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Innovation and SDGs through Social Media Analysis: Messages from FinTech Firms

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Abstract: Financial technology-based firms (FinTech) are crucial to promoting new technologies and advances in innovations related to the financial field, sustainable development, and financial inclusion. This paper aims to assess the Sustainable Development Goals (SDGs) and open innovation integrated within the public discourse in the social media of FinTech firms, using machine-learning-based social media analysis (SMA). Accordingly, we tracked the behavior of 21 firms based on the empirical material of 32,716 posts on Twitter. The outcomes showed dissimilar discourses based on FinTech firms' activities. However, it was found that only financial infrastructure, lending, and personal finance fields have a discourse related to innovation and, to a lesser extent, related to the SDGs thematic. Thus, awareness of sustainable objectives is still far from being a relevant issue for FinTech, which, in general, has neglected to significantly mention SDGs; nonetheless, innovation and related terms are a consistent topic in this area. Furthermore, hints of the implementation of the open innovation paradigm and interest in novel technologies are demonstrated, in addition to the promotion of different actors and events on social media that serve as a showcase for firms that have a presence on Twitter.

Keywords: innovation; FinTech; open innovation; Sustainable Development Goals; social media analysis; Twitter; text mining; natural language processing

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1. Introduction

Knowledge-intensive business services (KIBS) include an extensive scale of services that are mainly involved in the business-to-business domain. KIBS involves a set of activities through intermediary inputs that impact the quality and efficiency of firms' activities, cover a broad spectrum of services, and are tied to the production processes of their clients [1,2]. According to Lee and Miozzo [3], "science-based firms comprise firms in sectors such as software and specialized business services". Consulting, audit, transaction advisory, taxation, consulting, risk advisory, and technology-oriented firms are part of KIBS, and they add value through the accumulation, creation, or dissemination of knowledge for their client's needs [4].

In addition, under the umbrella of KIBS, financial services supply comprehensive access to global financial capital, for instance, credit, saving, and investment [5]. One example is the so-called FinTech companies, which are organizations based on new technologies and offer digital services (such as mobile payments, crowdfunding, and digital transfers), and are mostly start-ups operating via new digital means. Mosteanu and Faccia [6] note that, "in general, FinTech companies aim to provide the most innovative financial services which, thanks to digital technologies, can be developed and evolve to bring new benefits to end-users, individual consumers, large companies, or SMEs". Leong et al. [7] states that FinTech is a broad umbrella term that describes disruptive technologies in the financial services sector.

Considering the high implication of technology in the FinTech business model, the open innovation paradigm plays a relevant role in promoting the participation of interest groups in certain relevant issues using participatory channels that can lead to an active interaction between users of this type of financial services. Although it might require some efforts to sustain market open innovation by enabling new business models in a business-friendly regulatory environment [8], attracting investors and new clients with high social awareness could be achieved by demonstrating themes such as sustainable energy, care for the environment, social inclusion, and poverty reduction to maintain the interest of people in these topics. In this sense, corporate social responsibility creates innovation opportunities. In addition, it plays a relevant role concerning the commitment of organizations and their influence to lead initiatives with social content, which may create value [9].

According to Arner et al. [10], FinTech firms are a key driver of digital transformation, financial inclusion, and sustainable growth under the United Nations (UN) Sustainable Development Goals (SDGs). Thus, it may be of interest to compare how participants in the FinTech sector communicate digitally among themselves about innovation to understand their situation. Indeed, the UN acknowledged that innovation [11] plays an important role in addressing the SDGs. Moreover, the financial sector plays a vital role in the implementation of SDGs because they require a substantial sum of capital flows, investments, and redistribution of funds [12].

Through the usage of technology, social media opens new channels to spread FinTech firms' messages, allowing information about their products and services to be shared with clients and partners [13]; however, not all FinTech companies use social media. The impact of information technology on business and innovation is remarkable [14], and it has been considered critical to obtain knowledge from the information available in their social media channels. However, the wide range of possibilities related to technologies is also associated with new challenges in understanding the firms' discourse regarding certain topics. As an example, efforts regarding the data collected from social media are focusing on the development of new products and campaign performance to distinguish the preferences and trends of clients [15]. Moreover, as a business strategy, social media in innovation-driven companies has been continuously growing, considering the open innovation context, by leveraging digital communication and community tools [16]. The culture of the business world is continuously evolving, and social problems and FinTech's challenges are also part of this change. As part of the communication channel of companies implementing the open innovation paradigm, social media is a critical means to obtain valuable information [17].

The new technologies have generated a "data deluge" that reveals interesting insights from vast quantities of data. The popular microblogging platform Twitter and other social media platforms provide a prime environment for developing a framework that could facilitate information retrieval to support the analysis and management of big data on social media [18]. Furthermore, firms need to gain business value, incorporating social subjects into their discourse in social media, in addition to interacting with clients and publicizing services and products, among other purposes [19]. This is mainly because Twitter is a primary communication system in which there is an interest in building communities and creating a virtual environment for the flow of ideas. Indeed, Twitter can be considered to be part of the entrepreneurial innovation ecosystem, and the community of actors interacting with FinTech firms represents a unique scheme to produce inter-organizational streams of sustainable innovation and entrepreneurial behavior [20,21].

This research aims to understand how the topics of SDGs and innovation are incorporated into FinTech firms' public discourse in social media. Therefore, this work intends to answer the following research question: How do Fintech firms incorporate topics of SDGs and innovation into their public discourse based on their social media activities? Hence, the discourse of the FinTech environment—including open innovation and technologies associated—was used to explore text associated with these relevant topics. This

research used a quantitative approach based on data analysis from Twitter, implementing a comprehensive social media analysis (SMA). We carried out an exploratory investigation, emphasizing the ninth SDG related to "Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation", and titled "Industry, Innovation, and Infrastructure". However, to differentiate the firms' focus, we counted innovation separately from the other SDGs search terms. In addition, we conducted general scraping in those terms that refer to the SDGs, either through this acronym or key terms such as sustainability and the UN objectives.

This article is organized as follows. Section 2 outlines the background of the relevant topics considered for this study, which are mainly related to financial technologies, social media, innovation (including open innovation and new technologies associated), and SDGs. Section 3 describes the models of the machine learning techniques applied to our data collection of tweets. Section 4 presents our findings. A discussion of the results, the conclusion, and future work is presented in the last section.

2. Background

2.1. Social Media and the Digital Financial Sector

A recent literature review conducted by Olanrewaju et al. [22] highlights the importance of social media usage for the digital business development process, either for marketing, information search, business networking, or crowdfunding. They noted two research gaps that this study aims to address: (i) to examine how SMA and collective interaction features stimulate innovation; and (ii) to identify how these implicit or explicit interactions differ among different type of FinTech firms. Gomber et al. [23] present social media as one of the dimensions that requires further research, which is particularly related to the concepts applied to digital finance technologies and business. Prüfer and Prüfer [24] identified the use of different artificial intelligence (AI) techniques (i.e., basic text mining, information extraction, sentiment analysis, semantic similarity, topic modeling, linguistic and word count, machine learning, text analytics, and web data scraping) as key data science methods that are applied to digital business research. They note these approaches may require special data storage, accessibility, and processing due to the nature of the vast quantity of information generated by Twitter, LinkedIn, Facebook, Instagram, blogs, and web pages, and the complexity of the algorithms used.

Social media have been used to help managers promote their products and services and ensure that they are selected at the screening stage. Indirectly, social media also helps attract the attention of investors during negotiations in the last stage of the venture capital process [25]. In addition, social media helps with the identification of the personalities of individuals (e.g., entrepreneurs, managers, employees) via their tweets, thus allowing cross-comparison of entrepreneurial characteristics [26] to understand their strategy implementation. Najib et al. [27] noted that "FinTech managers need to use social media and increase the involvement of competent and influential figures in public conversations on social media about FinTech". Thus, the importance of this communication channel cannot be ignored, considering that entrepreneurs and other actors have benefited from the adoption of FinTech advantages by and assuming a technological niche to develop their own business.

