the examination of the lifecycles of management fashions, according to Clark [37], bibliographic analyses are associated with serious limitations such as low qualitative insights into the respective issues. As we aim to examine the development of the fashion discourse around Industry 4.0 as well as its content, purely counting relevant publications is not expedient. Thus, to qualitatively assess the content and type of rhetoric within the lifecycle of the management fashion, we complement the bibliographic analysis with a content analysis. Similar to the approach employed by Abrahamson and Eisenman [38], we refer to the abstracts of the articles for the bibliographic and content analysis because abstracts have been found to be a useful proxy for the entire full text [17].

As applied in this paper, the method of content analysis allows "a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding" [39]; thus, this method is considered beneficial for dealing with large volumes of data for examining trends and patterns in documents [40]. To enhance the understanding of the content of the publications and the rhetoric used as proposed by Kieser [34] and Abrahamson and Fairchild [17], we also conduct a rhetoric analysis of the abstracts. This approach allows for the evaluation of "opinionated text, which contains people's opinions toward entities such as products, organizations, individuals, and events" [41] (p. 151).

The high number of publications to be examined would require substantial efforts to manually code them in the subsequent content analysis step. Hence, we refer to a systematic text analytics approach by using the text analytics tool QDA Miner [42] and its extension WordStat [43] for the succeeding analysis step. Therefore, the abstracts are imported into QDA Miner, followed by a data cleansing step in which a check for duplicates is conducted. In this cleansing step, a total number of 740 duplicates could be detected and omitted from the sample. Finally, a sample of 3920 publications published between 2011 and 2019 remains for the analysis step. The aim of the content analysis is twofold. First, we intend to identify the patterns in the discourse on Industry 4.0 with respect to the industrial sectors and the key concepts associated with Industry 4.0. Second, our aim is to analyze the rhetoric used in the discourse.

The content analysis of the abstracts comprises different iterative steps. First, we perform a simple frequency analysis in the QDA Miner and its extension WordStat [43] by following the approach proposed by Martens et al. [44]. This step enables us to identify the most frequent words and phrases used within the discourse and gain deeper insights into the structure of the abstracts. Based on the extracted words and phrases, the results are scanned for the most frequently mentioned technologies, concepts and other patterns to define rule-based categories. In this coding procedure, each word (unigram) and phrase (n-gram) is assigned to defined categories such as industry sector, key technology and rhetoric patterns. The average frequencies of the unigrams (RFU_c) and n-grams (RFN_c) that are assigned to a particular category are subsequently calculated using the following formula:

$$RFU_c = \frac{\sum FU_c}{\sum FA} \text{ and } RFU_c = \frac{\sum FU_c}{FA} \quad (1)$$

where

RFU_c/RFN_c = average frequency of unigrams/n-grams assigned to a category;
FU_c/FN_c = frequency of unigrams/n-grams assigned to a category; and
FA = total number of abstracts.

To avoid subjective bias, the coding process is independently conducted by two different researchers according to the interrater agreement concept (IRA). This concept enables us to justify the similarity in rating processes [45] and thus to enhance the objectivity and validity of the cluster analysis. Finally, the results of this cluster analysis are synthesized and interpreted to describe the discourse lifecycle of Industry 4.0. To further examine the diffusion lifecycle of Industry 4.0, we search for primary studies on the level of adoption and diffusion of Industry 4.0. Overall, two studies have been identified

as relevant for the meta-analysis and synthesis step. The results of the diffusion lifecycle analysis enable us to draw a picture concerning the development of Industry 4.0 as a management fashion.

To sum up, the discourse lifecycle analysis is aimed at exploring the content and rhetoric of the debates about Industry 4.0 as well as their evolvement over time, whereas the diffusion lifecycle analysis is focused on examining to what extent Industry 4.0 has managed to diffuse in organizational practice. Thus, while the discourse lifecycle analysis enables us to examine the development of Industry 4.0 from the fashion setters' perspective, the diffusion lifecycle analysis helps us to study Industry 4.0 from the fashion users' perspective.

4. Discourse Lifecycle Analysis

4.1. Bibliographic Analysis

By quantifying the number of published articles addressing Industry 4.0 topics, we first aim to examine whether the lifecycle follows the typical patterns of a fashion. Management fashions already examined usually demonstrated a longer period of rest before a short-lived increase [17]. The result is a symmetrically shaped, bell-shaped popularity curve [9]. Similar to Abrahamson and Fairchild [17], we also distinguish between different types of publications:

(1) Academic publications such as academic journals, conference proceedings, academic working papers as well as academic book chapters;
(2) Practical publications comprising articles published in practical and semi-practical journals and other types of publications such as white papers, consultancy reports, working papers from professional bodies as well as magazine articles, newspaper or online news articles.

Figure 2 illustrates the absolute and relative distribution of each publication type over time from 2011 to 2019. The results of the bibliographic analysis indicate that the discourse begins in 2011 and significantly rises from 2014 onwards.

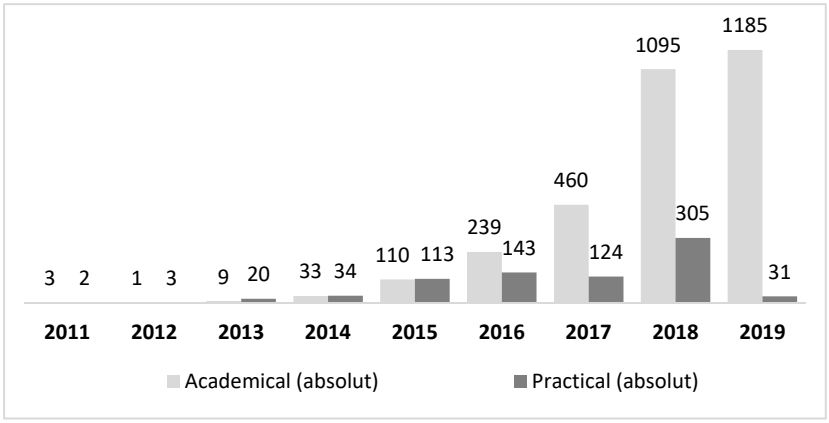

Figure 2. Distribution of academic and practical publications per year.

Consistent with Baskerville and Myers' [14] findings, research and practice in the Industry 4.0 field exhibited a parallel bell-shaped pattern, whereby practitioners' interest in Industry 4.0 topics was indeed higher in the beginning of the discourse (2011–2015) than the interest of academics. From 2016 to 2018, the number of academic publications sharply increased compared to the number of practical publications. Although the practitioners' attention to Industry 4.0 significantly declined in 2019, the number of new academic publications steadily grew from year to year. This observation is consistent with Baskerville and Myers' [14] findings, who state that research tends to appear slightly later when practitioner interest has already declined. By 2019, however, the growth in academic publications significantly decreased compared to previous years, which could be an indicator of the diminishing public interest in Industry 4.0. Another explanation for the practitioners' reduced

interest might be found in the simple fact that some publications such as news and newspaper articles that appeared in 2019 had not been indexed in the literature databases to date.

As depicted in Figure 3, popular outlets for the publications are academic publications such as conference papers and journal articles, which account for more than two-thirds of the entire literature sample, followed by practical publication outlets such as practical journal articles and magazine articles, news and newspaper articles. Overall, the results of the bibliographic analysis reveal that Industry 4.0 is at the peak of a discourse lifecycle of management fashions, with the typical observation of a rapid upswing within three to five years, as stated by Baskerville and Myers [14]. The beginning of the bell-shaped process is preceded by a resting phase [17] After the initially restrained years, a rising tendency can be seen in the academic course.

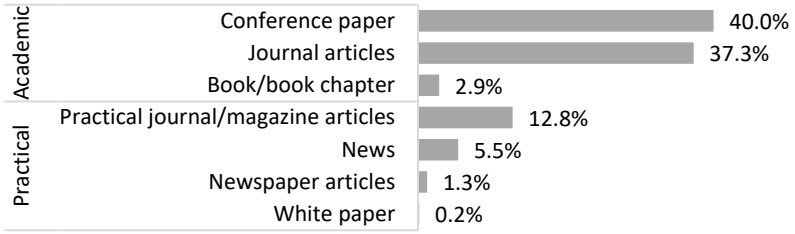

Figure 3. Publication types.

