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Scientific literature on Twitter as a subject research: Findings based on Bibliometric Analysis

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Abstract. Since its launch in 2006, Internet platform Twitter has rapidly expanded. As a phenomenon of the digital era, Twitter generates a new type of research data that has received a good deal of attention in the academic literature. It has turned into a popular subject research that has been widely investigated in the academic world in different fields ranging from the Social Sciences to Health Sciences, addressing various questions, methods approaches, and covering multiple data sets. This study provides some findings of a bibliometric study which was conducted to describe the scientific literature available on Twitter with descriptive, quantitative information and also in a qualitative approach, in addition to the previous studies and designed as a contribution to a broader picture of how the evolution of the current scientific literature about Twitter is related to bibliographic data sets. Results show a variety of findings that can provide a better comprehension of this social media platform which evolved from a data source for the research to, nowadays, being a research subject itself.

Keywords: Twitter, scientific literature, bibliometric analysis

1 Introduction

Since its launch in 2006, founded by Jack Dorsey and associates in San Francisco, California, USA, Internet platform Twitter (<https://twitter.com>) has rapidly expanded, “conceived as part of a long line of squawk media, dispatch, short messaging, as well as citizen communications services” (Rogers, 2014), with Dorsey trying to define Twitter as a new medium in itself, a public instant messaging system, meaning also a public information utility (Sarno, 2009).

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As a phenomenon of the digital era, Twitter generates a new type of research data related to this role as public information utility, emerging as an important source of the new digital paradigm, and has received a good deal of attention in the academic literature. It has turned into a popular research subject that has been widely investigated in the academic world in different fields, ranging from the Social Sciences to the Health Sciences, addressing various questions, method approaches, and covering multiple data sets, with early studies focusing on characterizing tweet types, determining how many of them are of value, and evaluating Twitter as, more or less, of interesting content (Rogers, 2014).

An analysis of the coverage of Twitter's first three years, performed by Arceneaux and Schmitz Weiss (2010), pointed out the prevalence of "food tweets" and the more general "mindless stream", emanating from Twitter in its early years, leading Rogers (2014) to ask what value lies in breakfast and lunch tweets, and responding that "geo-located food tweets may be of interest to those studying the geography of taste and other questions of cultural preference" (p. xiii-xiv).

Thus, together with other social web platforms, such as Facebook, blogs, Wikipedia, YouTube, and others, Twitter becomes a new source of information for many researchers in different disciplines, providing a variety of data to extract (Metaxas & Mustafaraj, 2014). Despite being behind services like Facebook in numbers (with 1.3 billion active users) and WhatsApp (500 million), this platform currently has about 284 million active users worldwide, with 500 million tweets being sent out every day in more than 30 different languages (Twitter, 2015). In 2014 the eMarketer Consultancy predicted that Twitter should reach 300 million monthly active users by 2016, and pass the 400 million mark by the end of 2018.

Since its launch Twitter has incorporated growing facilities for sharing content, with options to add links, images and videos, and efficient mechanisms to aggregate specific topics by hashtags: labels assigned to a term, preceded by the hash symbol (#), making the term an active link that allows recovery of all tweets with the hashtag. Hashtags not only gather and record the tweets on the same subject but also make it possible to recover its track record, through monitoring or mining. Moreover, Twitter's dynamics, where users develop a virtual community made up of a public identified by common interests - followers, who share and replicate content freely with each other in an intense interaction through actions, such as the "re-tweet" (RT), generating affiliations around themes, topics and identities (Zappavigna, 2011). All these characteristics make Twitter a major data source to track the performance of personal and institutional microblogs, communities and the most diverse subjects through systems that monitor the interactions of real-time messages generated on the platform, targeting to various analyses, hence the growth of scientific literature on Twitter.

Bruns and Weller (2014) pointed out that scientific publications, with "Twitter" explicitly in the title, are as follows: 1,400 on Scopus® database, 470 on Web of Science® (WoS) database and another 10,000 available via Google Scholar. In turn, Zimmer and Proferes (2014) conducted a content analysis study with a set of 382 academic publications that used Twitter from 2006 to 2012. Also, Weller et al (2014) published a comprehensive study on Twitter, addressing aspects of this social media related to its concepts and methods, even as

its perspectives and practices in use in society, as those from popular culture, brand and crisis communication, politics and activism, journalism, and in academia.