Haddad and Hornuf [28] categorize FinTech firms into nine different types of start-ups: financing, payments, asset management, insurance (InsurTechs), loyalty programs, risk management, exchanges, regulatory technology (RegTech), and other business activities. These categories resemble those of the Finnovating (Finnovating is a Spanish strategy consultancy focused on open innovation and the FinTech sector https://www.finnovating.com/ accessed on 23 January 2020) FinTech map, which is based on the taxonomy established by the different start-up activities. According to the July 2019 FinTech Spanish map version, 358 start-ups were identified, with the following classifications: lending, financial infrastructure, financial products distribution, tax and accounting solutions, personal finance, "neobanks", currencies, trade finance, equity finance, investment, and payments.

Despite the trend toward organizational flattening and the benefits of digitalization to access globalized sources of knowledge and funding, recent studies have identified that FinTech entrepreneurial activities usually take place in specific geographic regions known as start-up or FinTech hubs [28].

2.2. The Role of Open Innovation and Social Media as a Comparative Advantage for FinTechs

To employ social media, FinTech companies must address the open innovation strategy to boost their capabilities. The importance of the opportunities and challenges allows organizations to transform their business based on SMA. Dong and Wu [29] stated: "Open innovation is growing rapidly as the emergence of social media technologies". Moreover, social media is a highly important tool of technology watch, which is an innovation management technique and part of the process in many models to create long-lasting advantages for technological firms [30]. Du et al. [31] noted that social media has driven the open innovation concept, dedicating resources to cultivate a firm's sustainability orientation and integrating it into the new product development process; that is, open innovation is needed at a strategic level. Nonetheless, innovation management tools are necessary at an operational level to allow innovation actions to be carried out. Social media can provide access to novel information about customer needs and technological solutions unknown to the firm, and this advantage must be utilized by FinTech firms. Indeed, using social media input could increase innovation project performance as firms obtain access to novel market insights and innovative technical solutions [32]. In addition, valuable information could be obtained by examining the discourse on Twitter.

Once the comparative advantages of social media and open innovation in the field of FinTech are established, it appears that organizations are willing to create a strategy that emphasizes the contribution of innovation and resources, sharing a vision and goals, and providing an appropriate framework for change [33]. The combination of open innovation and FinTech firms creates a disruptive business model that is capable of disrupting traditional financial markets [34]. Corral de Zubielqui et al. [35] addressed the leveraging of new mechanisms to access information from outside actors, customers, and other social media users to facilitate innovation and firm performance. Furthermore, large firms (e.g., Goldman Sachs and JP Morgan Chase) have envisioned the adoption of FinTech entrepreneurship, organizing teams and individuals to promote new actions through open innovation and exchanging knowledge with startups and other stakeholders [36,37].

2.3. Twitter: A Vast Repository for Social Media Analysis

In social media platforms, users contribute to the creation of content, distribute it, and share it with others [38]. In addition, companies, politicians, artists, and ordinary citizens have taken advantage of this new scenario, allowing new forms of interactions, disseminating ideas, and offering products and services, concerns, and even business strategies. Furthermore, social media include blogs, content communities' networking sites, virtual game worlds, and virtual collective worlds. To assess the role of social media and its impact on the relationship between companies and users, modern online social and technological systems are producing real changes in the traditional networking paradigms and the way that we communicate with each other [39]. As a result, the activity of users has increased in recent years on platforms such as Facebook, Twitter, LinkedIn, Instagram, and YouTube.

Twitter has several characteristics and functionalities, such as its extensive open network in the public domain, and tweets can feature hashtags (#), which join a post to a particular theme and allow users with equal or opposing views to be identified. In addition, a retweet (rt) is a means of reprinting messages of different users, thus representing a powerful mechanism for information sharing [40]. Twitter users can search for information such as breaking news, posts about celebrities, and comments about users (e.g., companies, individuals). As a result, it is an ideal source for locating information about societal interests and general opinions [41]. Furthermore, researchers can use it to study

the perceptions and interactions between users and FinTech firms and these companies' networking activity. For example, American entrepreneurial networks were identified from Twitter data, highlighting the importance of interactions between companies with similar socioeconomic and demographic profiles [42] as a result of research techniques including web scraping, network analytics, community projection, and flow maps.

Twitter messages, called "tweets", are limited to a length of 280 characters and can be viewed by a user's followers. Researchers have shown interest in tweets as an expression of peoples' emotions, including favorited tweets and retweets in some situations [43]. Tweets provide a type of measure that could be useful to analyze Twitter users and their network behavior. For this research, Twitter provides a significant capability for studying the behavior of the FinTech ecosystem and working with big data applications to obtain keywords, based on the large quantities of information that can be retrieved and processed more quickly. This enables sentiment-related insights that would be difficult to discern with small quantities of data [44].

Among machine learning techniques, natural language processing (NLP) deals with the natural language in the form of text, voice, etc. [45] through the interaction between humans and computers. This was developed using the ability of a specific computer program to recognize the human language. In the context of Twitter, the focus of this research, the use of NLP, implies a large collection of tweets. A major task in the field of NLP is opinion mining, which is also called sentiment analysis and is the approach used to develop strategies to automatically retrieve opinions about products or entities from text. Opinion mining is the process of computationally identifying, categorizing, and analyzing the opinions, sentiments, and subjectivity expressed in text to determine the writer's attitude concerning a topic [46–48]. Research in this area began in the early 2000s, and much progress has subsequently been made [49].

2.4. Sustainable Development Goals: The Context for FinTech's Discourse

In 2015, the UN published its 2030 agenda for sustainable development (https://www.un.org/sustainabledevelopment/development-agenda/ accessed on 19 February 2020). This agenda is a plan to address the greatest global challenges related to the sustainable triple helix, which is aimed at balancing the achievements of economic, social, and environmental sustainability. A list of 17 SDGs was defined to implement this agenda, among which can be mentioned: no poverty, quality education, affordable and clean energy, industry, innovation, and infrastructure, and climate action, just to cite a few examples. In total, the SDGs' five key areas of significant relevance for humanity are people, planet, prosperity, peace, and partnership. These areas are often part of the corporate social responsibility of companies.

To shed light on how social media can be applied to interact with users regarding topics such as SDGs, Arnaboldi et al. determined that social media technology is mainly used by people under 30 years old, enabling them to connect with other users globally, and access, post, and share information on a regular and continuous basis [50]. Companies and others can collect, organize, and analyze the mass of information available on social media to improve business performance across a wide range of corporate functions.

Information and digital technology were previously seen as a tool in the context of financial industries. Currently, FinTech firms are digital-based companies entering the financial sector for three main reasons: (i) they offer new products and solutions that fulfill customers' needs that have not sufficiently been addressed by incumbent financial service providers; (ii) they have created novel opportunities for selling products and services through the application of novel technologies and concepts; and (iii) they provide services in a highly innovative environment. In addition, using ICTs, such as Internet-based social media apps, helps to create a permanent culture of transparency that includes trust, empowerment, social capital, and bureaucratic acceptance [51]. Therefore, analysis of Fintech companies is a suitable approach to assess the progress toward the achievement of the SDGs.

Since changes and developments in the domain of communication and information technologies can be rapid and dynamic, companies in this field need to be agile and innovative. Therefore, such IT companies often have a culture that is distinctively different from that of established financial service providers. IT companies are sufficiently agile and innovative to place pressure on the established players. FinTech firms concentrate on affordable and cost-efficient Internet-based business models to challenge established financial services providers [23].

3. Methodological Framework

This section introduces the steps comprehensively to carry out the SMA implementation to understand the FinTechs public discourse in the social media domain. The methodology has been designed to address relevant topics such as the UN SDGs and innovation field, including open innovation and novel related technologies.