According to Abrahamson [9,16], the so-called "fashion-setting community", "fashion-setting organizations", "fashion setters" or "opinion leaders", being responsible for the creation or dissemination of new fashions, consist of consulting firms, business mass media, business schools and management gurus such as academic and consultant gurus as well as hero managers. Similarly, Kieser [34] uses the term "arena of management fashion" to describe the group of main participants involved in the fashion-setting process by shaping the rhetoric and thus contributing to the attractiveness of the arena. As illustrated in Figure 4, the fashion arena around Industry 4.0 also comprises different participants who actively shape the fashion discourse. This is evident from the list of authors of our literature sample as well as the results of our bibliographic and content analyses.

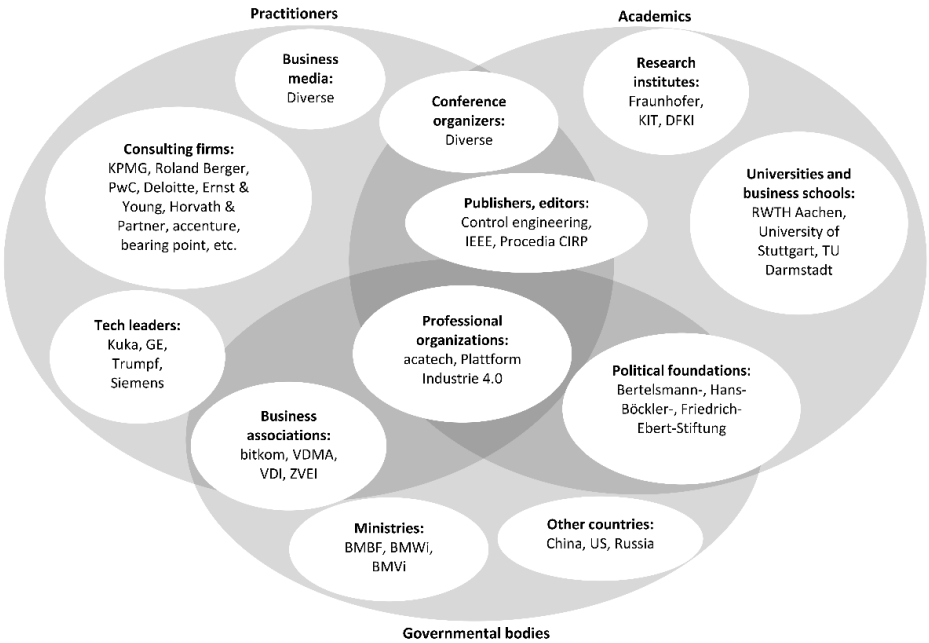

Figure 4. Fashion setters involved in the Industry 4.0 discourse.

Since the Industry 4.0 concept was first introduced by the German government in 2011, in the beginning the debate was shaped by political actors with the main aim to promote its benefits and thus support its diffusion [46]. With a few minor exceptions, the Industry 4.0 debate has primarily taken place within the German political and practical circle until 2014. In their role as intermediates between the practical, academic and political circle, German professional organizations such as acatech or Plattform Industrie 4.0, business associations such as BITKOM, VDMA or VDI and political foundations have been involved in the public discourse of Industry 4.0 in different ways to provide strategic considerations and recommended actions for the German government [2,47].

Academic participants have subsequently entered the fashion arena. In 2014, the public discourse accelerated, with the publication of the first articles in practical and academic journals addressing the potential of Industry 4.0 in terms of cost savings and efficiency benefits [48–50]. A few years later, consultancy reports, book chapters and articles in practical journals were published by consulting firms (e.g., KPMG, McKinsey, Roland Berger) to demonstrate their competency concerning the fashion topic [51–53]. Academics from universities, business schools and other research institutes [32,54–58] similarly enter the fashion arena by providing more founded insights into the fashion topic and underlining the importance of Industry 4.0 for research and practice. Their active involvement in the fashion-setting process is considered beneficial because it provides legitimacy for the fashion [34]. Tech leaders from the manufacturing industries, such as Trumpf, Kuka, General Electric (GE) and Siemens, are further actors who also actively participate in the Industry 4.0 debate by offering their products, services and best practices to potential fashion followers. Aside from these actors, other typical fashion setters such as conference organizers, publishers and business media also shape the Industry 4.0 discourse with their activities.

In sum, the ongoing increase in the Industry 4.0 discourse that started in 2014 indicates that the fashion discourse is indeed within the upswing phase. Thus, with reference to RQ1 and RQ3, the corresponding propositions can be given:

Proposition 1a. *Compared to previous management and IT fashions, fashion political actors played a leading role in promoting Industry 4.0 at the outset, whereas practitioners and academics actively contributed to the discourse at a later stage.*

Proposition 3c. *The results of the bibliographic analysis reveal that Industry 4.0 has reached the peak of its discourse lifecycle, with the typical observation of a rapid upswing within three to five years from 2014 onwards. Research and practice in the Industry 4.0 field demonstrate a parallel bell-shaped pattern, whereby practitioners' interest in Industry 4.0 topics was indeed higher in the beginning of the discourse than the interest of academics.*

4.2. Content Analysis

After evaluating both the volume and the actors of the discourse around the concept of Industry 4.0, the next goal is to examine the content of the fashion discourse in more detail. To this end, we initially shed light on the industry sectors involved in the discourse before investigating the key concepts covered.

As expected, the results indicate that Industry 4.0 is most associated with manufacturing. In 2011, for example, the Industry 4.0 fashion discourse is dominated by terms that describe its reference to the manufacturing industry, such as "manufacturing", "production" and "manufacturing sector". In subsequent years, the attention to Industry 4.0 in the specific context of the manufacturing industry has remained at a high level. Other industry sectors that have also been involved in the fashion discourse include the automotive, logistics, construction and health sectors. However, compared to the manufacturing sector, the role of Industry 4.0 in health, construction, logistics and other sectors is by far less frequently addressed within the fashion discourse. As also indicated by the results, the interest in Industry 4.0 in these industrial sectors is only displaying small increases from 2012 onwards.

Aside from the analysis of the most covered industry sectors, the next objective is to examine the most frequently addressed technologies. Recent studies on Industry 4.0 mostly portray this concept as a bundle of technologies that enable the three basic characteristics of vertical and horizontal integration as well as the digital integration of engineering across the entire value chain [33,59]. In the course of the preliminary frequency analysis, 18 technologies and concepts could be identified that emerge in the Industry 4.0 fashion discourse.

Figure 5 illustrates the 10 most frequently mentioned Industry 4.0 technologies and concepts, namely the Internet of Things (IoT), big data, RFID and sensors, simulation and modelling, robotics and cyber-physical systems (CPS). Other enablers of Industry 4.0 include cloud computing as one basic technology, artificial intelligence (AI), augmented and virtual reality (AR/VR) and blockchain technology. The dominance of the big data concept within the fashion discourse is not surprising, considering the fact that the use of RFID and sensors in CPS or IoT environments would logically generate a vast amount of data that require advanced techniques for their storage, processing and analysis [60–62].

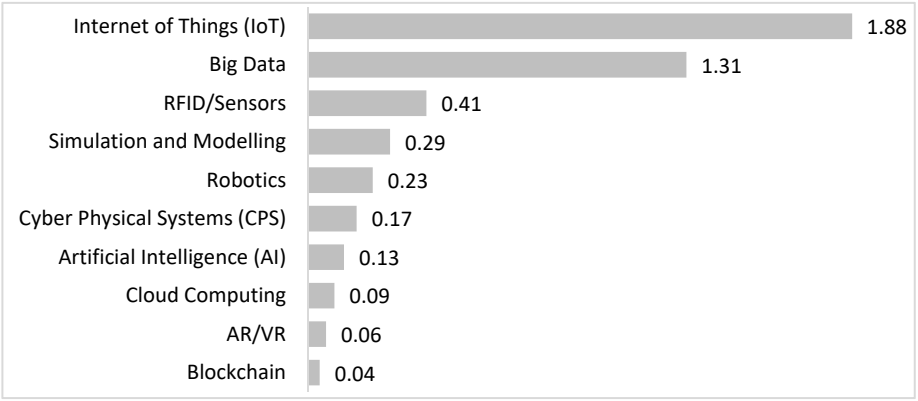

Figure 5. Top 10 key technologies of Industry 4.0 according to the average frequency of unigrams and n-grams.

