Global analysis of Twitter communication in corporate social responsibility area: sustainability, climate change, and waste management

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Many people now consider social media to be an integral part of their daily routines, which has enabled companies to implement successful corporate social responsibility campaigns through these platforms. The direct interaction with stakeholders offered by social media helps companies to build understanding, trust, and their image. The aim of this study was to identify key topics and trends communicated in connection with corporate social responsibility on the Twitter social network from 2017 to 2022. Analysis of 520,638 tweets by 168,134 unique users identified a predominance of environment-related topics: Sustainability, Climate Change, and Waste management. However, Charity remains the largest single topic. Based on the trend analysis, the areas of ESG, Social Impact, and Charity were identified as growth areas in communication, while Green and Philanthropy, on the other hand, were identified as decreasing.

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Abstract

Many people now consider social media to be an integral part of their daily routines, which has enabled companies to implement successful corporate social responsibility campaigns through these platforms. The direct interaction with stakeholders offered by social media helps companies to build understanding, trust, and their image. The aim of this study was to identify key topics and trends communicated in connection with corporate social responsibility on the Twitter social network from 2017 to 2022. Analysis of 520,638 tweets by 168,134 unique users identified a predominance of environment-related topics: Sustainability, Climate Change, and Waste management. However, Charity remains the largest single topic. Based on the trend analysis, the areas of ESG, Social Impact, and Charity were identified as growth areas in communication, while Green and Philanthropy, on the other hand, were identified as decreasing.

Introduction

37 Corporate social responsibility (CSR) initiatives have become a priority for business
38 organisations around the world in recent years (Chae and Park, 2018; Suttipun et al., 2021; Wang
39 et al., 2016), as a result of increased competition among businesses to obtain customers by
40 building their image in society through socially responsible activities such as support of
41 employee's well-being, charity's programs, cooperation with the local community, or
42 environmental initiatives (Rizwana et al., 2012; Tan et al., 2022; Yang et al., 2020).
43
44 As the global emphasis on economic and environmental sustainability grows, firms are
45 compelled to declare their corporate social responsibility (Chen et al., 2018; Nguyen et al.,
46 2021). Regulators, investors, and other stakeholders, particularly in emerging economies, are
47 interested in this trend toward mandating CSR disclosure (Wu et al., 2021).
48
49 The exponential growth of social media (SM) has evolved in a transformation in the
50 communication environment in which stakeholders as users are able to publish and share their
51 opinions about businesses and their products (D'Andrea et al., 2019). This is a particularly
52 important activity as recent studies have shown the benefits of CSR communication with
53 stakeholders (Bartikowski and Berens, 2021; Husnaini et al., 2018; Viererbl and Koch, 2022;
54 Withisuphakorn, 2018). This means that the board of directors, attorneys, the HR department,
55 sales department, customer service department, marketing and PR department, and other
56 divisions can use social media in practically every aspect of an organisation's operation (Edyta et
57 al., 2016). In the context of the increasing popularity of social media, which now has over 4.6
58 billion users, social media presents significant conceptual and theoretical challenges to a CSR
59 monitoring and reporting literature that has previously mostly concentrated on one-way, yearly
60 communication. Disclosure with CSR reports has been impacted by social media, which provides
61 a more dynamic, participatory public forum (Neu et al., 2020).
62
63 Twitter is one of the most popular social networking platforms, used by 329 million monthly
64 active users worldwide (Dixon, 2022). The rise in popularity of Twitter, as well as people's
65 acceptance of it, has created an opportunity for more research on this social media medium
66 (Manuel, 2015). In the last decade, Twitter has established itself as an essential research
67 platform, which has been used in more than ten thousand research articles (Antonakaki et al.,
68 2021), because Twitter allows for obtaining a large amount of real-time textual data of public
69 opinion on the monitored issue (Gaytan Camarillo et al., 2021), tracking trends (Vargas et al.,
70 2021), and analysing sentiment (Park et al., 2022). In the field of CSR, Twitter was used as a
71 data source, for example, in a study by Dong and Rim (2019), which identified and interpreted
72 the non-profit organisations communication strategies used when they are communicating on
73 Twitter about their CSR collaborations; a study by Okazaki et al. (Okazaki et al., 2020) analysed
74 the level of interaction in eight brands' CSR Twitter dialogues and investigated the reason for the
75 observed level of interaction; or in the study by Ali et al. (2017), where the author identified the
76 determinants of corporate social media accounts for CSR disclosures. However, none of the