Figure 1 provides an overview of the framework and research approach implemented in this work, as it provides a system to capture information messages from social media. It starts with the identification of FinTechs start-ups (358 firms) and the Twitter activity analysis of each sample with a criterion of minimum tweets for its later modeling implementation. Once the firms have been selected (21 firms) in the designated period, we proceed to filter based on hashtags to obtain the collection of documents (JSON files) to be processed according to selected tweet variables. After collecting documents, the pre-processing phase includes the NLP applications, which comprises loading data, data cleaning, exploratory analysis, and preparing data for interpretation. Finally, the text analysis and classification are compiled in a Twitter word cloud to check the outputs of unigrams and their consequent algorithms such as a bag of words and topic modeling implementations, which are mainly used for uncovering hidden structures in a collection of texts. Indeed, the purpose of our study is to extract the discourse that occurs in social media. In this way, we have built a helpful methodological framework to address the main steps of a comprehensive topic understanding. We explain in detail the whole process in the following sections.

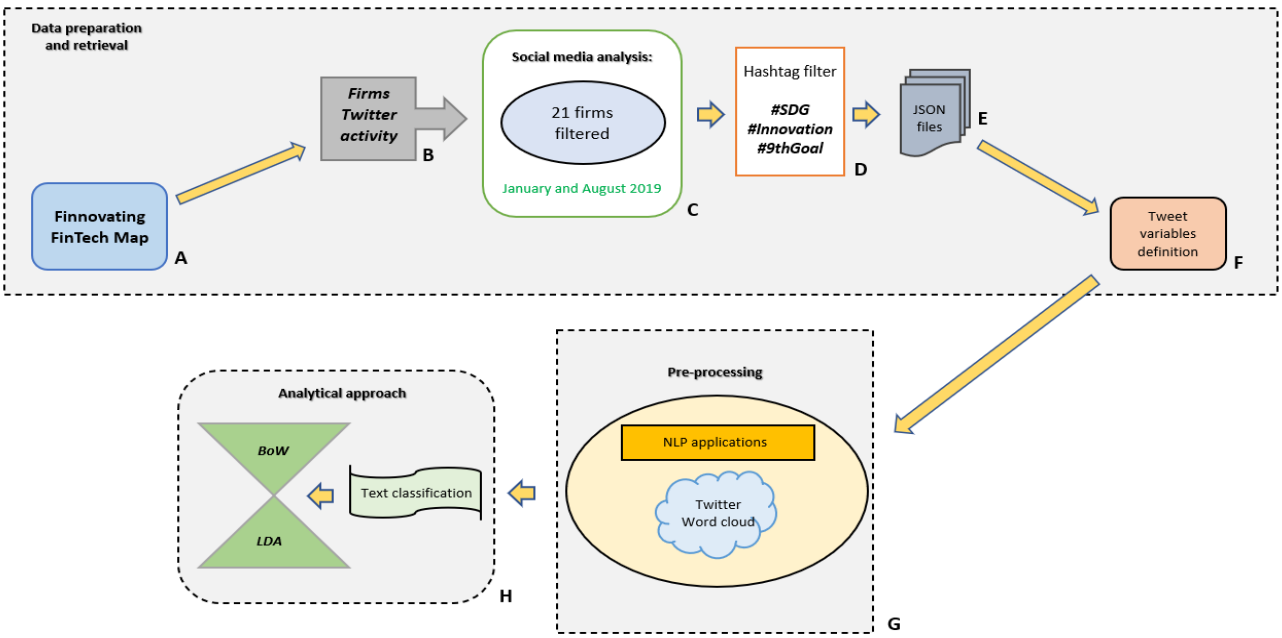

Figure 1. Overview of the methodology. The steps (**A**–**H**) described in this Figure are detailed along the Methodological Framework section.

3.1. Data Preparation and Retrieval

We selected these companies based on the Finnovating Spanish map (see Figure 1A), which provides a helpful taxonomy that precisely indicates the category of activity in which the FinTech firms operate: lending, financial infrastructure, financial products distribution, tax and accounting solutions, personal finance, currencies, equity finance, investment, and payments. The SMA was conducted for eight months, between January and August 2019.

Subsequently, we analyzed from the total amount of 358 firms those who have displayed constant activity on this form of social media. This research encompassed the Twitter accounts of FinTech firms based mainly in Spain and including those start-ups with a presence in other countries. The focus of this phase was to select the start-ups divided by their economic activity containing those who are most active on Twitter (Figure 1B). Therefore, the required samples to have insights from machine learning implementations must establish feasible requirements and obtain meaningful outcomes, providing those who meet a reasonable number of tweets, to be correctly processed [52]. Then, we established as a selection criterion those with more than 400 tweets in the period designated for this investigation. Hence, the base of minimum tweets amount per organization has been set so that this sample can be sufficiently robust to have the correct functioning of the machine learning algorithms be implemented in a later stage.

Table 1 lists 21 companies, based on their financial activity, and the number of tweets retrieved during the research period. Data were collected from a sample of 32,716 public tweets retrieved using the Twitter Scraper (see https://github.com/taspinar/twitterscraper/ accessed on 30 January 2020) and based upon FinTech firms' usernames (Figure 1C).

Table 1. The 21 FinTech companies selected based on their Twitter activity.

#	Financial Activity	Company Name	Number of Tweets
1	Lending	Creditea	827
2	Lending	Goteo Funding	2749
3	Lending	Aplazame	988
4	Financial infrastructure	Ariadnext	503
5	Financial infrastructure	Eurobits	512
6	Tax and accounting solutions	Docuten	406
7	Tax and accounting solutions	Quaderno App	901
8	Financial products distribution	Credimarket	481
9	Financial products distribution	iAhorro	1615
10	Personal finance	Sonect	907
11	Personal finance	Livetopic	419
12	Personal finance	Fintonic	2294
13	Investment	Rankia	6411
14	Investment	Finect	8627
15	Investment	Housers	822
17	Currencies	Onyze	834
16	Currencies	Kantox	916
18	Equity	The Crowd Angel	521
19	Equity	Fellow Funders	985
20	Payments	Stripe	501
21	Payments	LemonWay	497
	Total		32,716

In this study, the purpose was to emphasize the discourse regarding the SDGs, innovation, and related filtering terms, by retrieving information from each analyzed firms' Twitter account. In the performed SMA, these accounts provided the keywords for classifying messages (Figure 1D). Accordingly, we examined the way Twitter and its users broadly identified the conversation regarding these topics—that is, the Twitter hashtags #SDG and #9thGoal—combined with the keywords assigned to #Innovation.

The data collection was based on a Twitter database that consisted of JSON (The acronym of JavaScript Object Notation) files from each of the companies' accounts (Figure 1E). These tweets denoted the individual expressions or emotions required for linguistic analysis and constituted the primary element of our analysis approach, which was conducted in subsequent stages. Each tweet consists of seven variables: timestamp, the text of the tweet, favorites, retweets (which is the same as reposted tweets), followers, tweet ID (which is a unique number used to identify a tweet), and username.

The variables in a tweet are shown in Table 2. However, the approach implemented in this study focused on three variables: (1) timestamp, which is used to define the analyzed period; (2) text, which provides the primary base for algorithm implementation; and (3) username, which is crucial to identify Twitter users (Figure 1F).

Table 2. Tweet variables.

#	Variables	Description
1	Timestamp	Original date post
2	Text	Plain text corpus to be analyzed
3	Favorites	The accumulated number of likes
4	Retweets	The accumulated number of repost
5	Followers	The accumulated number of followers of each account
6	Tweet ID	The unique number that identifies each tweet
7	Username	The name of the user account

3.2. Pre-Processing Stage

To perform text mining, tweet dates were chosen to define the periods under study. The subsequent focus was the text, from which we extracted all the information for our analysis, as depicted in Figure 1G. The NLP approach was executed to clean the text from the database of tweets and to establish the text corpus, which can be defined as a collection of texts that is representative of a particular natural language [53].

The pre-processing phase was defined according to the following NLP steps [45], which consists of extracting the regular expressions (RE), the standard notation for characterizing text sequences; normalization, in which the same terms are unified regardless of whether they are written in different formats or languages; tokenization, in which words are separated by white spaces, sentences, and certain kinds of punctuation; filtering, which consists of removing hashtags, odd characters, and Twitter jargon; other pre-processing, which comprises secondary tasks such as eliminating repeated words or characters, numbers, and blank spaces; and, finally, correcting grammatical errors in the post and converting the entire text to lowercase.