Another interesting picture is offered with regard to the content of the fashion discourse according to its primary focus. Therefore, we assigned all unigrams and n-grams to the "Technical (T)", "Economic (E)", "Social (S)", "Political (P)" and "Ecological (Eco)" dimensions, depending on their meanings. The results of this cluster analysis reveal that both the academic and practical discourses are constantly shaped by technically focused contents. From the beginning of the fashion launch, technical aspects were increasingly taken into account in the discourse, as indicated by the increase in the coded unigrams and n-grams. Furthermore, the fashion discourse demonstrates a relatively high share of political content, which is not surprising given the fact that Industry 4.0 was initially introduced by the German government. Despite the far-reaching implications that Industry 4.0 might entail for business and society, the technical aspects are dominating in the fashion discourse, whereas the social, economic and ethical considerations have received less attention. This finding is consistent with those of other former studies, in which the authors have emphasized the lack of social, ethical or legal focus in research and practice [33,63,64].

After the introduction of Industry 4.0 in 2011, a large number of articles are constantly focused on proposing artefacts such as conceptual frameworks, system architectures and other artefacts and approaches for Industry 4.0 and related topics [65–70]. The economic aspects that are discussed in the fashion discourse relate to the financial implications that Industry 4.0 entails for companies in particular and for the industry sector in general. The adoption of Industry 4.0 is associated with a wide range of economic benefits that are expected to have multiple positive impacts on the processes and business models of companies [52,53,71–73], resulting in improved efficiency, quality, productivity and competitive advantage, to name a few [33,74–76]. Moreover, Industry 4.0 is considered as an aid for

companies to solve problems associated with energy and power consumption; thus, it helps companies to improve their sustainability [77–82]. Aside from the economic, process and ecological benefits, social benefits are rarely mentioned, such as improved collaboration and enhanced safety [83–85].

The challenges and barriers of Industry 4.0 are also addressed in multiple publications [75,86–89]. Based on the extracted terms from the abstracts, economic challenges such as limited resources, high costs and high risks as well as social challenges such as training and education, shortage of expertise and lack of trust are considered the main reasons for the low diffusion rate of Industry 4.0 [57,90–95]. Schneider [96] identified 18 managerial challenges that must be overcome by firms when attempting to implement Industry 4.0 in the organization, including operational and strategical considerations with regard to human resources, business models, change and leadership, to name a few. Technical issues such as security and privacy concerns as well as the lack of standards are other reasons for the non-adoption of Industry 4.0 [97–99]. Overall, the content of the Industry 4.0 discourse is shaped by a focus on technical topics and content, including a slight increase in the interest in economic aspects, while social, ethical and legal aspects are lacking. Based on the findings from the content analysis, we are able to answer RQ2 as follows:

Proposition 2a. *The results of our content analysis reveal that in the discourse lifecycle, Industry 4.0 is mainly discussed with a specific reference to the manufacturing sector. The role of Industry 4.0 in other sectors such as health, construction and logistics is by far less frequently addressed.*

Proposition 2b. *In research and practice, Industry 4.0 is portrayed as a bundle of technologies that comprise big data, IoT, RFID, CPS and many more. Based on the content of the fashion discourse, technical aspects are dominating, whereas social, economic and ethical considerations have received by far less attention.*

Proposition 2c. *On the one hand, Industry 4.0 is associated with economic benefits that positively impact the processes and business models of companies, resulting in improved efficiency, quality, productivity and competitive advantage.*

Proposition 2d. *On the other hand, economic challenges such as limited resources, high costs and high risks as well as social challenges such as training and education, shortage of expertise and lack of trust are considered the main reasons for the low diffusion rate of Industry 4.0.*

4.3. Rhetoric Analysis

Aside from the content of the fashion discourse, we also aim to examine the various types of rhetoric used by different actors to promote the fashion. In our analysis of the discourse around Industry 4.0, we have detected shifting patterns in the language and rhetoric used by various fashion setters. The results of our rhetoric analysis provide evidence for Abrahamson and Fairchild's [17] proposition concerning the existence of three types of discourses during the upswing phase. As illustrated in Figure 6, each type of discourse takes its own course over time.

First, the problem discourse is built around the source of problems that may necessitate the adoption of the particular fashion, which again triggers a debate that delivers responses and solutions by promoting the magical benefits of the fashion and suggesting it is worthwhile to adopt [17]. In the case of Industry 4.0, the rhetoric used within the problem discourse is shaped by general terms such as "critical", "drivers" and "problem" to describe the critical situation (cf. Table 2).

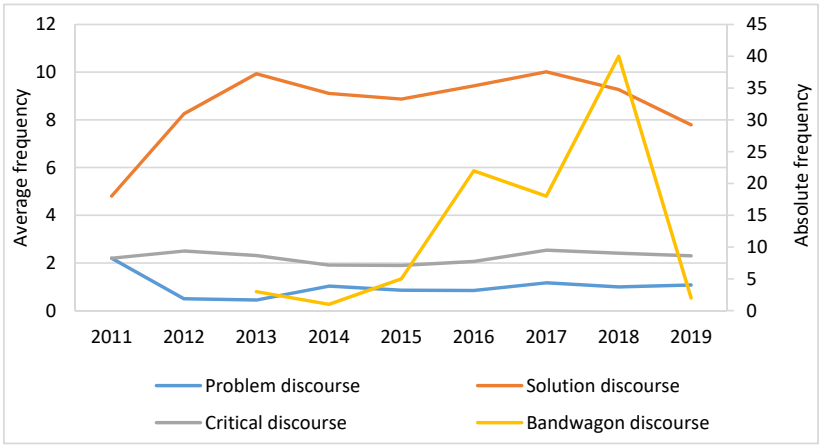

Figure 6. Types of fashion discourses according to the average frequency of unigrams and n-grams.

Table 2. Rhetoric used within the problem discourse according to the unigrams and n-grams.

Discourse	Dimension	Category	Unigrams and n-grams
Problem discourse	Diverse	General rhetoric	critical; drivers; problem; problems
	External forces	Competition	competition; competitive; competitiveness; global competition; global economy
		Customer demand	consumer; consumption; customer; customer requirements; customers; customization; customized; customized products; demand; demands; increasing demand; mass customization; mass production
	Internal forces	Status quo	traditional; traditional manufacturing
		Complexity	complexity; increasing complexity; scheduling problem
		Sustainability	energy consumption; energy system; power consumption

Most notably, the necessity to adopt the fashion is frequently argued by external forces such as the intensifying global competition and the growing demand for individualized products, as indicated by the terms "customer requirements" and "customized products", among others. Recent studies reveal that customers increasingly wish to adapt their products to their own wishes and, for example, receive the goods on the same day after the order has been placed [100]. Aside from the external forces, additional aspects such as growing complexity and high energy consumption are considered as internal forces that necessitate the adoption of Industry 4.0 [63,65,98,101]. This inference is supported by the fact that many production processes are unsustainable from an ecological viewpoint. Fashion setters promote Industry 4.0 in the upswing of the fashion discourse by claiming that organizations need to adopt Industry 4.0 to radically optimize their production processes and thus achieve dramatic improvements in energy efficiency [102]. Rhetorically, we have observed that fashion setters tend to promote Industry 4.0 in the problem discourse with "great drama and fanfare" in an attempt to emphasize the threats that might emerge when ignoring the fashion and the opportunities that arise from their adoption. As illustrated in Figure 6, the problem discourse was more present in the introduction phase of Industry 4.0 in 2011, but it later remained at a relative low level. From the mentioned internal and external forces, the impression is that the ensuing performance gap represents a threat to the companies' existence, which in turn renders the indispensability of the adoption of Industry 4.0.