This study provides some more insights in this matter through a bibliometric study which was conducted to describe the scientific literature available on Twitter, with quantitative information and also in a qualitative approach, in addition to the previous studies and designed as a contribution to a broader picture of how the evolution of the current scientific literature about Twitter is related to bibliographic data sets.

2 Methods

The methodological approach chosen for this study is Bibliometric Analysis, an original area of study generally covering books and publications and whose principle, according to Tague-Sutcliffe (1992), is the analysis of scientific or technical activity through quantitative studies of publications. Bibliometric Analysis provides insights on which stage a given research area lies, and it is a methodology also used in several areas, with the objective of characterizing the published research output and the forecasting of trends, yielding results that are also useful to support decision-making (Rostaing, 1996).

Through Bibliometric Analysis it is possible to study some quantitative parameters of the publications, periodicals, authors, keywords, users and citations (Pao, 1989). But nowadays Bibliometric Analysis integrates the broader area of metric studies of the information, with different scopes and finalities in the discovery of information characteristics in general, not just about science, comprising and combining different methodologies and tools to provide a more comprehensive view of its objects of study (Cronin & Sugimoto, 2014).

This Bibliometric Analysis was carried out for the indexed literature in the period from 2006 (when Twitter was released) until 2014, and only included articles with the word "Twitter" in the title, abstract and/or keywords. Analysis was conducted on the results of the Scopus® database (from Reed-Elsevier), which has a wider coverage than WoS® (from Thomson Reuters). The 2,338 documents retrieved were analyzed on two levels. The first was a basic one related to quantitative indicators, according to the average growth in the number of publications per year, identifying main research areas that have published about Twitter, as well as journal titles, most prolific authors, institutions and countries. This was followed by a second level with a deeper analysis, considering citations and the 'hot topics' of the literature, through the combination of techniques and tools of lexical analysis and content about the corpora, with the software Sphinx Lexica®, that allows the researcher to differentiate in a semi-automatic form the main terms, identifying those that are 'hot topics' in the publications about Twitter, and CorText Manager³, that was used to discover the relationships between the different topics and countries involved, providing maps of heterogeneous networks as thematic and collaborative maps, sorted by term frequency per countries and by a chi-squared (χ^2) distribution of the "hot topics".

³ CorText Manager: [urlhttp://www.cortext.net/](http://www.cortext.net/).

3 Results

3.1 Quantitative indicators

The academic literature with Twitter as research subject has seen an average growth rate of 52.23% per year, from one sole article published in 2006 to the 720 published in 2014. Figure 1 shows that this growth was ongoing and has accelerated after 2009, reaching the peak in 2014. This result points out that in fact Twitter is becoming a consolidated object of research.

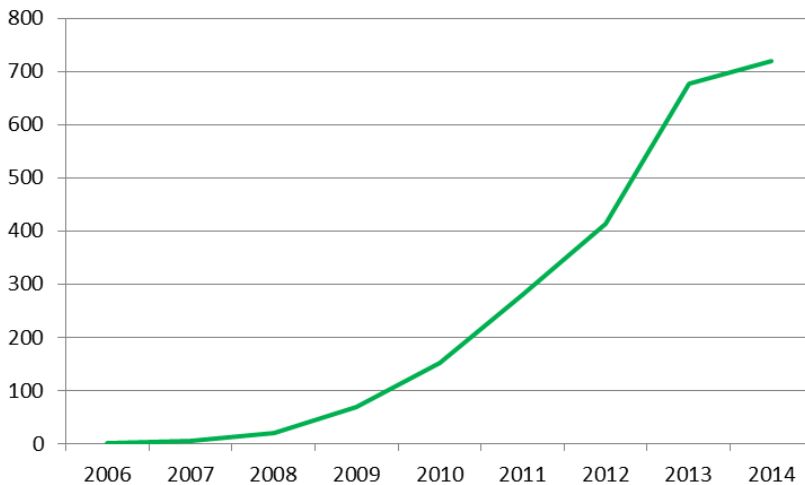


Fig. 1: Growth of the scientific literature about Twitter (2006-2014).