3.3. Analytical Approach

Following preparation of the text collection, data analysis is critical to obtain the valuable information needed to perform the machine learning techniques (see Figure 1H). In this study, the analysis started with a collection of tweets, which comprised a database based on the key terms associated with SDGs, innovation, and related words. Therefore, period definition, text cleaning, and tweet classification were the first steps undertaken in our analytical approach. For this stage, we used the R computational language, which is a free software environment for statistical computing and graphics.

3.3.1. Text Analysis and Classification

Text classification, also known as categorization [54], defines the class of a given text and incorporates text sources by topic [55]. A collection of sentences consists of words, and in linguistics and probability, an N-gram is a contiguous sequence of N words from a given sample of text. Here, we describe the main tasks implemented in our quantitative approach to extract the features from data. This approach started with unigrams, which consist of a one-word representation, to be used for term frequencies.

Text analysis is the starting point of the IR method, which is best represented concisely using text analysis tools. According to Feinerer [56,57], structured design is performed by computing a term-document matrix (TDM) from either the text corpus or the text database. The sentences of the document are split into a set of words using the space or the punctuation characters [58].

3.3.2. Bag of Words Model

The TDM is a "bag of words" (BoW) mechanism containing term frequencies for all documents in the corpus. The extracted words form a virtual BoW, and there is no ordering or connection between them. The BoW that handles each word or group of words, known as N-grams, is a unique characteristic of a text collection [59]. In this approach, word order and grammatical word types are not considered. The BoW model is a simplified version of information retrieval and NLP approaches. This model represents a multiset of words divided by unigrams. The model defined the percentage of mentions about innovation, SDGs, and related terms, establishing 3% as the minimum percentage of the total number of tweets that talk about these topics.

3.3.3. Topic Modeling

Topic modeling is a machine learning algorithm that assumes a document as a mixture of topics; that is, this method can learn the thematic structure from extensive document collections without human supervision. Since it was first published [60], it has played an essential role in a variety of text mining tasks, in fields such as social and political science, bioinformatics, and digital humanities [61]. This technique consists of statistical modeling to discover the abstract themes present in a large collection of documents, or, in the case of this research, a database of tweets. As a result, topic modeling [62] is broadly used as a conjuncture of text mining and the NLP tool to discover significant unknown information in a given text corpus.

The latent Dirichlet allocation (LDA) algorithm is an unsupervised machine learning technique that identifies latent topic information in large document collections. LDA uses a BoW approach, treating each document as a vector of word counts. Each document is represented as a probability distribution over some topics, and each topic is represented as a probability distribution over several words [63]. LDA is a Bayesian version of probabilistic latent semantic analysis, and it uses Dirichlet priors for document or word topics, applying an improved generalization [60].

Thus, LDA represents each word in each document that comes from a topic, and the topic is selected from a per-document distribution over topics. There are two matrices:

(1) $\theta td = p(t \mid d)$ portrays the probability distribution of topics in documents.

(2) $\Phi wt = p(w \mid t)$ portrays the probability distribution of words in topics.

The probability of a word in a given document, for example, $p(w \mid d)$, is equal to

$$\sum_{t \epsilon T} \quad p(w|t,d)\ p(t|d), \tag{1}$$

where T is the total number of topics.

Assuming that there are W words in the corpus for all of the documents, conditional independence is assumed such that

$$p(w \mid t, d) = p(w \mid t).$$

Hence, $p(w \mid d)$ is equal to

$$\sum_{t=1}^{T} p(w|t)\ p(t|d), \tag{2}$$

that is, the dot product of θtd and Φwt for each topic t.

4. Results

The implementation of the proposed methodology to the Twitter database allowed us to compare and obtain insights on FinTech firms' discourse, showing perceptions of how they communicate with their clients, and the highlighted topics based on their type of activity, including the terms that they use more frequently.

4.1. Discourse Analysis by Companies

Results from the examination of the discourse by company are shown as follows:

For Kantox, the main topics identified were about currencies, location as Barcelona, work, team, start-ups, and a Brexit reference. In the case of Onyze, they centered the discourse on cryptocurrencies, blockchain, digital, startups, banks, and the financial market. For Fellow Funders, topics reflected investment, projects, platforms and entrepreneurs, opportunities, and crowdfunding. For The Crowd Angel, basic themes were start-ups, investment rounds, venture capital, opportunities, and crowdfunding.

Regarding Ariadnext, the discourse was about digital identity, locations such as Paris Cyber Week and Rennes, CEO, French tech, and innovation. The Eurobits firm referenced in Twitter open banking, innovation, and Spain, and it referred to companies such as IBM and names such as Arturo McDowell. Credimarket discussion included mortgage, lending, and experts. iAhorro communication consisted of mortgage, renting, financial education, lending, and personal finance. Finect speech was about investments, funds, rent, and markets. Housers noted projects, crowdfunding and crowdlending, real estate, investment, and start-ups. Rankia mentioned investment, stock exchange, market, webinar, and Ibex.

Aplazame mainly mentioned financing, e-commerce, marketing, Think Tank, shopping, and employment. Creditea discourse included the football team Rayo Vallecano, Ecofin magazine, and money. Goteo Funding highlighted crowdfunding, projects, campaigns, platforms, match funding, and sustainability. The Lemon Way company mentioned topics such as payment, crowdfunding, marketplace, lemon boost, and innovation. Stripe talked about support, business and service, and PayPal.

Fintonic mentioned applications and expenses, and referred to a name, Lupina Iturriaga. Livetopic mentioned finance, savings, and a name, Antonio Casal, in addition to "WealthTech", and "InsurTech". The main topics of Sonect were start-ups, Swiss, finance, and innovation. Docuten Twitter messages were about knowledge, blockchain, electronic account, firm, webinars, and people such as Brais Mendez. Quaderno App discourse was about sales tax, business, Amazon, and e-commerce.

4.2. Discourse Grouped by Activities

According to their activities, three groups of FinTech firms were chosen in relation to the appearance of terms, as percentages, based on the text classification (see Table 3). To delimitate the study, we selected three of these groups based on a significant incidence of innovation and SDG-related topics. The column "Innovation" refers to all the terms related to keywords such as innovative, open innovation, novel, new, disruptive. The column "SDGs" refers to all the terms related to sustainable goals or any mention of the UN SDGs in general.

The results of the BoW implementation were divided by activities, starting with financial infrastructure, in which the co-occurrences of words mainly referred to CEO (i.e., the acronym of Chief Executive Officer), digital, "RegTech" (i.e., regulation technology), Finnovating hub, and innovation. Following the lending group, three words were emphasized—campaign, financing, and crowdfunding—indicating the importance of the activity in this field. In addition, e-commerce, Rayo, or Rayo Vallecano (a Spanish football team), and documentary were highlighted. Regarding the personal finance field, start-up, app, personal, and CEO were identified as the main co-occurring words, which were followed by Spain, bank, money, success, and founder, which are related to the innovative and entrepreneurial domain.

Table 3. The percentage of innovation and SDG topics in fields with major appearances.

		Terms Percentages (%)	
Financial Activity	**FinTech Firms**	**Innovation**	**SDGs**
Financial infrastructure	Ariadnext	9	2
	Eurobits	22	-
Lending	Aplazame	5	-
	Creditea	3	-
	Goteo Funding	11	3
Personal finance	Fintonic	4	-
	Livetopic	3	2
	Sonect	8	-

4.3. Topic Modeling Scrutiny

Topic modeling based on the LDA algorithm was implemented to facilitate the arrangement of the tweets database, after the classification was divided into the three fields with the highest incidence of terms, such as innovation and other related terms, in addition to mentions of the SDGs. The results of this approach are shown as follows:

Financial infrastructure was the result of topic modeling applied to the companies Ariadnext and Eurobits, as shown in Table 4.

Table 4. Topic modeling results of the financial infrastructure field.