The second type of discourse, namely solution discourse, primarily aims to promote possible solutions for the presented problems to answer the question "What is the solution for this problem and why are these solutions beneficial?" As previously mentioned, the fashion setters' attention during the previous problem discourse is directed toward the apparent performance gap, which in turn signifies the need for companies to adopt Industry 4.0. In this context, fashion setters are focused on highlighting the significant potential and benefits that Industry 4.0 offers for the manufacturing industry. Interestingly, the solution discourse has accelerated over time, with a peak in 2017 and a slight decrease since this peak in 2017. In the solution discourse, Industry 4.0 is often argued to be the panacea for everything. As summarized in Table 3, recent efforts to promote Industry 4.0 as a favorable concept include positive rhetoric such as "easy", "great", "huge", "important", "promising", "strong" and many other emotionally charged terms. Additionally, a wide range of buzzwords is used to underline the disruptive impact of Industry 4.0, such as "cutting edge", "era", "evolution" and "paradigm shift".

As mentioned in the preceding section, Industry 4.0 is also associated with multiple positive impacts on companies' productivity, performance and competitiveness as well as the efficiency of production processes. This is indicated by multiple terms that describe these favorable aspects, such as "potential benefits", "competitive advantage", "leadership", "effectiveness", "operational efficiency", "productivity" and "business opportunities". Aside from the buzzwords and benefits proposed, the solution discourse is also characterized by the provision of numerous technical solutions. The extracted unigrams and n-grams indicate that in the academic and practical literature, Industry 4.0 is associated with a highly integrated, smart, intelligent and automated, even autonomous manufacturing environment with interconnected information flows based on wireless sensor networks, platforms and web services (cf. Table 3). The solution discourse is shaped by the collective belief that the adoption of these technologies and solutions would generate the aforementioned benefits such as efficiency, productivity and competitiveness.

The third type of discourse, namely bandwagon discourse, also transpires in the upswing phase of a management fashion in which fashion setters might be put under pressure to "jump on the bandwagon" and adopt the fashion [17]. As Industry 4.0 best practices and success stories are rare, they cannot be identified through a frequency analysis. Instead, we manually screen the articles for potential cases and apply an article count for further analysis. Hence, the graph displaying the development of the bandwagon discourse (cf. Figure 6) represents the number of cases over time instead of the average frequency of unigrams and n-grams. In the bandwagon discourse, success stories and best practices are presented to actively promote the fashion. For example, several representatives from diverse companies participate in the bandwagon discourse to describe their journey within the adoption process, emphasizing the potential benefits that Industry 4.0 offers for their organizations [103–106]. The collective belief that Industry 4.0 is new, efficient and at the forefront of management practice [9] is accompanied by early adopter's enthusiasm, but it lacks real anecdotal success. The impression emerges that the companies are led by trustful hope rather than by convincing success. Interestingly, numerous companies claim to adopt Industry 4.0 by solely acquiring new machines or software. For example, Tetra Pak has mentioned the implementation of Plant Secure, a plant management system that aims to improve productivity and reduce costs [107]. Anderson Technologies similarly introduced machinery with higher injection pressure, with the same purpose of reducing costs and improving productivity [106]. However, the extent to which the adopted solutions constitute "real" Industry 4.0 technologies and concepts remains unclear in these examples. Instead, companies seemingly misuse Industry 4.0 as an umbrella term to announce their products and services or their engagement in digitization initiatives, or to describe their recent efforts to digitize or automate their manufacturing and business environments, regardless of the question of whether these efforts indeed have something to do with Industry 4.0. This is already evident when considering the title of such announcements, such as "TK surfs the Industry 4.0 wave" [105].

Table 3. Rhetoric used within the solution discourse according to the unigrams and n-grams.

Discourse	Dimension	Category	Unigrams and n-grams
Solution discourse	Positive rhetoric	Positive rhetoric	easy; emergence; great; greater; huge; importance; important; important role; improve; improved; improvement; improvements; improving; opportunities; opportunity; optimal; positive; possibilities; potential; promising; recent advances; solution; solutions; strong; success; successful; successfully
	Buzzwords	Buzzwords	crucial; cutting edge; digital economy; digital factory; digital manufacturing; digital transformation; emerging; emerging technologies; era; evolution; high level; high tech; high tech strategy; industrial paradigm; industrial revolution; industrial revolutions; knowledge economy; modern manufacturing; modern production; paradigm; paradigm shift; revolution; significant impact; significantly; technological development; technological innovation; transform; transformation; transformation process; transforming; transition; transition to industry; vision; vision of industry
	Benefits	Benefits	advantage; advantages; benefit; benefits; potential benefits; competitive advantage; leader; leadership; cost effective; low cost; low power; production costs; flexibility; flexible; flexible production; safety; collaboration; collaborative; decision support; effective; effectively; effectiveness; effects; efficiency; efficient; efficiently; faster; operational efficiency; development of knowledge economy; growth; high performance; increase productivity; industrial value creation; productivity; high quality; quality; quality control; quality management; quality of service; business model; business models; business opportunities; energy; energy efficiency; energy efficient; energy management; sustainability; sustainable; sustainable development; sustainable manufacturing; waste; water
	Technical solutions	Smart	autonomous; intelligence; intelligent; smart; smart cities; smart city; learning factory; smart factories; smart factory; smart logistics; smart manufacturing; smart production; smart products
		Automation	algorithm; algorithms; automated manufacturing; automated production; automation; automation and data exchange; automation systems; factory automation; industrial automation; programmable logic; synchronization
		Vertical and horizontal integration	horizontal; horizontal and vertical; information flow; information flows; interconnected; interconnection; interoperability; machine to machine; vertical; vertical and horizontal; vertical integration
		Networks	industrial networks; industrial wireless; wireless communication; wireless sensor network; wireless sensor networks
		ICT	agile; communication systems; communication technologies; decentralized; digital; digital technologies; digital technology; digitalization; digitization; dynamic; dynamics; ecosystem; industrial systems; open source; platform; platform based; platforms; remote monitoring; web services

As illustrated in Figure 6, the bandwagon discourse has increased in recent years from 2015 onwards, whereas the solution discourse has declined since 2017. Consistent with the results of the bibliographic analysis, this development reveals that the interest in Industry 4.0 has diminished, indicating the beginning of a downswing. However, fashion setters still attempt to promote Industry 4.0 with the help of positive rhetoric, buzzwords and success stories by emphasizing the potential and technical solutions that Industry 4.0 offers for their "performance gap". This observation of emotionally charged, uncritical rhetoric is partly consistent with those of previous research. As stated by Hirschheim et al. [22], the absence of "unreasoned" discourse at the upswing phase is characterized by a lack of pluralism, as only the technical and economical perspectives are included while the social aspects are neglected at the early stages of the Industry 4.0 fashion discourse.

However, the results of our rhetoric analysis indicate that a critical and reasoned discourse focusing on the challenges and barriers of Industry 4.0 does exist, although it remains at a relatively low level. This inference is indicated by terms such as "point of view", "challenges and opportunities", "social", "barriers" and "challenges" (cf. Table 4). As similarly depicted in Figure 6, this critical discourse has slightly increased in recent years. This development, in turn, represents another indicator for a beginning downswing phase.

Table 4. Rhetoric used within the critical discourse according to the unigrams and n-grams.