77 previous research dealt with the topic structure of CSR and the sentiment that the communicated
78 topics evoke. Similarly, previous studies have yet to deal with trends in CSR communication on
79 Twitter. Based on these findings, the aim of this study is to investigate the use of hashtags, the
80 topic structure, sentiments, and trends in corporate social responsibility (CSR)-related
81 discussions on Twitter.
82 To achieve the research aim, this study will address the following research questions:
83   1. What are the most frequently used hashtags in tweets related to CSR?
84   2. What is the topic structure of CSR-related discussions on Twitter?
85   3. What sentiments are expressed in CSR-related topics on Twitter?
86   4. What are the trends in connection with CSR communicated on Twitter?
87
88 This study used a social media data analysis with a focus on hashtags and tweets to identify key
89 characteristics of CSR communication on the Twitter social network worldwide. This article
90 contributes to the literature in several ways. First, some previous studies have focused on the
91 social media data analysis of CSR communication at the national (Amin et al., 2021), or
92 analysing selected companies (Maiorescu-Murphy, 2022; Okazaki et al., 2020); this paper offers
93 a comprehensive view and offers new findings and insights into CSR communication on Twitter
94 worldwide. When examining the detection of characteristics of CSR communication on Twitter,
95 the article uses an automated machine learning approach to automatically analyse content in
96 tweets instead of using the manual coding techniques commonly used in mainstream CSR
97 communication research. From a methodological point of view, this article represents a new
98 research approach to the analysis of CSR communication on Twitter. The study also expands the
99 current knowledge by identifying dominant topics communicated on Twitter, identifying the
100 sentiment that the communicated topics evoke, and identifying the trend of individual hashtags in
101 connection with the hashtag #CSR independently of the trend of the entire topic #CSR.
102

103 **Theoretical background**
104 According to Hoffman (2007) the concept of corporate social responsibility dates back to the
105 1920s, where during this period, there was a shift away from the individual ethic required for
106 westward expansion, and a corresponding rise in the importance of the social ethic necessary for
107 achieving industrial harmony. Throughout the years it has been referred to by a variety of
108 acronyms, including corporate sustainability, voluntary projects, philanthropy, and even just
109 social responsibility (Wang et al., 2016). Several decades later, the concept had become more
110 specific, with (Chonko and Hunt, 1985) arguing that the "social responsibility" of corporations
111 needed to explicitly name social and environmental interests in particular, Hopkins (1997)
112 stating that social responsibility meant the obligations a company had to all of its stakeholders,
113 and Singhapakdi et al. (1994) linking social responsibility to a corporation's image, saying
114 companies needed to improve their public brand by implementing actions beyond just
115 philanthropic giving.
116

117 Today, Li et al. (2021) argue that the most fundamental definition of corporate social
118 responsibility that has stood the test of time is the one developed by John Elkington (1994),
119 defining corporate social responsibility as a company's "triple bottom line," i.e., instead of only
120 being motivated by economic gains, a company also needs to take into account social and
121 environmental perspectives.
122
123 CSR reporting
124 Communication CSR activities are undoubtedly part of the CSR strategy (Kent and Taylor, 2016;
125 Ting, 2021). In the last few years, the number of firms that have built standardised reports and
126 governance systems to evaluate, assess, drive, and communicate sustainability activities has risen
127 rapidly (Eccles et al., 2014). Prior studies (Brochet et al., 2012; Capurro, 2005) support the fact
128 that companies with a high level of sustainability (economic viability, environmental protection,
129 and social equity) are more likely to have developed stakeholder engagement mechanisms, to be
130 more long-term oriented, and to monitor and disclose non-financial data more frequently.
131 Arvidsson (2010) and Nielsen and Thomsen (2017) found that company communications around
132 corporate social responsibility could actually counter negative publicity around an organisation
133 by altering public perception. Research has found a number of additional positive benefits
134 associated with a company disclosing its corporate social responsibility strategy: to differentiate
135 themselves from its competitors (Porter and Kramer, 2006); to increase the possibility of
136 consumers purchasing their products (Lee and Shin, 2010; Wang and Korschun, 2015); to help
137 consumers identify more with the company (Tsai et al., 2015; Wang and Korschun, 2015); to
138 improve the company's image and transparency, as well as enhancing investor trust in its
139 investment decisions (Yusoff et al., 2013).
140
141 Wehmeier and Schultz (2011) posit that any corporate social responsibility storytelling needs to
142 be based on the values of the corporation, particularly values that stakeholders share and
143 experience themselves, and that these values can be communicated in a way that emphasises the
144 moral implications of the company's actions. Additionally, corporate social responsibility stories
145 are best received when their narratives focus not just on the current actions a company is taking,
146 but on aspirations the company has for initiatives and programmes to effect a change in the
147 future (Castelló et al., 2013). Further research indicates that for corporate social responsibility
148 communication to be effective, it needs to focus on credibility and the use of well-respected
149 sources, incorporating third-party endorsements from reliable organisations such as non-profits
150 and non-governmental organisations, streamlining media and communication channels, and
151 involving stakeholders themselves (Maignan and Ferrell, 2001; Morsing et al., 2008; Pomering
152 and Dolnicar, 2009; Schlegelmilch and Pollach, 2005). Involving stakeholders can be as simple
153 as tailoring corporate social responsibility communications content to include events and
154 examples considered relevant by stakeholders (Graham Spickett-Jones et al., 2004;
155 Schlegelmilch and Pollach, 2005), though it can also involve directly communicating with
156 stakeholders themselves via social media interactions.