#	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7	Topic 8
1	openbanking	Spain	know your customer	frenchtech	payment services directive	numérique	payment services directive	know your customer
2	payment services directive	rt	Finnovating hub	Rennes	Spain	CEO	eurobitstech	numérique
3	eurobitstech	world	startup	CEO	innovation	money	innovation	Marc Norlain
4	aggregation	innovation	Amsterdam	sales	openbanking	Rennes	openbanking	Paris fintech forum
5	services	blockchain	Marc Norlain	Finnovating hub	new	know your customer	Arturo MacDowell	idnum
6	IBMcloud	CEO	identity	rt	asocfintechins	sales	Spain	digital identity

Table 5 shows the results of Aplazame, Creditea, and Goteo Funding, which are grouped in Lending activity.

Table 5. Topic modeling results of the lending field.

#	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7	Topic 8
1	crowdfunding	projects	credit	crowdfunding	Creditea with elrayo	projects	snap	financing
2	campaign	crowdfunding	findout	campaign	entry	campaign	financing	ecommerce
3	projects	days	rayo vallecano	projects	credit	crowdfunding	pay	shop
4	documental	through	vamos rayo	days	football	financing	explain	advantage
5	with	campaign	football	want	rayo	social	ecommerce	method
6	social	minimum	discover	money	solicit	platform	business	explain

Regarding the personal finance field, the three companies analyzed were Fintonic, Livetopic, and Sonect, for which results are shown in Table 6.

Table 6. Topic modeling results of the personal finance field.

#	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7	Topic 8
1	year	hello	app	thanks	hello	veximx	finance	Holaualet
2	app	app	banks	app	app	mosabi	saving	prestanomico
3	banks	md consulting	success	mosabi	dm radio	sbcscalefintech	financial	start-ups
4	md consulting	dm (radio)	freelancers	veximx	money	mangolifemx	saving	Mangolifemx
5	case	euros	money	start-ups	new	bargeld	antonio	Swiss
6	top	power	year	prestanomico	user	danke	finect	app

The outcomes of the financial infrastructure field (Table 4) highlighted technologies such as IBM cloud and blockchain, and displayed the events promoted by the FinTech firms, such as French tech, eurobitstech, Finnovating hub, and Paris FinTech forum, and places such as Amsterdam, Rennes, and Spain. In addition, names such as Marc Norlain and Arturo MacDowell are an indication of their presence at these events. The results of the lending field (Table 5) indicate a focus on campaigns such as crowdfunding initiatives and references to financial, payments, shops, and e-commerce. Moreover, sponsorship linked to a football team—Rayo Vallecano—refers to activities outside the financial domain. The personal finance field (Table 6) includes references to technology (apps) and companies such as Ualet, Mosabi, Mangolifemx, and Veximx. Additionally, there are allusions to success and freelancers as part of these firms' field.

5. Discussion

Based on the following discussion, some propositions are compiled to guide the future research on Fintech firms and their public discourse on social media:

Proposition 1. *Social media provides a helpful framework to understand Fintech's public discourse about open innovation and SDGs.*

The present study provides an improved comprehension of the interplay of FinTech firms and online social media, focused on Twitter. The analysis showed that this platform could help synthesize, trace, and understand relevant topics discourse. Interactions reveal the growing specter of firms embracing innovation-driven and exploiting dynamic utilities into the FinTech ecosystem, as illustrated in previous works [64–66]. This paper also addresses the current research gaps identified by scholars regarding social media, open innovation, and digital business [22].

Regarding the discourse by companies, except for a small number of companies, awareness about innovation and a more direct mention of the open innovation strategy engaging—and the SDGs—seemingly that is not part of the core conversations on Twitter. This might indicate that the topics are more centered on the company's interests, based on their field of activity, and the news, actors, and publicity about which they boost their activity, as another communication channel. It is still a challenge for this sector to embrace social related topics, and the focus is related to emerging technologies such as artificial intelligence, blockchain, smart contracts, and machine learning [37]. Social messages on social media may have more relevance as far as (i) CSR may pay more attention to SDG and (ii) the implementation of the open innovation paradigm could attract interest for sustainable solutions regarding mentions of new technologies and social awareness, from which investors and clients could be part of new "green" projects [8,27,67].

Based on their discourse classified by financial activity showed that financial infrastructure, lending, and personal finance were the fields with the most mentions of terms related to innovation and SDGs (see Table 3). In contrast, equity finance showed the least activity on Twitter and the smallest number of terms related to this activity. The financial

infrastructure group showed a strong focus on open banking and payments. This can be explained by the fact that the social media discourse of FinTech companies, which are in this case start-up organizations, differs from that of large companies, which publish more information in the Twittersphere, including that related to SDGs [12,68,69].

However, it can be deduced that 35% of FinTech companies have little or no activity on Twitter. This can be explained because the potential on Twitter is not sufficiently exploited. Furthermore, the majority are SMEs and start-ups who may not have developed a good communication channel. These results contradict expectations based on theory because social media has been proven to be a good repository for collecting big data from companies [70–72], which in turn can provide insights to assess the implementation of SDGs. In addition, the use of social media is a suitable method to make accounting interventions beyond traditional organization-centric reporting, such as GRI standards [68].

Proposition 2. *Twitter is a suitable platform to calibrate algorithms needed to conduct machine learning analysis of FinTech's information extraction.*

As a result of the BoW model grouped by activity, the focus of each group is synthesized as follows: the financial infrastructure group uses more words related to technology and innovation. This view is rather different from that provided by topic modeling, which is explained in the next paragraph. The lending group is focused on campaigns with Spanish football teams to promote financing via crowdfunding. The personal finance group also includes words related to their business model, such as the successful use of apps for personal savings. Therefore, as can be deduced from these topics, the current challenge is to learn how to benefit and exploit even more from social media's potential for innovation purposes [64], including social awareness. The relationship between SDGs and crowdfunding in the entrepreneurial financial landscape can be explained due to the importance of capital flows, investment, and redistribution of funds to implement entrepreneurial projects, not only for the incumbent FinTech but also for the client start-ups that use a FinTech platform to obtain funding [12].

The topic modeling implementation allowed us to identify the most relevant discussion emphasized by each FinTech activity. The financial infrastructure group has a strong focus on open banking and payments. This group pays the greatest attention to innovation and highlights the digital technologies applied in their service offerings, such as blockchain and the cloud. The lending group concentrates on crowdfunding platforms and on a recent campaign undertaken entertainment, possibly to incentivize online sales and commerce. The personal finance group highlights the mobility enabled through FinTech's savings apps. It also presents an international discourse, involving FinTech companies not only in Europe, but also in Latin America and African regions. This can be explained because FinTech firms usually apply digital technologies that enable outcomes, such as mobile apps (e.g., highly mentioned by the personal finance group) or digital platforms (e.g., highly mentioned by the lending group) [73]. Haddad and Hornuf [28] stated that FinTech firms establish new ecosystems or hubs of entrepreneurial activities in specific geographic regions; however, our study shows that social media can be used to establish international FinTech hubs with companies that are not located in different regions, as proven by the personal finance group. Therefore, the decision to locate a FinTech firm is less crucial due to the digitalization and flattening of the financial world.

Proposition 3. *FinTech ecosystem in Twitter illustrates the use of open innovation and tech business models.*

The references to new types of technologies and actors in a number of tweets indicate that the analyzed FinTech firms may be willing to embrace cooperation (which implies the open innovation implementation) with the visualization of novel business models, if there is constant feedback and consequent follow up from social media, due to the disruptive nature of the financial technology business [34]. However, limitations of information

regarding adopting new open innovation approaches should be confirmed through surveys or interviews directed to managers and CEOs of the firms involved. This final point is outside of the scope of this research.

Proposition 4. *Social media serve as a showcase to promote figures, events, and activities implemented by FinTech firms.*

The interaction of companies in social media provides a source of public debate and a conversation that could be of interest to monitoring. Assessment of the main topics, as undertaken in this study, can provide a feasible barometer focused on innovation. In addition, the visibility that Twitter provides to those companies immersed in technological and innovative initiatives provides a unique opportunity to understand the value of social media and its role in catalyzing the spread of FinTech innovations [66].