Discourse	Dimension	Category	Unigrams and n-grams
Critical discourse	Discussion and thoughts	Discussion and thoughts	challenges and opportunities; infrastructure; lack; opportunities and challenges; overcome; point of view; research challenges; social; social and economic; society; socio economic
	Challenges	Challenges	barriers; challenge; challenges; challenges faced; challenges of industry; challenging; current challenges; key challenge; key challenges; major challenges
		High costs	cost; costs
		High risks	psychosocial risk; risk; risks
		Lack of expertise	expertise; skills
		Lack of trust	trust; trust based communication
		Limited resources	human resource; investment; labor; people; resource; resources
		Security and privacy	cyber security; cybersecurity; privacy; secure; security; security and privacy
		Standards	standardization; standards
		Training and education	education; higher education; training

Returning to RQ1, we can summarize our answer as follows:

Proposition 1b. *The results of our rhetoric analysis provide evidence for the existence of three types of discourses during the upswing phase, namely problem, solution and bandwagon discourse.*

Proposition 3a. *From the recent bandwagon discourse, companies seemingly misuse Industry 4.0 as an umbrella term to announce their engagement in digitization initiatives or to describe their recent efforts to digitize or automate their manufacturing and business environments, regardless of the question of whether these efforts indeed have something to do with Industry 4.0.*

Proposition 3b. *The findings from the discourse lifecycle analysis indicate that the bandwagon discourse has passed its peak, with a parallel decrease in interest in the solution discourse. Overall, fashion setters still*

attempt to promote Industry 4.0 with the help of positive rhetoric, buzzwords and success stories by emphasizing the potential and technical solutions that Industry 4.0 offers for their "performance gap".

Proposition 3c. *In addition to the problem, solution and bandwagon discourse as described above, the results reveal the existence of a parallel critical and reasoned discourse focusing on the challenges and barriers of Industry 4.0 at a relatively low level. Overall, this development might be the first indicator for a beginning downswing phase.*

5. Diffusion Analysis

Aside from the supply side of the management fashion, which we examined in a similar manner to previous literature, we also aim to gain deeper insights into the demand side of the fashion. Despite its relevance as one of the main parts of the management fashion-setting process, the diffusion lifecycle of a fashion is claimed to be an under-investigated area of research [108]. The body of literature has instead dedicated more attention to the examination of the discourse lifecycle based on bibliographic and content analyses while neglecting the demand side of the fashion, which is crucial for answering the question of whether the fashion is enduring. According to van Rossem and van Veen [108], an "awareness phase" occurs between the supply and implementation of a management fashion, in which managers become aware of the fashions in different ways, leading to a segmentation of the management population. To be more specific, individuals or groups demanding the "fashion" are managers and chief information officers (CIOs) or organizations that are interested in adopting the fashion. In comparing the discourse lifecycle of a particular fashion with its diffusion lifecycle, a further question is whether and to what extent these two lifecycles exhibit a similar pattern (e.g., by drawing the typical bell-shaped pattern over time) [17].

To further examine the diffusion lifecycle of Industry 4.0, we refer to existent primary studies on the level of adoption and diffusion of Industry 4.0. In addition to the literature search as described in the research method section, we also conduct a broad search in Google to gather relevant studies, surveys or reports that can be used for documenting the level of adoption of Industry 4.0. Overall, two studies have been identified as relevant for the meta-analysis and synthesis step.

5.1. Industry 4.0 Adoption Indicators

The survey "Deutsche Industrie 4.0 Index" (German Industry 4.0 index) has been conducted since 2014 by the consulting firms Staufen AG and Staufen Digital Neonex [109]. The results of the survey only represent the perceptions of German companies from the mechanical engineering, automotive and electrical industry; nevertheless, the survey constitutes one of the most representative and long-term studies that enable a timely view on the Industry 4.0 diffusion.

The second indicator, "Industry 4.0 investments", comprises estimations on the investments in Industry 4.0 in numerous industry sectors, including chemical, pharmacy, automotive, mechanical engineering, electrical, agriculture, logistics, public, health, retail and telecommunication. The investments, which are based on estimations of the market research institute Experton Group, are available on the statistics platform Statista [47]. In addition to the German Industry 4.0 index, the investment statistics enable us to draw a more holistic picture of the actual Industry 4.0 diffusion.

5.2. Industry 4.0 Diffusion Lifecycle

As depicted in Figure 7, both Industry 4.0 adoption indicators exhibit a continuous increase over time. Similar to the bell-shaped pattern observed in the fashion discourse (cf. Figure 2), the German Industry 4.0 index first sharply increased in 2015, with a slight slowdown in the following years. This slowdown can also be observed for the total Industry 4.0 investments from 2018 onwards. Introduced in 2014, the "Deutsche Industrie 4.0 Index" is used to measure the interest and adoption rate of Industry 4.0 in German companies. Based on the results of a comprehensive survey, an index

of 16 was initially reported in 2014, which can be interpreted as a moderate interest and adoption rate given the possible range of 0 to 100. Although the indicators are only based on the reflections of the surveyed companies as well as estimations made by a consulting firm, they can be used for assessing and predicting the adoption rate of Industry 4.0.

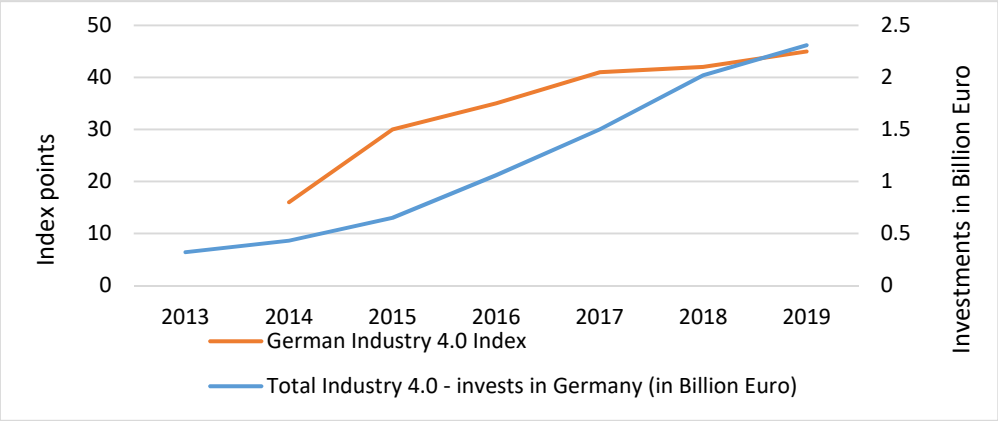

Figure 7. Selected Industry 4.0 adoption indicators.

An interesting picture emerges when comparing the relative number of academic and practical articles published on Industry 4.0 topics with the relative number of companies claiming to be at different stages of Industry 4.0 adoption. First, a noticeable trend is that a large number of companies are already implementing selected Industry 4.0 projects (pilot projects). In 2014, the number of Industry 4.0 pilot projects was relatively low (stage 3: 14%); by contrast, in 2019, 48% of the surveyed companies claimed to have implemented selected Industry 4.0 projects. However, as stated in Section 4.3, the question of whether the implemented projects constitute "real" Industry 4.0 technologies and concepts or whether the surveyed companies misuse Industry 4.0 as an umbrella term to describe their engagement in other digitization initiatives must be addressed.

As also illustrated in Figure 8, stage 4 adopters of Industry 4.0 are still rare, the relative number of companies that claim to implement Industry 4.0 on a wider scale has stagnated at a relatively low level since 2016, with an adoption rate of only 9% in 2019 compared with 7% in 2016 [109]. As stated by the authors of the German Industry 4.0 index, the ensuing impression is that even as German companies keep experimenting with Industry 4.0 pilot projects, these firms do not manage to consequently integrate Industry 4.0 into their manufacturing and business processes in a more holistic manner [109]. These observations are consistent with those in former studies of other IS and management fashions. For example, an investigation of the diffusion lifecycle around big data reveals the existence of a "deployment gap" and a "limbo stage", in which companies keep experimenting but do not proceed to deployment due to the intent to adopt big data [11]. With regard to the diffusion lifecycle of Industry 4.0, this "gap" can be identified between the stage 3 and 4 adopters.

The reluctance of the adopters is surprising, as the majority of the Industry 4.0 adopters consider their projects successful (58%), whereas only 25% recognize them as unsuccessful or neutral (17%) [109]. The pilot adopters adopt a "wait-and-see" mentality after completing their Industry 4.0 pilot projects instead of expanding their adoption engagements on a wider scale. Another indicator for the decreased interest in Industry 4.0 adoption is the fact that the relative number of companies that are in the planning and testing phase has stagnated since 2017.