157
158   CSR reporting and social media
159   General information may be communicated through a variety of communication instruments and
160   channels. A company can promote its CSR initiatives through official documents such as an
161   annual corporate social responsibility report, brochures, websites, advertising, pamphlets,
162   product packaging, television spots, cause-related marketing, and organising dialogues and other
163   events emphasising corporate social responsibility (Lodhia, 2004, 2006; Morsing et al., 2008).
164
165   Despite the ubiquity of annual reports as a means for corporate social responsibility
166   communication, recent research may indicate that such reports are gradually becoming less
167   effective and impactful as a communication tool (Aikat, 2000; Saat and Selamat, 2014).
168   Communicating with stakeholders via social networking sites has become an increasingly
169   common practice in the corporate world (Aichner et al., 2021; Araujo et al., 2015; Cartwright et
170   al., 2021; Dwivedi et al., 2021; Okazaki et al., 2020; Suárez-Rico et al., 2018). Because of the
171   inherently interactive nature of social networking sites, these platforms are one of the best
172   mediums for creating an open dialogue between companies and stakeholders, one of the
173   aforementioned highly effective methods for engaging public interest in corporate social
174   responsibility activities (Araujo et al., 2015; Lee et al., 2013; López et al., 2017; Ruehl and
175   Ingenhoff, 2015). Social media dialogue about CSR helps organisations build understanding,
176   trust, and social capital between organisations and the public (Kent and Taylor, 2016).
177
178   Around 4.6 billion users are currently active on social networks worldwide (Dixon, 2022). In the
179   context of classic mass media such as radio, television, and newspapers, these users are not
180   merely passive recipients but create an active and passive digital footprint (Deeva, 2019). Given
181   the fact that in terms of the world's total population (7.9 billion people), social networks are used
182   by around 58% of the population (Worldometer, 2022), analysis of this big data is important in
183   understanding the attitudes, experiences, and behaviours of the individual users on these
184   platforms (Childers et al., 2019; Pilař et al., 2017; de Veirman et al., 2017; Zhang et al., 2020).
185
186   The huge popularity of these social networks is obvious to businesses, which use these platforms
187   to communicate with the wider public (Pardo et al., 2022). Tao and Wilson (2015) report that
188   Twitter is a communication priority for many organisations. Social media interactions with a
189   company on Twitter are more specifically linked to brand identification and loyalty (López et al.,
190   2017). Since Twitter is a well-established social media platform for people to connect with
191   others who share common goals and interests (Etter, 2014), it is a logical medium for companies
192   to target for corporate social responsibility communications, which are aspirational and value-
193   based in nature. The benefits of engaging on Twitter for corporations are twofold: tweeting about
194   corporate social responsibility is a more effective way to communicate CSR initiatives than other
195   communication methods, and tweets about corporate social responsibility tend to be viewed
196   more favourably than other company tweets (Lee et al., 2013) and may lead to an increase in

197 follower count and engagement with the company's social media account (Araujo and Kollat,
198 2018).
199

Materials & Methods

201 The data analysis was based on the extended SMAHR framework (Pilař, et al., 2021). The data
202 analysis process based on SMAHR framework consisted of four steps (Fig 1):
203