The promotion of technologies related to innovative finance (e.g., crowdfunding) appears to be part of the natural behavior of spreading new ideas. Thus, these companies are able to significantly influence the activity in their network and inside and outside their areas of action. For this reason, pairing online platforms can also help to promote SDGs and innovation, creating awareness about the sustainable topics' agenda.

Another important topic related to the FinTech public image is corporate social responsibility and its implication in social activities. As Liu et al. [74] pointed out, its role is still moderate but promising in the Chinese banking sector. In another context, in the study conducted by Rabbani et al. [75], they addressed that Islamic finance has solid connections to financial stability and corporate social responsibility based on helping the poor and marginalized with financial technologies. From this perspective, the reputation of FinTechs could be benefited due to the social activities, as the start-ups could promote their community services, as appeared in the recurrent topics based on our analysis, such as those related to sports, crowdfunding activities, innovation, and to a lesser extent, the sustainable goals. In this sense, social responsibility-related topics could give us extra insights to enable new categorizations of sentiment analysis approaches.

A relevant question to be addressed is that the studied companies should be analyzed from other perspectives and not limiting the analysis to the variable Twitter. For example, what are the financial resources or incomes generated by those companies? These new outcomes may also be influenced by company size. The used sample in this work is based on small companies with few employees. However, future works might monitor the evolutions over time of these companies as far; some results may be determined by the growth of companies, as more size may provide a different look to include in SGDs awareness and open innovation once the technical expertise is already gained. In addition to these issues, looking at the companies only by their social media activity could be too limited. Perhaps the bigger the company, the larger its social media activity in absolute terms but not necessarily in relative terms per worker. Therefore, deeper analysis and a better descriptive analysis of the sample are required.

Conclusions and Future Work

Based on their discourse in social media, it can be deduced that FinTech firms are not fully involved in the global awareness of innovation and the SDGs. Innovation is clearly promoted as a topic that could be part of an open innovation strategy, so current and potential clients have additional room to interact, providing new ideas and feedback on innovation through social media. One means of enriching these interactions would be to bring SDGs into the innovation discourse. However, many of these firms neglect the importance of social media, particularly Twitter, for promoting sustainable businesses, start-ups, and high technological new services. The results of this study identify different types of collaboration with external actors and topics related to the open innovation implementation in certain firms and activities. This is reflected in the mention of other companies, technologies, and different types of organizations related to innovation. A good strategy could also

be to attract new types of clients and investors using the promotion of sustainable goals and boosting cooperation under the umbrella of the open innovation strategy.

Founded on the current findings, this work contributes to understanding the discourse regarding innovation and the role of the SDGs in FinTech firms' activity and showed varying approaches to discourse in public information streams. The low usage of Twitter indicates that these powerful media channels could be used more actively, including in campaigns related to financial inclusion, green energies, and new types of novel business. However, it appears that this channel is not properly exploited. Of the 358 firms we examined at the beginning of this study, which were deemed to be significant technology companies, only 65% undertook constant activity using this form of social media. Many of these companies are start-ups in the process of expansion. Despite the relatively low activity noted in these firms—except for the promotion of their services—technology and innovation references were present in messages relating to activities in which they were involved due to their business nature.

This research was based on the use of text mining and algorithm implementation in a specific case study. This area has been less analyzed in social sciences, and the current research thus adds knowledge to the use of quantitative methods in innovation management studies. In addition, it would be valuable to reproduce new mixed methods in other types of firms related to Twitter and other social media databases. This study might contribute to the further development of organization models to generate knowledge for innovation and SDGs, helping firms to evaluate their discourse based on the SMA.

This study is limited only to the conversation that occurs on social media. We focus on the FinTech firms (where the majority included in this analysis are start-ups) within the Twitter environment. The inclusion of other sources such as surveys and interviews and variables such as income, number of employees, and other financial resources could open new avenues for future analysis. Another limitation is the geographical approach, where different means of complementing this research would be to contrast the results among diverse countries or regions. However, our results can be applied to other regions considering that many of the analyzed firms also have a presence in other countries.

The inclusion of other relevant topics such as social responsibility, firms' reputation, media influence, and bots activity should be considered for new approaches. Another topic could refer to longitudinal studies to assess the impact of social media in entrepreneurial activities related to networking, performance, communication, and engagement, not only for innovation and SDGs' purposes but also regarding performance measurement for both FinTech firms and the entrepreneurial ecosystem.

In addition, to complement our SMA proposition, future studies could use other analytical tools, such as deep learning, natural language understanding, and other trend topic relationships [76]. In summary, it would be of interest to examine how the entrepreneurial discourse in innovation and SDGs differs between large and SME companies. It would also be valuable to investigate how social media support the entrepreneurial process from opportunity recognition and business planning to project execution and launch, in the open innovation framework.

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References

1. Kox, H.L.M.; Rubalcaba, L. Analysing the Contribution of Business Services to European Economic Growth. *Bruges Eur. Econ. Res. Pap.* **2007**. Available online: http://www.coleurop.be/eco/publications.htm (accessed on 25 April 2021).
2. Hipp, C.; Gallego, J.; Rubalcaba, L. Shaping innovation in European knowledge-intensive business services. *Serv. Bus.* **2015**, *9*, 41–55. [CrossRef]
3. Lee, H.-F.; Miozzo, M. Which types of knowledge-intensive business services firms collaborate with universities for innovation? *Res. Policy* **2019**, *48*, 1633–1646. [CrossRef]
4. Miles, I.; Kastrinos, N.; Flanagan, K.; Bilderbeek, R.; Den Hertog, P.; Huntink, W.; Bouman, M. *Knowledge-Intensive Business Services: Users, Carriers and Sources of Innovation*; European Commission: Brussels, Belgium, 1995.
5. Rubalcaba, L.; Toivonen, M. Internationalisation of services: Modes and the particular case of KIBS. In *The Handbook of Service Business*; Bryson, J.R., Daniels, P.W., Eds.; Edward Elgar Publishing Ltd.: Gloucestershire, UK, 2015; pp. 278–300. [CrossRef]
6. Mosteanu, N.; Faccia, A. Fintech Frontiers in Quantum Computing, Fractals, and Blockchain Distributed Ledger: Paradigm Shifts and Open Innovation. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 19. [CrossRef]
7. Leong, C.; Tan, B.; Xiao, X.; Tan, F.T.C.; Sun, Y. Nurturing a FinTech ecosystem: The case of a youth microloan startup in China. *Int. J. Inf. Manag.* **2017**, *37*, 92–97. [CrossRef]
8. Goo, J.J.; Heo, J.-Y. The Impact of the Regulatory Sandbox on the Fintech Industry, with a Discussion on the Relation between Regulatory Sandboxes and Open Innovation. *J. Open Innov. Technol. Mark. Complex.* **2020**, *6*, 43. [CrossRef]
9. Husted, B.W.; Allen, D.B. Strategic Corporate Social Responsibility and Value Creation among Large Firms: Lessons from the Spanish Experience. *Long Range Plan.* **2007**, *40*, 594–610. [CrossRef]
10. Arner, D.W.; Buckley, R.P.; Zetzsche, D.A.; Veidt, R. Sustainability, FinTech and Financial Inclusion. *Eur. Bus. Organ. Law Rev.* **2020**, *21*, 7–35. [CrossRef]
11. EtheRaj, P.; Wahab, S.A.; Osman, S.I.W.; Zawawi, N.M.; Fazal, S.A. Sustainable Development and Innovation: Reviewing the Concept and Malaysian Participation. *Int. J. Acad. Res. Bus. Soc. Sci.* **2018**, *8*. [CrossRef]
12. Avrampou, A.; Skouloudis, A.; Iliopoulos, G.; Khan, N. Advancing the Sustainable Development Goals: Evidence from leading European banks. *Sustain. Dev.* **2019**, 1–15. [CrossRef]
13. Abdillah, L. An Overview of Indonesian Fintech Application. In Proceedings of the International Conference on Communication, Information Technology and Youth Study (I-CITYS 2019), Bayview Hotel Melaka, Melaka (Malacca), Malaysia, 23 December 2019; p. 8.
14. Aral, S.; Dellarocas, C.; Godes, D. Introduction to the Special Issue—Social Media and Business Transformation: A Framework for Research. *Inf. Syst. Res.* **2013**, *24*, 3–13. [CrossRef]
15. Venkatraman, V.; Clithero, J.A.; Fitzsimons, G.J.; Huettel, S.A. New scanner data for brand marketers: How neuroscience can help better understand differences in brand preferences. *J. Consum. Psychol.* **2012**, *22*, 143–153. [CrossRef]
16. Tirabeni, L.; Soderquist, K.E.; Soderquist, E.K. Connecting the Dots: Framing Employee-Driven Innovation in Open Innovation Contexts. *Int. J. Innov. Technol. Manag.* **2019**, *16*. [CrossRef]
17. Sundström, M.; Alm, K.H.; Larsson, N.; Dahlin, O. B2B social media content: Engagement on LinkedIn. *J. Bus. Ind. Mark.* **2021**, *36*, 454–468. [CrossRef]
18. García-Crespo, Á.; Ceballos, M.; González-Carrasco, I.; Lado, N.; López-Cuadrado, J.L. Innovation in the Spanish Twittersphere: An Ontology and Stakeholders' Salience Analysis. In *Revolution of Innovation Management*; Palgrave Macmillan: London, UK, 2017; pp. 97–128. [CrossRef]
19. Culnan, M.J.; Mchugh, P.J.; Zubillaga, J.I.; Uarterly, M.Q.; Xecutive, E. How large U.S. Companies can use Twitter and other Social media to gain business value. *MIS Q. Exec.* **2010**. Available online: http://syncapse.com/media/syncapse-value-of-a-facebook- (accessed on 25 March 2020).
20. Autio, E.; Kenney, M.; Mustar, P.; Siegel, D.; Wright, M. Entrepreneurial innovation: The importance of context. *Res. Policy* **2014**, *43*, 1097–1108. [CrossRef]
21. Gastaldi, L.; Appio, F.P.; Martini, A.; Corso, M. Academics as orchestrators of continuous innovation ecosystems: Towards a fourth generation of CI initiatives. *Int. J. Technol. Manag.* **2015**, *68*, 1–20. [CrossRef]
22. Olanrewaju, A.-S.T.; Hossain, M.A.; Whiteside, N.; Mercieca, P. Social media and entrepreneurship research: A literature review. *Int. J. Inf. Manag.* **2020**, *50*, 90–110. [CrossRef]