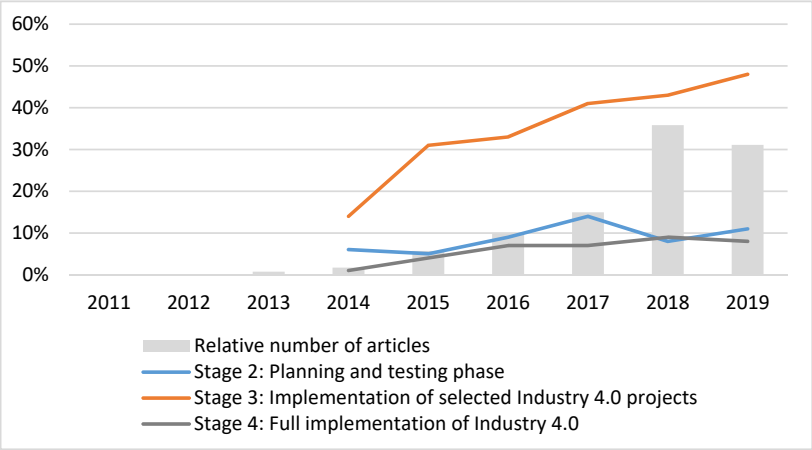

Figure 8. Industry 4.0 adopters (stage 2–4) compared with the relative number of articles.

The presented findings imply the lack of indicative evidence of the institutionalization of Industry 4.0. According to Perkmann and Spicer [110], management fashions can be institutionalized through "professionalization", a bottom–up process of permanent adoption within organizations. Permanent adoption and diffusion is acquired when the fashion has managed to be anchored within field-wide institutions after being *"broadly accepted as important, reasonable, and vital"* [110], (p. 813). In order for this to be achieved, the skilled and decentralized institutional work performed by various actors is needed. First, political work should enable the configuration of actors and the establishment of rules and property rights to create a supportive environment. Second, technical work must have been performed to facilitate the design of frameworks and third, cultural work is required to help to establish values and beliefs toward Industry 4.0 [110]. In the case of Industry 4.0, political work is provided by the German government as well as other political actors who aim to support and promote its adoption. Technical work is evident in the high number of technical experts from academic and practice integrated into initiatives, professional associations, technical consultancies, research groups and managers who are focused on the development of conceptual frameworks, standards and reference architectures [98, 111–113]. However, as the results of the discourse lifecycle analysis indicate, cultural work that supports the establishment of values and beliefs toward Industry 4.0 by addressing the social and ethical aspects of technology adoption is rather rare. Early adopters of Industry 4.0 often report the shortage of qualified personnel and resources, outdated leadership cultures or the lack of acceptance as the major challenges that hinder the achievement of the intended results of their Industry 4.0 pilot projects [109]. Thus, the following answer can be given with reference to RQ3:

Proposition 3d. *As indicated by the findings of the discourse lifecycle analysis, the recent hype surrounding Industry 4.0 has created a serious and sustainable fashion. Based on the findings of the diffusion lifecycle analysis, however, indicative evidence of the institutionalization of Industry 4.0 is lacking. Even as German companies keep experimenting with Industry 4.0 pilot projects, they do not manage to consequently integrate Industry 4.0 into their manufacturing and business processes in a more holistic manner.*

Proposition 3e. *As previously stated, the intensifying critical and reasoned nature of the discourse might be the first indicator for a beginning downswing phase. Another indicator for the diminished interest in Industry 4.0 adoption is the fact that the relative number of companies that are in the planning and testing phase has stagnated since 2017.*

6. Explanatory Model

Before discussing the results of the discourse and diffusion lifecycle analysis, we aim to summarize the main findings within an explanatory model. As illustrated in Figure 9, the proposed explanatory

model integrates the main findings of this study with empirically validated findings on former management and IT fashions from extant research to provide an enhanced understanding of the observed findings. Furthermore, the answers and propositions (*P1–P3*) to the research questions (RQs) are integrated into the explanatory model to enhance the overview of the findings. Beginning with RQ1, the results of our bibliographic analysis confirm that the Industry 4.0 fashion arena consists of various political, practical and academic actors being responsible for the fashion supply, with political actors playing a leading role in promoting Industry 4.0, while practitioners and academics actively contribute to the discourse at a later stage (*P1a*). Our results are thus congruent with the findings of Reischauer (2018), who critically describes Industry 4.0 as a "policy-driven innovation discourse in manufacturing industries that aims to institutionalize innovation systems that encompass business, academia, and politics" [46] (p. 31). Overall, these actors from business, science and politics shape the fashion discourse of Industry 4.0 by acting as opinion leaders within the debate, which is in line with the principles of management fashion theory.

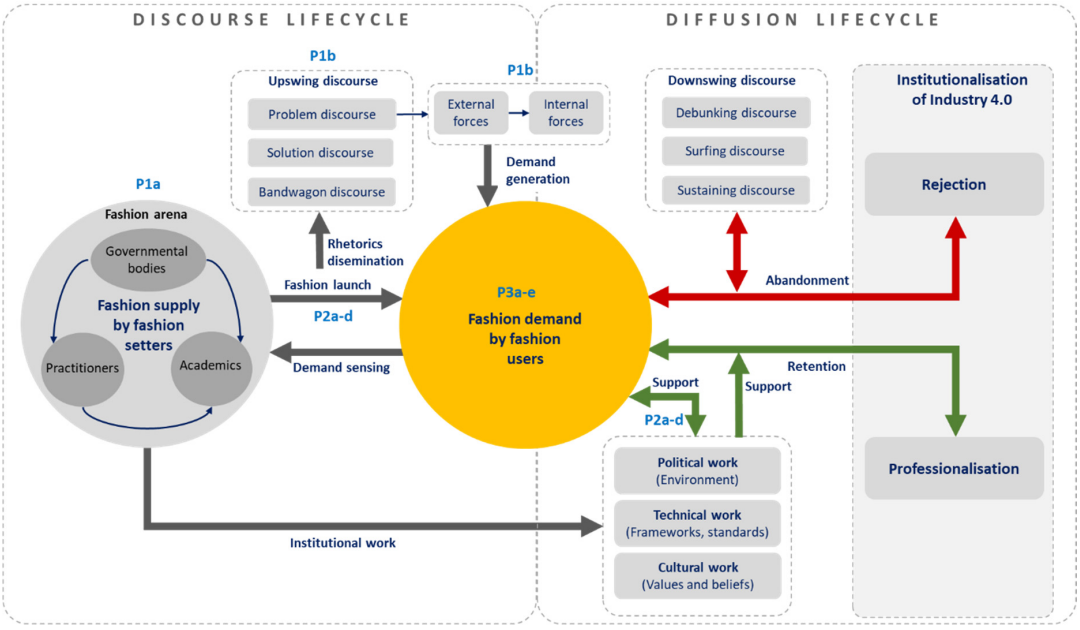

Figure 9. Explanatory model for the Industry 4.0 fashion development path.

Based on our investigation of the rhetoric disseminated by fashion setters during the fashion launch process (*P2a-d*), to answer RQ2, we have observed that Industry 4.0 is primarily associated with the manufacturing sector. Although the term Industry 4.0 was introduced in 2011, a proper definition of Industry 4.0 is still lacking [114]. In the literature, Industry 4.0 is portrayed as a bundle of technologies that comprise, big data, IoT, RFID and CPS, among others. The fashion discourse around Industry 4.0 is shaped by a technological focus, with less attention on social, economic and ethical considerations (*P2a-b*). The rhetoric is also shaped by a strong focus on economic benefits and positive impacts such as improved efficiency, quality, productivity and competitive advantage (*P2c*). On the contrary, multiple challenges are mentioned, which hinder the broad adoption of Industry 4.0 (*P2d*).