As for the research areas which have published about Twitter, Figure 2 shows the dominance of certain disciplines with more than 100 publications, such as the Social Sciences, with 1,014 articles (33% of the total sample); and Computer Science, with 826 articles (27%), followed by Medicine, with 327 articles (11%). But we can observe that other disciplines also appear with relevant participation, such as Business Management and Accounting, and Engineering, which had 284 and 273 papers, respectively, both reaching 9% of the total sample; followed by Arts and Humanities, with 215 (7%) and Mathematics, with 105 (4%).

Related to journal titles with more than 10 publications in this matter, results were as follows: PLoS One ($n = 46$); Computers in Human Behavior ($n = 37$); Journal of Medical Internet Research ($n = 37$); First Monday ($n = 36$); Information Communication and Society ($n = 35$); Public Relations Review ($n = 34$); *Estudios Sobre El Mensaje Periodistico* ($n = 19$); Social Science Computer Review ($n = 18$); E-content ($n = 17$); Cutting Edge Technologies in Higher Education ($n = 16$); New Media and Society ($n = 15$); Expert Systems with Applications ($n = 14$); ACM Transactions on Intelligent Systems and Technology, Journal of Communication, Government Information Quarterly, and PC World San Francisco CA, 13 articles each; Journal of the American Society for Information Science and Technology, and

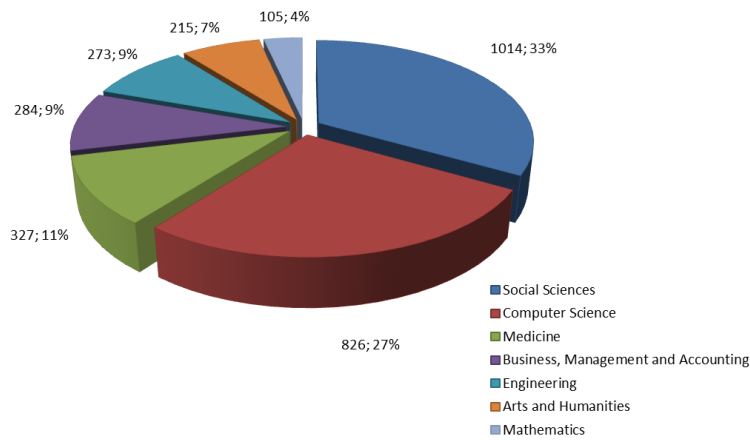


Fig. 2: Number of articles by disciplines.

Online Wilton Connecticut with 12 articles each; American Behavioral Scientist ($n = 11$); Cyberpsychology Behavior and Social Networking, Proceedings of the ASIST Annual Meeting, and Studies in Computational Intelligence, with 10 articles each [Figure 3].

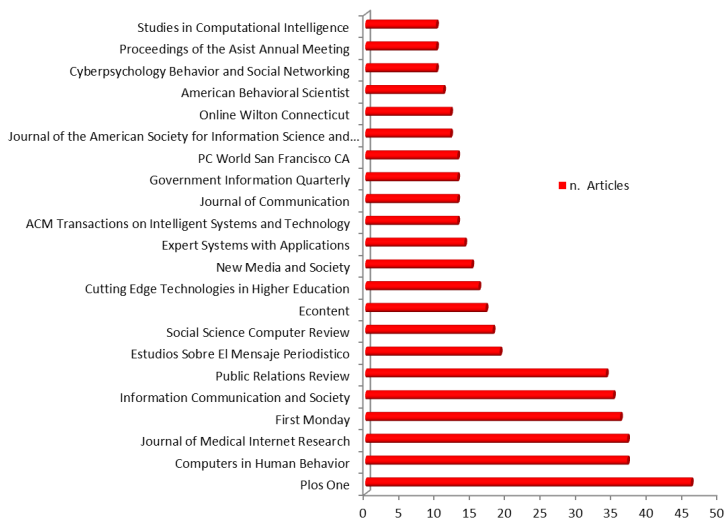


Fig. 3: Top journal titles with articles published about Twitter (2006-2014).