204 Figure 1 Four steps of social media analysis based on the framework for hashtag research
205 (SMAHR).
206

207 Source: own elaboration
208

209 1) **Data acquisition**:
210   The aim of this step was to collect data from the Twitter social network that contain the
211   hashtag #csr on the Twitter social network from January 1st, 2017 to April 30th, 2022,
212   using the Twitter API.
213

214   The Twitter API was used to obtain the data (Platform, 2022).
215   Tweets were downloaded from the Twitter social network using the Twitter API v2
216   (Platform, 2022). The Tractor software was used for this purpose (Tractor, 2023). The
217   software downloaded tweets that included the hashtag #csr. During that timeframe,
218   520,638 Tweets of 168,134 unique Twitter users were recorder. This dataset includes all
219   tweets with the hashtag #csr that users posted to the Twitter social network during the
220   observation period.
221

222 2) **Data filtering**: In the next stage, it was necessary to filter messages that referred to the
223   topic of corporate social responsibility. An example is the computer game "CSR Racing".
224   Filtering was perform manually using the MS Excel program via the content filtering
225   function.
226

227 3) **Data mining**:
228   The aim of this step is to extract useful and relevant information from the vast amounts of
229   data generated by users on social media platforms.
230   The network was described using the techniques listed below:
231   a. Frequency: A metric called frequency describes how frequently a hashtag appears
232   in a network. The aim of this step was to identify the most used hashtags.
233   Through Hashtag extractor software (Pilař et al., 2021), all hashtags were
234   extracted from individual Tweets. The calculation of the number of individual
235   hashtags was performed by importing into Gephi 0.9.2 software (Bastian et al.,
236   2009).

237

238   b. Topic analysis:

239   Topic analysis is a method used to identify the main topics or themes that are
240   being communicated within a large dataset, such as social media posts. In
241   complex networks, such as social media networks, some nodes (i.e., hashtags or
242   words) are more interconnected with each other than with the rest of the network.
243   It is possible to identify topics based on clusters of individual hashtags.

244   The aim of this step was to identify topic structure of CSR-related discussions on
245   Twitter. Compared to frequency analysis, topic analysis was created based on
246   whole tweets (not only hashtags). For topic analysis, Graphext software was used
247   (Graphext, 2023). To analyse the community structure of our network, Graphext
248   utilized a modified version of the Louvain algorithm (Blondel et al., 2008). The
249   network was created based on the interconnectedness of individual words in the
250   Tweet. The Louvain algorithm employs an iterative process of allocating nodes to
251   clusters with the aim of optimizing a performance metric known as modularity.
252   This metric gauges the relative density of edges within clusters compared to those
253   between clusters. The number of distinct communities in the dataset was
254   calculated as follows:

$$\Delta Q = \left[\frac{\Sigma_{in} + 2k_{i,in}}{2m} - \left(\frac{\Sigma_{tot} + k_i}{2m}\right)^2 \right] - \left[\frac{\Sigma_{in}}{2m} - \left(\frac{\Sigma_{tot}}{2m}\right)^2 \right],$$

255   where $\sum in$ is the sum of weighted links inside the community, $\sum tot$ is the total
256   number of weighted connections inside the community, k_i is the total number of
257   weighted links related to community hashtags, and i, $k_{i,in}$ is the total weighted
258   linkages from an individual to community hashtags, and m is the normalization
259   factor, calculated as the total weighted links over the entire graph (Blondel et al.,
260   2008).

261

262   c. Visual analysis - Network visualization techniques such as force-directed layouts
263   can be used to highlight different aspects of a network, such as the density of
264   connections, or polarization of topics. The aim of this step was to identify the
265   polarity of the identified topics.Based on the ForceAtlas2 layout technique, a 2-
266   dimensional graph was generated for visual analysis. An improved version of the
267   ForceAtlas algorithm called ForceAtlas2 focuses on massive networks was used.
268   This approach uses visual representations of smaller samples to identify network
269   communities' intercommunity connections (Jacomy et al., 2014). Visual analysis
270   was created using Graphext software (Graphext, 2023).

271

272   d. Sentiment analysis - The purpose of sentiment analysis on Twitter social media is
273   to determine the general attitude or opinion expressed in tweets about a particular
274   topic. Sentiment analysis is a process of categorizing text into positive, negative,
275   or neutral sentiment based on the context and tone of the language used.