Additionally, the results from our rhetoric analysis provide evidence for the existence of three types of discourses used by fashion setters during the upswing phase, namely problem, solution and bandwagon discourses *(P1b)*. The fashion setters use emotionally charged and positive rhetoric within these discourses to emphasize the external forces such as the intensifying global competition and the growing demand for individualized products and internal forces such as increasing complexity and high energy consumption (*problem discourse*). These forces, in turn, are then used to highlight the need for adopting Industry 4.0 with the promise of the potential benefits that Industry 4.0 offers for efficiency gains and competitive advantage (*solution discourse*), illustrated in

best practices and success stories (*bandwagon discourse*). As stated by Abrahamson [9], the selection of a management fashion is affected by external and techno-economic forces. In the case of Industry 4.0, the aforementioned internal and external forces highlighted in the problem discourse are used for creating this fashion demand (*P1b*).

The answer to the question of whether the recent hype around Industry 4.0 constitutes a serious and enduring fashion that will soon be institutionalized (RQ3) can only be partially answered to date. From the rhetoric analysis, various key findings can be reported on the fashion demand that has been created as a result of the fashion launch process. First, the content and rhetoric of the bandwagon discourse indicate that fashion followers misuse Industry 4.0 as an umbrella term for their digitization projects, regardless of the question of whether these projects indeed constitute an Industry 4.0 project (*P3a*). Anecdotal evidence has also demonstrated that the bandwagon discourse is still ongoing, with a parallel increasing interest in the solution discourse as well as a more silent, critical and reasoned discourse focusing on the challenges and barriers of Industry 4.0 at a relatively low level. This development, in turn, might be the first indicator for a beginning downswing phase (*P3b-c*).

The recent hype around Industry 4.0, as indicated by the results of the discourse lifecycle analysis, has led to a serious and enduring fashion that goes beyond the borders of German-speaking countries. Consistent with the results from the discourse lifecycle analysis, the diffusion lifecycle of Industry 4.0 also displays a bell-shaped pattern that indicates an increase in the companies' interest towards the Industry 4.0 concept at a similarly high level as has been presented in the discourse lifecycle analysis. However, indicative evidence of the wide institutionalization of Industry 4.0 in business practice is still lacking (*P3d*). As consistently stated in the literature, the widespread adoption of Industry 4.0 has not occurred thus far despite the opportunities that Industry 4.0 offers for business and society [94]. As confirmed by David and Strang [115], managerial enthusiasm and acceptance begin to decline when implementation problems on the adopted fashion arise. This case is true for Industry 4.0. Contrary to the positive portrayal of Industry 4.0 as a panacea for a broad range of problems, which is evident from the fashion discourse, fashion setters have not managed to eradicate the concerns of fashion followers. Although German companies keep experimenting with Industry 4.0 pilot projects, they do not manage to consequently integrate Industry 4.0 into their manufacturing and business processes in a more holistic manner (*P3d*).

As previously stated, the intensifying critical and reasoned nature of the discourse might be the first indicator for a beginning downswing phase. Another indicator for the diminished interest in Industry 4.0 adoption is the fact that the relative number of companies that are in the planning and testing phase has stagnated since 2017 *(P3e)*. Previous management fashion research has indicated that the institutionalization of fashions can be facilitated by the skilled and decentralized institutional work performed by various actors [110]. In the case of Industry 4.0, this institutional work is provided by multiple fashion setters from the fashion arena (*P2a-d*). Political work is provided to create a supportive environment for Industry 4.0 adoption, whereas technical work is conducted via conceptual frameworks, standards and reference architectures to develop a solid technical foundation [98,116,117]. However, as also indicated by the results of the discourse lifecycle analysis, cultural work that helps to establish values and beliefs toward Industry 4.0 by addressing social and ethical aspects of the technology adoption is still at a relatively low level.

Overall, the results of the discourse and diffusion lifecycle analysis indicate that the fashion around Industry 4.0 signifies a serious and enduring fashion. Based on the rhetoric analysis, a slight indication for the beginning of a debunking discourse is apparent. According to management fashion theory, the downswing discourse consists of a debunking discourse, followed by a surfing and sustaining discourse [17]. In these phases, the discourse turns into a more qualified, reasoned and unemotional debate.

Given these findings, the possible development paths of Industry 4.0 are manifold. As illustrated by the green arrows in the explanatory model, the provision of more institutional work would help to boost the demand of the fashion users and to facilitate the retention of its institutionalization process via

professionalization. Another development path of Industry 4.0 includes its abandonment and rejection (red arrows), which is already evident considering the existence of a reasoned discourse as well as the decreased interest in Industry 4.0 topics, as described above. Thus far, the question of whether this fashion will be institutionalized via professionalization depends on the extent to which the institutional work will proceed to help fashion users overcome their concerns about the reported major challenges such as the shortage of qualified personnel and resources, outdated leadership cultures and the lack of acceptance (Staufen 2019, p. 22). In the case of a successful "professionalization", Industry 4.0 will be a permanent part within organizations after being *"broadly accepted as important, reasonable, and vital"* [110].

7. Discussion

7.1. Implications for Research and Practice

Informed by empirically validated findings on former management and IT fashions as well as the principles of management fashion theory, the proposed explanatory model offers a summary and synthesis of the main findings of this study. In sum, the presented results are expected to be of value for research and practice for multiple reasons.

First, the results of this paper contribute to the ongoing discourse on Industry 4.0 by analyzing this phenomenon through the lens of management fashion theory and thus enabling a more holistic understanding of the recent developments around Industry 4.0. This enhanced understanding, in turn, helps us to assess the possible development paths of this fashion and identify possible actions for the involved political, practical and academic actors. Companies that are interested in the Industry 4.0 concept, for example, can analyze and adjust their own beliefs toward Industry 4.0 based on the results of this study prior to continuing their adoption efforts. Researchers can use the results to identify possible directions that can be pursued in future studies. The examination of recent technological innovations through the lens of management fashion theory, as is the case with Industry 4.0, can further help to compare the development path with those of former management fashions.

The presented findings of the analyses reveal that Industry 4.0 indeed constitutes a management fashion that has recently reached its peak in terms of the discourse and diffusion lifecycle, with the first signs for an upcoming downswing. However, the decline of a fashion's popularity does not automatically imply that it has failed to institutionalize. As has been stated by extant research, fashions wear out on use [20]. In the case of the business process reengineering fashion, for example, "wearing out through use" has been found to account for the concept's decline [20]. With regard to Industry 4.0, however, indicative evidence of the wide institutionalization of Industry 4.0 in business practice is lacking. At this point, one aspect requires clarification—a concept labelled as a management fashion, such as Industry 4.0, does not automatically imply that it is necessarily senseless or lacking usefulness. Previous studies have indicated that some management and IT fashions have managed to diffuse in organizational practice, emphasizing their enduring acquirement in organizational life. For example, this case holds for enterprise resource planning [22], customer relationship management [25] or mobile banking [13].

Given these findings, several implications emerge for fashion setters, fashion users and other involved actors. Similar to previous management fashions, the Industry 4.0 fashion arena including the involved political, practical and academic participants still uses rhetoric to play co-operative games within the fashion arena and promote the new fashion [34]. To date, the fashion discourse on Industry 4.0 is shaped by an emotionally charged, positive and enthusiastic as well as largely uncritical sound that is aimed to promote the benefits of Industry 4.0. As Industry 4.0 entails not only benefits but also challenges for organizations, the debate must be enriched by a more unemotional and reasoned perspective. As previously stated, the discourse lifecycle analysis indicates the existence of a critical and reasoned discourse focusing on the challenges and barriers of Industry 4.0 at a relatively low level. However, the results of the diffusion lifecycle analysis reveal that fashion users still hesitate

to adopt Industry 4.0 for several reasons. On the one hand, a large number of companies already implement selected Industry 4.0 projects [109]. On the other hand, these pilot adopters hesitate to expand their adoption engagements on a wider scale after completing their Industry 4.0 pilot projects. Another indicator for the reduced interest in Industry 4.0 adoption is the fact that the relative number of companies that are in the planning and testing phase has stagnated since 2017, according to recent studies. The reason for this hesitation might be found in the fact that early adopters of Industry 4.0 often report the shortage of qualified personnel and resources, outdated leadership cultures or the lack of acceptance as the major challenges that hinder the achievement of the intended results of their Industry 4.0 pilot projects [109].