The most prolific authors were H. W. Park with 13 articles and A. Bruns, with 12 ones, but others authors also figured with a good research output in this matter, such as J. J. Jung and T. Highfield, both with 9 articles; P. R. Spence and S. H. Burton, with 8 articles; and A. O. Larsson, I. Himmelboim, J. K. Harris and M. Thelwall with 7 articles each [Table 1].

Table 1: Most prolific authors who published about Twitter (2006-2014)

Author	n. Articles
Park, H.W.	13
Bruns, A.	12
Jung, J.J.	9
Highfield, T.	9
Spence, P.R.	8
Burton, S.H.	8
Larsson, A.O.	7
Himmelboim, I.	7
Harris, J.K.	7
Thelwall, M.	7

As for institutions with more than 15 contributions, results show Yeungnam University with the most number of articles published (30 contributions); followed by Queensland University of Technology ($n = 22$); Pennsylvania State University, the University of Oxford and the University of Toronto ($n = 18$ each); University of Texas at Austin ($n = 17$); University of Maryland and Indiana University ($n = 16$ each); Seoul National University, University College, (London), Carnegie Mellon University, University of New York State at Buffalo, with 15 articles each [Figure 4].

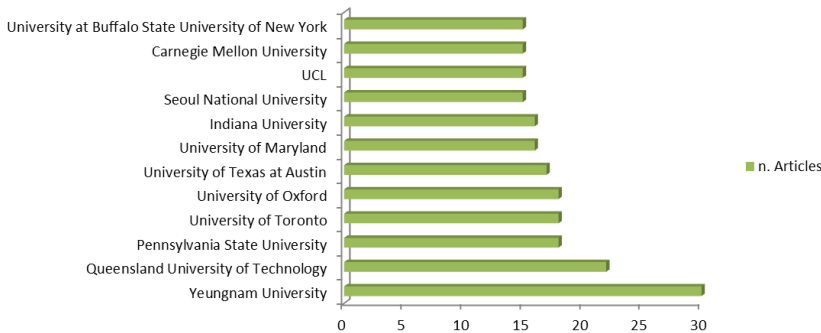


Fig. 4: Top institutions with more than 15 articles published about Twitter (2006-2014).

The following countries had more than 50 articles: the United States (USA) with 912 publications (39% of the total sample); the United Kingdom (UK) with 216 (9.23%); Spain, 148 (6.33%); Australia, 119 (5.1%); South Korea, 116 (4.9%); China, 99 (4.23%); Canada, 98 (4.2%); Germany, 65 (2.8%); Japan, 63 (2.7%); and The Netherlands, 51 (2.2%) [Figure 5].

Ahead, in this analysis, we will show those same countries according to the topics most published by them, forming clusters by equivalent subject.

10 Main countries publishing about Twitter

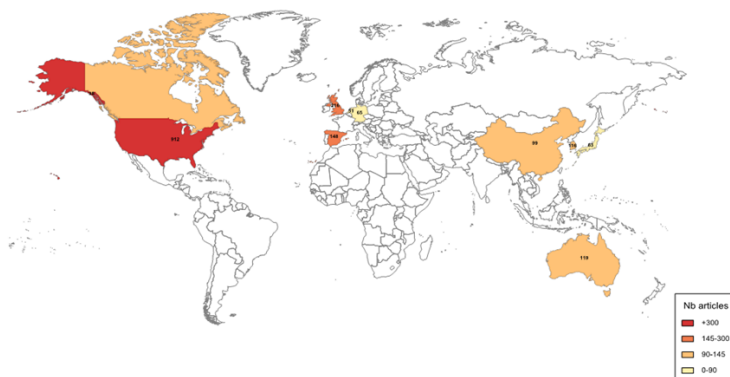


Fig. 5: Top countries with more than 50 articles published about Twitter (2006-2014).