23. Gomber, P.; Koch, J.-A.; Siering, M. Digital Finance and FinTech: Current research and future research directions. *J. Bus. Econ.* **2017**, *87*, 537–580. [CrossRef]
24. Prüfer, J.; Prüfer, P. Data science for entrepreneurship research: Studying demand dynamics for entrepreneurial skills in the Netherlands. *Small Bus. Econ.* **2019**, *55*, 651–672. [CrossRef]
25. Aggarwal, R.; Singh, H. Differential Influence of Blogs Across Different Stages of Decision Making: The Case of Venture Capitalists. *MIS Q.* **2013**, *37*, 1093–1112. [CrossRef]
26. Obschonka, M.; Fisch, C.; Boyd, R. Using digital footprints in entrepreneurship research: A Twitter-based personality analysis of superstar entrepreneurs and managers. *J. Bus. Ventur. Insights* **2017**, *8*, 13–23. [CrossRef]
27. Najib, M.; Ermawati, W.; Fahma, F.; Endri, E.; Suhartanto, D. FinTech in the Small Food Business and Its Relation with Open Innovation. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 88. [CrossRef]
28. Haddad, C.; Hornuf, L. The emergence of the global fintech market: Economic and technological determinants. *Small Bus. Econ.* **2019**, *53*, 81–105. [CrossRef]
29. Dong, J.Q.; Wu, W. Business value of social media technologies: Evidence from online user innovation communities. *J. Strat. Inf. Syst.* **2015**, *24*, 113–127. [CrossRef]
30. Albors-Garrigos, J.; Igartua, J.I.; Peiro, A. Innovation management techniques and tools: Its impact on firm innovation performance. *Int. J. Innov. Manag.* **2018**, *22*. [CrossRef]
31. Du, S.; Yalcinkaya, G.; Bstieler, L. Sustainability, Social Media Driven Open Innovation, and New Product Development Performance*. *J. Prod. Innov. Manag.* **2016**, *33*, 55–71. [CrossRef]
32. Roberts, D.L.; Piller, F.; Lüttgens, D. Mapping the Impact of Social Media for Innovation: The Role of Social Media in Explaining Innovation Performance in the PDMA Comparative Performance Assessment Study. *J. Prod. Innov. Manag.* **2016**, *33*, 117–135. [CrossRef]
33. Hitchen, E.L.; Nylund, P.A.; Ferràs, X.; Mussons, S. Social media: Open innovation in SMEs finds new support. *J. Bus. Strat.* **2017**, *38*, 21–29. [CrossRef]
34. Lee, I.; Shin, Y.J. Fintech: Ecosystem, business models, investment decisions, and challenges. *Bus. Horizons* **2018**, *61*, 35–46. [CrossRef]
35. de Zubielqui, G.C.; Fryges, H.; Jones, J. Social media, open innovation & HRM: Implications for performance. *Technol. Forecast. Soc. Chang.* **2019**, *144*, 334–347. [CrossRef]
36. Brunswicker, S.; Chesbrough, H. The Adoption of Open Innovation in Large Firms. *Res. Manag.* **2018**, *61*, 35–45. [CrossRef]
37. Mention, A.-L. The Future of Fintech. *Res. Manag.* **2019**, *62*, 59–63. [CrossRef]
38. Hanson, G.; Haridakis, P.M.; Cunningham, A.W.; Sharma, R.; Ponder, J.D. The 2008 Presidential Campaign: Political Cynicism in the Age of Facebook, MySpace, and YouTube. *Mass Commun. Soc.* **2010**, *13*, 584–607. [CrossRef]
39. Borge-Holthoefer, J.; Rivero, A.; García, I.; Cauhé, E.; Ferrer, A.; Ferrer, D.; Francos, D.; Iñiguez, D.; Pérez, M.P.; Ruiz, G.; et al. Structural and Dynamical Patterns on Online Social Networks: The Spanish May 15th Movement as a Case Study. *PLoS ONE* **2011**, *6*, e23883. [CrossRef]
40. Lynn, T.; Rosati, P.; Nair, B.; Bhaird, C.M.A. An Exploratory Data Analysis of the #Crowdfunding Network on Twitter. *J. Open Innov. Technol. Mark. Complex.* **2020**, *6*, 80. [CrossRef]
41. Khan, A.Z.H.; Atique, M.; Thakare, V.M. Combining Lexicon-based and Learning-based Methods for Twitter Sentiment Analysis. *Int. J. Electron. Commun. Soft. Comput. Sci. Eng.* **2015**, 89–91. Available online: https://www.proquest.com/openview/3bb4518ced02bbd25b28594d28b35094/1?pq-origsite=gscholar&cbl=2029261 (accessed on 15 March 2020).
42. Wang, F.; Mack, E.A.; Maciewjewski, R. Analyzing Entrepreneurial Social Networks with Big Data. *Ann. Am. Assoc. Geogr.* **2016**, *107*, 130–150. [CrossRef]
43. Cesteros, J.S.; Almeida, A.; López De Ipiña, D. *Sentiment Analysis and Polarity Classification in Spanish Tweets*; TASS: Moscow, Russia, 2015; pp. 23–28.
44. Thelwall, M. Sentiment Analysis for Small and Big Data. Second. In *The SAGE Handbook of Online Research Methods*, 2nd ed.; Fielding, N.G., Lee, R.M., Blank, G., Eds.; SAGE Publications Ltd.: London, UK, 2017; pp. 344–360.
45. Jurafsky, D.; Martin, J.H. Speech and Language Processing. In *An Introduction to Natural Language Processing, Computational Liguistics, and Speech Recognition*, 2nd ed.; Norvig, P., Russell, S., Eds.; Pearson Prentice Hall: Upper Saddle River, NJ, USA, 2008. Available online: http://www.cs.colorado.edu/~{}martin/slp2.html (accessed on 15 March 2020).
46. Pang, B.; Lee, L. Opinion Mining and Sentiment Analysis. *Found. Trends Inf. Retr.* **2008**, 1–135. [CrossRef]
47. Pang, B.; Lee, L.; Vaithyanathan, S. Thumbs up? Sentiment classification using machine learning techniques. In Proceedings of the ACL-02 Conference on Empirical Methods in Natural Language Processing—EMNLP '02, Morristown, NJ, USA, 2–10 July 2002; pp. 79–86. [CrossRef]
48. Villena Román, J.; García Morera, J.; García Cumbreras, M.A.; Martinez-Camara, E.; Martín-Valdivia, M.T.; Ureña-Lopez, L.A. *Overview of TASS*; SEPLN: Alicante, Spain, 2015; pp. 13–21.
49. Mukherjee, S.; Bala, P.K. Detecting sarcasm in customer tweets: An NLP based approach. *Ind. Manag. Data Syst.* **2017**, *117*, 1109–1126. [CrossRef]
50. Arnaboldi, M.; Busco, C.; Cuganesan, S. Accounting, accountability, social media and big data: Revolution or hype? *Account. Audit. Account. J.* **2017**, *30*, 762–776. [CrossRef]