As emphasized by Perkman (2008), the institutionalization success of management fashions is affected by multiple factors such as political networks, technical capabilities and cultural work, which help to frame a fashion. Given these considerations, a key point to underscore is the need for further institutional work to help Industry 4.0 fashion users with their adoption engagements and hence achieve "professionalization" at an organizational level. For example, technical work helps to turn the vague concept of Industry 4.0 into a more interpretable one and thus contribute to an enhanced understanding of the technical concept behind a management fashion such as Industry 4.0 to help potential fashion users to implement it [110]. By contrast, political work helps with creating a supportive environment, including the necessary rules and infrastructure to be diffused. In addition, cultural work helps fashion users to "embed a fashionable management practice within wider systems of values, notably professional skills and identities" [110]. Further cultural work that helps with the establishment of values and beliefs toward Industry 4.0 constitutes an urgent necessity to address the social and ethical aspects of technology adoption.

As implied by the results of the discourse lifecycle analysis, another important direction for future studies is concerned with the perspective of the research. To address the challenges caused by the increasing digitization of business environments in the context of Industry 4.0, the investigation of the implications of this transformation process from multiple perspectives is necessary. For example, future research should focus not only on technical issues but also on social and ethical concerns (e.g., the perspective of the employees, including their expectations and perceptions toward the challenges). In this context, a key aspect to highlight is the need for further interdisciplinary research that combines knowledge from different disciplines to address these challenges in a more holistic manner. As stated in previous management and IT fashion literature [14,118], the academic discourse on fashions tends to appear relatively later within a discourse lifecycle. With regard to the fashion discourse on Industry 4.0, this tendency can be confirmed. Hence, increased academic involvement is therefore needed to actively shape the fashion-setting process by providing a more critical perspective on the ongoing fashion at an earlier stage of the fashion lifecycle.

The results presented in this study also cast doubt on several best practices and success stories on Industry 4.0 being reported in recent years. As has been found in the rhetoric analysis, fashion setters misuse Industry 4.0 as a buzzword to announce and promote new products or services. Fashion users similarly interpret Industry 4.0 as an umbrella term to describe their engagement in digitization initiatives or recent efforts to digitize or automate their manufacturing and business environments, regardless of the question of whether these efforts indeed have something to do with Industry 4.0. The reason is that even nine years after its introduction, the term Industry 4.0 still leaves room for interpretation. The term "interpretative viability", in the context of management fashions, underscores the ambiguity in the fashion's content [20,34,119]. According to Benders and Veen (2001), interpretative viability constitutes a key characteristic of management fashion, implying that the fashion users' interpretation of a fashion depends on what they believe in, thus allowing for different interpretations and uses of a fashion. To enhance the understanding of the fashion users' interpretation of the Industry 4.0 term, further research should focus on the analysis of the adoption of Industry 4.0 in business practice. Previous studies on the adoption of Industry 4.0 have already highlighted the lack of understanding of Industry 4.0 adoption, while confirming the necessity to further examine the adoption patterns of

Industry 4.0 technologies in business practice [71]. Thus, future research could focus on investigating how the term Industry 4.0 is interpreted by fashion users and the extent to which the concept is actually implemented by the pilot and full adopters of Industry 4.0. The findings could help to solve the ambiguity in the concept and identify the reasons for the adopters' hesitation to expand their adoption engagements on a wider scale after completing their pilot projects.

Given these findings, the question of whether the recent hype around Industry 4.0 constitutes a short-lived fashion must be neglected. Rather, Industry 4.0 demonstrates the characteristics of a serious and enduring IT fashion. Compared to the emperor's invisible clothes in Hans Christian Andersen's tale "The Emperor's New Clothes", there is indeed something to see in the case of Industry 4.0. However, given the ambiguity surrounding the Industry 4.0 concept, the question of what is really visible depends on the issue of what the fashion setters and fashion users believe in.

7.2. Limitations

Notwithstanding the knowledge gain described above, this study is subject to some limitations that also provide starting points for future research. First, the results of the discourse lifecycle analysis are based on a sample of 3920 academic and practical publications that we identified as relevant for this study. Although we accessed various interdisciplinary literature databases for the search, such approach cannot guarantee the inclusion of all the relevant publications. Furthermore, the sample exclusively consists of publications written in English and German. Consequently, the results solely reflect the management fashion discourse on "Industry 4.0" in English- and German-speaking countries. Thus, the debate in other geographical regions (including some very economically strong ones) is disregarded in this study. Possible extensions of this research could include publications in other languages to obtain a more holistic picture of this fashion discourse.

Another limitation is concerned with the data used for the diffusion lifecycle analysis. As the results on the level of adoption and diffusion of Industry 4.0 are based on only two selected indicators, the results cannot be generalized. Furthermore, the selected indicators only represent the perceptions of German companies from the selected industry sectors. Thus, the conclusions made based on the results of the diffusion analysis are restricted to the included industry sectors in the German-speaking area. The examination of the adoption and diffusion levels of Industry 4.0 in other geographical areas signifies another necessary step for future research to obtain a more comprehensive picture of the actual diffusion of Industry 4.0.

The third limitation of our discourse analysis relates to the method of analysis applied. As explained in Section 3, we performed a frequency analysis that served as the basis for a statistically-based text interpretation [120].Thus, patterns within publications were identified. To obtain these results, a coding procedure was initially conducted, which was used for assigning each unigram and n-gram to iteratively defined categories. Importantly, several overlaps emerged between the individual categories, hence, unigrams or n-grams could have been assigned to more than one category. Although this coding process was independently conducted by two researchers to enhance objectivity, we cannot guarantee that the coding procedure is free from selection and subjective biases.

One other major limitation of this study relates to its focus on the examination of Industry 4.0 and some related synonyms such as Industrial Internet and Internet Plus. Although Industry 4.0 represents an attractive subject for analysis due to the increased attention being paid to it, other digitization initiatives and similar management fashions merit an examination. Further research is needed to extend and validate the findings of this research with the results from other fashions.

8. Conclusions

This paper examines the recent hype around the Industry 4.0 phenomenon. By using management fashion theory as a theoretical foundation, our primary purpose is to enhance the understanding of the question of how Industry 4.0 has emerged as a management fashion, which actors play a major role in this fashion and the extent to which this fashion has diffused in organizational practice.

The findings confirm that the Industry 4.0 fashion discourse is shaped by various political, practical and academic actors being responsible for the fashion supply, with political actors playing a leading role in promoting Industry 4.0; meanwhile, practitioners and academics actively contributed to the discourse at a later stage. In the literature, Industry 4.0 is portrayed as a bundle of technologies that comprise, among others, big data, IoT, RFID and CPS. The focus within the Industry 4.0 fashion discourse is directed toward technological aspects, with less attention on social, economic and ethical considerations. Overall, fashion setters still attempt to promote Industry 4.0 with the help of positive rhetoric, buzzwords and success stories by emphasizing the potential and technical solutions that Industry 4.0 offers for their "performance gap". The increased attention being paid to Industry 4.0 in business and academic literature, combined with political efforts in promoting its adoption, has led to a serious and enduring IT fashion, with organizations across industries embarking on digital transformation initiatives. However, the general picture that emerges from the discourse lifecycle and diffusion lifecycle analysis is contradictory. The discourse around Industry 4.0 creates a picture of this concept as a panacea for all business problems; by contrast, the results of the diffusion lifecycle analysis indicate that fashion users still hesitate to adopt Industry 4.0 on a wider scale due to the ambiguity in the conceptual interpretation. Thus far, the question of whether Industry 4.0 will be institutionalized in corporate practice depends on the extent to which the institutional work will proceed to help fashion users overcome their concerns about this conceptual ambiguity. The institutionalization and professionalization of Industry 4.0 in organizational practice would help achieve a more widespread diffusion of the Industry 4.0 concept, on the way to a more sustainable future of work and society in an environmental, economic and social sense.

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