3.2 Citations and textual analysis

Most cited authors and journals. In addition to the basic quantitative indicators shown before, we also examined the data sample to verify the most cited papers in order to get insights about the impact of that scientific literature with Twitter as subject research. Table 2 shows articles with more than 100 citations, summarized by authors, article titles, publication year, journal titles, number of citations received and the topics.

The most cited authors were Kaplan and Haenlein (2010), with an article published in the “Business Horizons” journal, which reached 1,296 citations. As the journal title points out, the main topic of this paper is Business. Next, the authors cited about 400 times were Jansen et al (2009), with an article cited 438 times, in the topic of Information in the “Journal of the American Society for Information Science and Technology;” and Bollen, Mao and Zeng (2011), cited 430 times, with a paper on the topic of Computation, in the “ Journal of Computational Science”.

The third group of most-cited authors, which reached about 200 citations, were Kietzmann et al (2011) with an article on the topic of Business, again in the “Business Horizons” journal, with 283 citations; Marwick and Boyd (2011) on the topic of Information in “New Media and Society,” with 243 citations; and, finally, Yardi, Romero and Schoenebeck (2009), with an article in “First Monday” on the General topic that reached 239 citations.

The fourth and last group of most-cited authors spanned 116 to 176 citations and includes 14 journals, with topics like Science (3 occurrences), Health (5 occurrences), Information (2 occurrences), Computation (2 occurrences) and Business (1 occurrence) [Table 2].

Only four journals with most-cited articles are also in the top journals list with more than 10 articles published about Twitter, as follows: “PLoS One” has published 46 articles on Twitter and also figured among the most-cited with two articles, from Chew and Eysenbach

Table 2: Most prolific authors who published about Twitter (2006-2014)

Author	Title	Year	Journal	n. Citations	Topic
Kaplan A.M.; Haenlein M.	Users of the world, unite! The challenges and opportunities of Social Media	2010	Business Horizons	1296	BUSINESS
Jansen B.J.; Zhang M.; Sobel K.; Chowdhury A.	Twitter power: Tweets as electronic word of mouth	2009	Journal of the American Society for Information Science and Technology	438	INFORMATION
Bollen J.; Mao H.; Zeng X.	Twitter mood predicts the stock market	2011	Journal of Computational Science	430	COMPUTATION
Kietzmann J.H.; Hermkens K.; McCarthy I.P.; Silvestre B.S.	Social media? Get serious! Understanding the functional building blocks of social media	2011	Business Horizons	283	BUSINESS
Marwick A.E.; Boyd D.	I tweet honestly: I tweet passionately: Twitter users, context collapse, and the imagined audience	2011	New Media and Society	243	INFORMATION
Yardi, S.; Romero, D.; Schoenebeck, G.	Detecting spam in a Twitter network	2009	First Monday	239	GENERAL
Chew C.; Eysenbach G.	Pandemics in the age of Twitter: Content analysis of tweets during the 2009 H1N1 outbreak	2010	PLoS One	176	SCIENCE
Hawn C.	Report from the field: Take two aspirin and tweet me in the morning: How twitter, facebook, and other social media are reshaping health care.*	2009	Health Affairs	170	HEALTH
Boyd D.; Crawford K.	Critical questions for big data: Provocations for a cultural, technological, and scholarly phenomenon	2012	Information Communication and Society	167	INFORMATION
Golder S.A.; Macy M.W.	Diurnal and seasonal mood vary with work, sleep, and day/length across diverse cultures	2011	Science	161	SCIENCE
Signorini A.; Segre A.M.; Polgreen P.M.	The use of Twitter to track levels of disease activity and public concern in the U.S. during the influenza A H1N1 pandemic	2011	PLoS One	161	SCIENCE
Scanfield D.; Scanfield V.; Larson E.L.	Dissemination of health information through social networks: Twitter and antibiotics	2010	American Journal of Infection Control	147	HEALTH
Junco R.; Heiberger G.; Loken E.	The effect of Twitter on college student engagement and grades	2011	Journal of Computer Assisted Learning	143	COMPUTATION
O'Keefe G.S.; Clarke-Pearson K.; Mulligan D.A.; et al.	Clinical report - The impact of social media on children, adolescents, and families	2011	Pediatrics	131	HEALTH
Theilwall M.; Buckley K.; Paltoglou G.	Sentiment in Twitter events	2011	Journal of the American Society for Information Science and Technology	131	INFORMATION
Ebner M.; Lienhardt C.; Rohs M.; Meyer I.	Microblogs in Higher Education - A chance to facilitate informal and process-oriented learning?	2010	Computers and Education	131	COMPUTATION
Vance K.; Howe W.; Dellavalle R.P.	Social Internet Sites as a Source of Public Health Information formation	2009	Dermatologic Clinics	128	HEALTH
Hennig-Thurau T.; Malthouse E.C.; et al.	The impact of new media on customer relationships	2010	Journal of Service Research	121	BUSINESS
Lee Hughes A.; Palen L.	Twitter adoption and use in mass convergence and emergency events	2009	International Journal of Emergency Management	116	HEALTH