51. Bertot, J.C.; Jaeger, P.T.; Grimes, J.M. Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. *Gov. Inf. Q.* **2010**, *27*, 264–271. [CrossRef]
52. Zaghouani, W.; Charfi, A. Arap-Tweet: A Large Multi-Dialect Twitter Corpus for Gender, Age and Language Variety Identification. In Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC 2018), Miyazaki, Japan, 7–12 May 2018. Available online: http://arap.qatar.cmu.edu (accessed on 2 April 2020).
53. Xiao, R. Corpus Creation. In *The Handbook of Natural Language Processing*, 2nd ed.; Indurkhya, N., Damerau, F., Eds.; CRC Press: London, UK, 2010; pp. 147–165. Available online: http://www.lancaster.ac.uk/fass/projects/corpus/ZJU/xpapers/Xiao_corpus_creation.pdf (accessed on 28 February 2020).
54. Rusell, S.; Norvig, P. Artificial Intelligence. In *A Modern Approach*, 3rd ed.; Prentice, H., Ed.; Pearson Education, Inc.: Upper Saddle River, NJ, USA, 2010.
55. ChandraKala, S.; Sindhu, C. Opinion mining and sentiment classification: A survey. *ICTACT J. Soft. Comput.* **2012**, *3*, 420–425. [CrossRef]
56. Feinerer, I.; Hornik, K.; Meyer, D. Text Mining Infrastructure in R. *J. Stat. Softw.* **2008**, *25*, 1–54. [CrossRef]
57. Feinerer, I. A Text Mining Framework in R and Its Applications. Ph.D. Thesis, WU Vienna University of Economics and Business, Wien, Austria, 2008.
58. Psomakelis, E.; Tserpes, K.; Anagnostopoulos, D.; Varvarigou, T. Comparing methods for Twitter Sentiment Analysis. In Proceedings of the 6th Conference on Knowledge Discovery and Information Retrieval, Rome, Italy, 21–24 October 2014. Available online: https://arxiv.org/pdf/1505.02973.pdf (accessed on 7 February 2020).
59. Hacohen-Kerner, Y.; Miller, D.; Yigal, Y. The influence of preprocessing on text classification using a bag-of-words representation. *PLoS ONE* **2020**, *15*, e0232525. [CrossRef] [PubMed]
60. Blei, D.M.; Ng, A.Y.; Jordan, M.I. Latent Dirichlet Allocation. *J. Mach. Learn. Res.* **2003**, *3*, 993–1022.
61. Tang, J.; Meng, Z.; Nguyen, X.; Mei, Q.; Zhang, M. Understanding the Limiting Factors of Topic Modeling via Posterior Contraction Analysis. In Proceedings of the 31st International Conference on Machine Learning, Beijing, China, 21–26 June 2014; pp. 190–198.
62. Grün, B.; Hornik, K. topicmodels: AnRPackage for Fitting Topic Models. *J. Stat. Softw.* **2011**, *40*, 1–30. [CrossRef]
63. Hong, L.; Davison, B.D. Empirical study of topic modeling in Twitter. In Proceedings of the 1st Workshop on Social Media Analytics (SOMA 2010), Washington, DC, USA, 23–25 July 2010; ACM Press: New York, NY, USA, 2010; pp. 80–88. [CrossRef]
64. Bhimani, H.; Mention, A.-L.; Barlatier, P.-J. Social media and innovation: A systematic literature review and future research directions. *Technol. Forecast. Soc. Chang.* **2019**, *144*, 251–269. [CrossRef]
65. Mention, A.-L.; Barlatier, P.-J.; Josserand, E. Using social media to leverage and develop dynamic capabilities for innovation. *Technol. Forecast. Soc. Chang.* **2019**, *144*, 242–250. [CrossRef]
66. Mai, F.; Shan, Z.; Bai, Q.; Wang, X.; Chiang, R.H. How Does Social Media Impact Bitcoin Value? A Test of the Silent Majority Hypothesis. *J. Manag. Inf. Syst.* **2018**, *35*, 19–52. [CrossRef]
67. Romero-Rodríguez, J.-M.; Ramírez-Montoya, M.-S.; Aznar-Díaz, I.; Hinojo-Lucena, F.-J. Social Appropriation of Knowledge as a Key Factor for Local Development and Open Innovation: A Systematic Review. *J. Open Innov. Technol. Mark. Complex.* **2020**, *6*, 44. [CrossRef]
68. Bebbington, J.; Unerman, J. Achieving the United Nations Sustainable Development Goals: An enabling role for accounting research. *Account. Audit. Account. J.* **2018**, *31*, 2–24. [CrossRef]
69. Laurell, C.; Sandström, C.; Suseno, Y. Assessing the interplay between crowdfunding and sustainability in social media. *Technol. Forecast. Soc. Chang.* **2019**, *141*, 117–127. [CrossRef]
70. Amato, F.; Moscato, V.; Picariello, A.; Piccialli, F. SOS: A multimedia recommender System for Online Social networks. *Future Gener. Comput. Syst.* **2019**, *93*, 914–923. [CrossRef]
71. Fuchs, C. From digital positivism and administrative big data analytics towards critical digital and social media research. *Eur. J. Commun.* **2017**, *32*, 37–49. [CrossRef]
72. Manca, S.; Caviglione, L.; Raffaghelli, J. Big data for social media learning analytics: Potentials and challenges. *J. e-Learn. Knowl. Soc.* **2016**, *12*. [CrossRef]
73. Cavallo, A.; Ghezzi, A.; Dell'Era, C.; Pellizzoni, E. Fostering digital entrepreneurship from startup to scaleup: The role of venture capital funds and angel groups. *Technol. Forecast. Soc. Chang.* **2019**, *145*, 24–35. [CrossRef]
74. Liu, Y.; Saleem, S.; Shabbir, R.; Shabbir, M.S.; Irshad, A.; Khan, S. The relationship between corporate social responsibility and financial performance: A moderate role of fintech technology. *Environ. Sci. Pollut. Res.* **2021**, *28*, 20174–20187. [CrossRef]
75. Rabbani, M.; Bashar, A.; Nawaz, N.; Karim, S.; Ali, M.; Rahiman, H.; Alam, S. Exploring the Role of Islamic Fintech in Combating the Aftershocks of COVID-19: The Open Social Innovation of the Islamic Financial System. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 136. [CrossRef]
76. Stieglitz, S.; Mirbabaie, M.; Ross, B.; Neuberger, C. Social media analytics—Challenges in topic discovery, data collection, and data preparation. *Int. J. Inf. Manag.* **2018**, *39*, 156–168. [CrossRef]