(2010) which received 176 citations, and from Signorini et al (2011), with 161 citations. The “First Monday” has published 36 articles on Twitter and received 239 citations in the article by Yardi, Romero and Schoenebeck (2009). The “Information Communication and Society” has published 35 articles and received 167 citations from Boyd and Crawford (2012). Finally, the “New Media and Society” journal published 15 articles on Twitter and received 243 citations to the Marwick and Boyd’s article (2011).

So there isn’t a clear relationship between the largest number of published articles on Twitter and a greater number of citations received, as only four (18, 18%) from a total of 22 journals with more than 10 publications on Twitter received more than 100 citations.

“Hot Topics” in the literature about Twitter. Continuing our analysis, we proceeded in the mining of the most frequent topics into literature about Twitter, through applying the software Sphinx Lexica® in a semi-automatic lexical corpus analysis, after removing the term “Twitter” from it, identifying specific terms with more than 100 occurrences by year to observe their evolution in frequency during the analyzed period of 2006-2014. All terms were joined together in groups of equivalent ones.

Results show several most frequent topics, with “social media” leading in a total of 3,197 occurrences, with an ongoing growth in its frequency over the period, followed by the topic “social networks,” with the total of 1,981 occurrences, also with an ongoing growth in its frequency over the same period.

“Hot topics” also very often include the topic of “learning” (human learning), with 360 occurrences; “health” (330); “political activity” (324), among others represented in Table 3.

Representative keywords were evolving rapidly. For example, “Second Life” was representative in the early years. In turn “big data” and “data mining” appear over the whole time period. It was observed that in general most of the topics had a continued growth in frequency since the year in which they first appeared in the literature on Twitter, and this evolution of their frequency can predict the trends of these topics.

This topic analysis also allowed the mapping of these topics by clusters, according to related lexical similarities, e.g. a topic cluster related to “health” groups terms such as “public health,” “patient” and “health care,” (represented in clear blue in Figure 6), as well as a topic cluster related to terms such as “political activity,” “social movements,” “public relations” and “mass communication” (represented in clear yellow in Figure 6, that also shows the other topic clusters that emerged in this analysis).

This “hot topic” analysis also allowed clustering topics related to their frequency by countries, as shown in Figure 6, and also pointing out the relations between countries by thematic collaborations, next in Figure 7.

In Figure 6 there are countries that are more present in each cluster, addressing related topics sorted by decreased term frequency, such as USA, China, UK, Spain, Australia, Canada, South Korea, Japan, etc. But in Figure 7 it is possible to observe the thematic collaborations between these countries and others that were checked through the institutional affiliations (by country) in the recovered articles, with a chi-squared (χ^2) distribution of the “hot topics”. It was observed that there are only 340 papers with international collaborations,

Table 3: “Hot topics” and their evolution in literature about Twitter (2006-2014)

Topics	2006	2007	2008	2009	2010	2011	2012	2013	2014	TOTAL
social_media	0	0	1	23	10	370	494	984	1211	3197
social_networks	0	4	19	50	128	221	373	592	593	1981
learning	0	0	0	1	10	38	61	93	157	360
health	0	0	0	4	11	30	35	122	127	330
political_activity	0	0	0	0	3	38	44	114	125	324
mobile	0	2	2	14	28	32	67	68	69	282
real_time	0	0	6	1	11	28	38	60	53	197
content_analysis	0	0	0	0	10	20	30	58	73	191
sentiment_analysis	0	0	0	0	0	12	25	56	89	182
marketing	0	0	0	5	8	22	34	61	45	175
twitter_users	0	0	1	2	2	11	29	48	69	162
case_study	0	0	0	5	5	11	30	47	57	155
opinion	0	0	0	0	0	13	23	45	66	147
public_health	0	0	0	4	5	18	21	40	50	138
facebook	0	0	0	3	9	24	17	25	48	126
news	0	0	1	1	4	22	24	32	41	125
qualitative_analysis_data	0	0	0	0	3	18	19	24	54	118
web_sites	0	0	1	4	19	19	23	25	23	114
big_data	0	0	0	0	0	0	27	30	55	112
large_scale	0	0	0	0	6	7	23	26	43	105
higher_education	0	0	0	1	10	18	16	36	22	103
user_activities	0	0	0	0	1	2	19	28	49	102
second_life	0	1	0	1	5	10	0	2	0	19

13% of the whole corpus, which is a very low percentage compared to other domains in international research.

These clusters, for example, show such themes as “collective action”, “big data”, “text and web mining”, “marketing”, “political activity” and “user generated content” and were common topics in the collaborations between Brazil, France, India, Italy, UK, and others. In turn, topics such as “crisis communication”, “corporate communication”, “traditional education”, “political activity” and “sentiment classification”, were most common in collaborations between Belgium, Switzerland, The Netherlands, and Turkey. This analysis is useful to realize which countries have collaborations in the research of specific topics about Twitter.

4 Discussion and concluding remarks

These findings indicate that there was a steady growth in the academic literature which includes Twitter as research subject in the period from its founding, in 2006, to 2014. The subject areas with most contributions were the Social Sciences, followed by Computer Science and Medicine. There is a long tail of journal titles that have published articles on this subject, with 22 titles in more than 10 publications, all of them in English, apart from a single title in

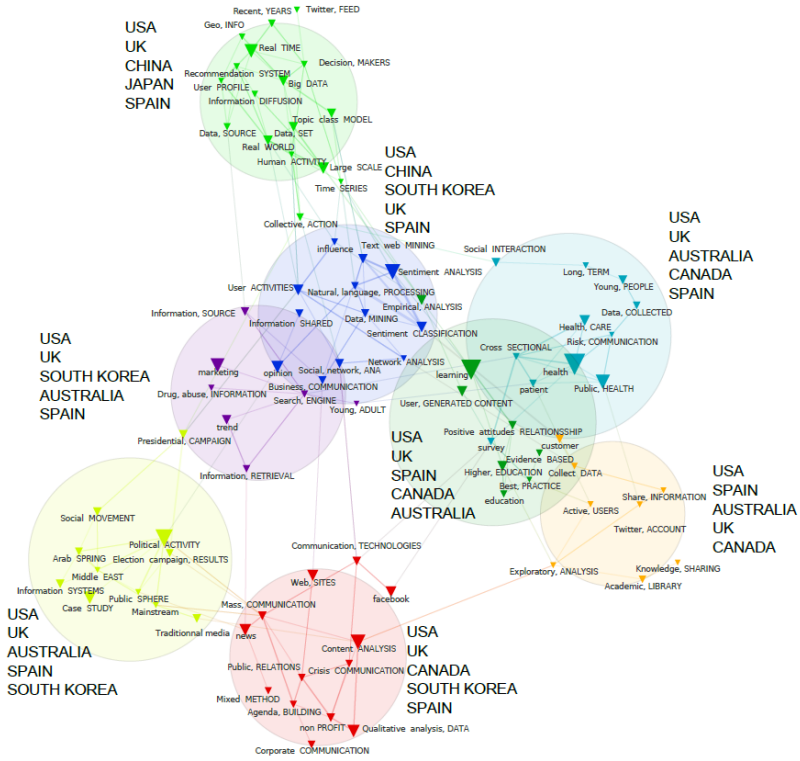


Fig. 6: “Hot topics” by countries sorted by decreased term frequency.

Spanish. Two authors stand out in terms of the number of articles, and various institutions have made contributions, most of them being universities from North America (USA and Canada) and Europe (UK, Spain, Germany and The Netherlands), although Asia (China, Japan and South Korea) and Oceania (Australia) also stood out.

With a second-level analysis in a deeper manner, it was possible also consider citations and the “hot topics” of the literature about Twitter, in order to verify their impact, and to identify which topics were more discussed in this literature, as well as to find out with a mapping tool how these topics were distributed by subject groups and countries, including collaborations between these countries. It was observed that there is a group of papers which received more than 100 citations, but there was not a clear relation between the largest number of published articles on Twitter and a greater number of citations received.

There are several “hot topics” that were addressed in the literature on Twitter, with “social media” and “social networks” leading with 3,197 and 1,981 occurrences, respectively, and the majority of these topics had a continued growth in their frequency in the literature during the analyzed period. Twitter analysis is strongly related to social issues and enhanced problems linked to youth populations, as health (obesity), public health, international disasters, drug abuse, but also to the learning and education process. Three other important fields of analysis are social behavior (opinion), political activity and branding/media strategy.

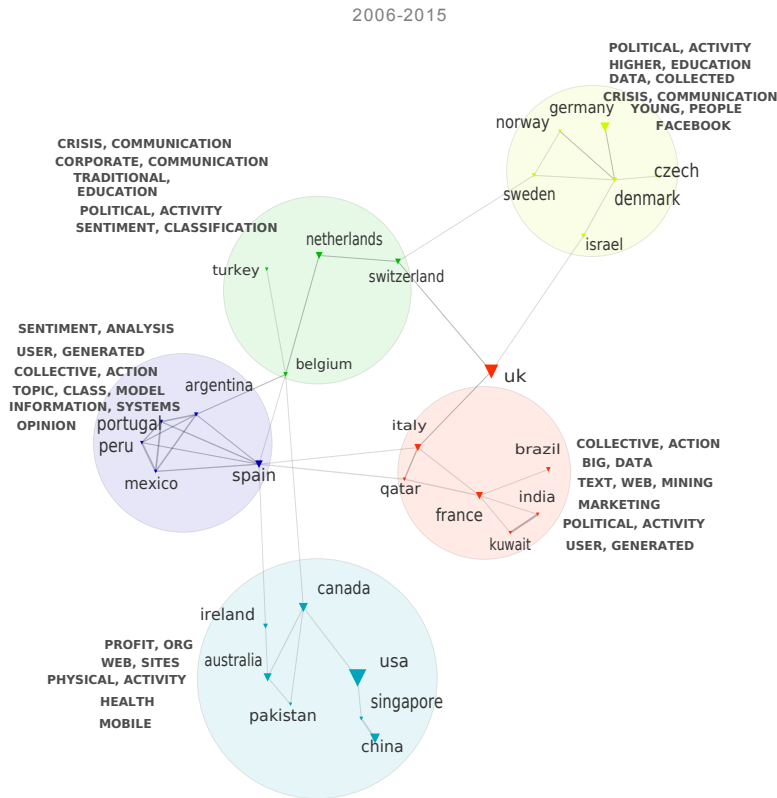


Fig. 7: “Hot topics” by country collaborations sorted by χ^2 distribution.

It was interesting to see how these “hot topics” were organized under common subjects and how they were distributed between different countries, including collaborations between these countries in the research of certain topics about Twitter. There are a few international collaborations (13% of the corpus) and it is mostly delimited to traditional collaborator countries (between USA, UK, and those from Asia – China and South Korea).

All these findings add to and group together with previous studies about Twitter and aim at a contribution to a better comprehension of this social media platform which evolved from a data source for the research to, nowadays, being a research subject itself.

Future directions of the investigation of this role of Twitter as an object of study through Bibliometric Analysis are a continuous task that point to other approaches which can provide more detailed insights, such as how the research network is drawn from the cited references.

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