276	The aim of this step was to identify sentiments, which are expressed in CSR-
277	related topics on Twitter.
278	In this research, VADER (Valence Aware Dictionary and Sentiment Reasoner)
279	was used by sentiment analysis. VADER is a Lexicon and Rule-Based Sentiment
280	Analysis Tool (Hutto and Gilbert, 2014).
281	
282	e. Trend analysis - The purpose of trend analysis is to identify and understand
283	patterns and changes over time. The aim of this step was to identify the trends in
284	connection with CSR communicated on Twitter via hashtags trend analysis. For
285	trend analysis was used SPSS 21 software. In the field of trend analysis, three
286	following steps were used:
287	
288	i. Tests for trends in time series - There was assessed general development
289	tendency of all-time series through the linear trend function. Along with it
290	there was developed the null hypothesis, meaning that the slope measured
291	by regression coefficient is not statistically significant. To verify the reject
292	or fail to reject of the null hypothesis, the t-test was used. Decisions are
293	made by comparing the maximum first type error (the p-value), based on
294	our data, and the first type error of alpha (Tufféry, 2011).
295	ii. Cluster analysis - Time-series clustering is a process that can help us to
296	understand the pattern in fluctuating and large time series data (Tufféry,
297	2011). Time series clustering is an unsupervised learning problem similar
298	to the clustering in other data and variable types, but we also take the time
299	variable into account (Murtagh, Legendre, 2014). We mainly perform time
300	series clustering to minimize the data similarity across the clusters and
301	increase the similarity within the cluster. We used agglomerative
302	clustering in our analysis, because we explore the time series, and the
303	number of clusters is not known. We prepared the time series for analysis,
304	checked multicollinearity, and standardized all input values using z-score.
305	Then we calculated the similarity using Euclidian distance and we
306	employed Ward's method as the clustering algorithm. The homogeneity of
307	clusters was measured by R-square and Semipartial R-square (Tufféry,
308	2011). R-square is the proportion of the sum of squares explained by the
309	clusters (between-cluster sum of squares/total sum of squares). The nearer
310	it is to 1, the better the clustering will be. Semipartial R-square measures
311	the loss of the between-cluster sum of squares caused by grouping two
312	clusters together (Tufféry, 2011). Thus, the value should be small to imply
313	that we are merging two homogeneous groups.
314	iii. Chow test - We examined whether two parts of the time series show a
315	different slope. A method commonly method used for this is the Chow test

316 (Binkley, Young, 2020), which tests for group effects by comparing the
317 error sum of squares (ESS) from regressions on the individual time series
318 to the ESS from a pooled regression using an F-test.
319 Consider a standard k-variable regression model $Y = \alpha + X\beta$ (Binkley and
320 Young, 2020), where e is the usual error term and k includes an intercept.
321 Data is available from two distinct parts, the first and the second section of
322 the time series. Let us denote the groups as A and B, the interest is in
323 whether the same equation applies to both. There we test the Chow test
324 null hypothesis $\beta A = \beta B$. The Chow test statistic is as follows (Chow,
325 1960 in Binkley, Young, 2020):

$$F = \frac{ESS_P(ESS_A - ESS_B)}{ESS_A + ESS_B} \times \frac{n_A + n_B - 2k}{k}$$

326
327
328 where the ESS's are the error sum of squares from the regressions. The statistic
329 has an F-distribution with k and $nA + nB - 2k$ degrees of freedom. The null
330 hypothesis tested assumes equal regression coefficients.
331

332 4) **Knowledge Representation**: Knowledge Represenation is a procedure that uses
333 visualization tools to explain the findings of data mining. Knowledge representation
334 highlights the synthesis of individual values and outputs from the phase of data
335 evaluation. The aim of this step is to highlight important findings of previous analyses.
336

337 **Results and discussion**
338 First of all, data from the period 2017-2022 was used to analyse the frequency of hashtags in
339 relation to the #CSR hashtag. The hashtags most posted in connection with #CSR are
340 #sustainability, #esg, #green and #sdgs - see Table 1. According to many authors (Księżak and
341 Fischbach, 2018; Pan et al., 2021; Varyash et al., 2020), CSR is based on the Triple Bottom Line
342 concept, according to which a business is based on three pillars - profit, people, planet (Uadiale,
343 2012), i.e., it bears economic, social, and environmental responsibility for its activities (Braccini
344 and Margherita, 2018). The results of the hashtag frequency analysis on Twitter show that
345 environment-related hashtags are the most common. The top 30 most frequent hashtags in CSR
346 communication include #sustainability, #green, #sdgs, #sustainable, #environment and
347 #climatechange.
348

349 The World Commission on Environment and Development (UN – United Nations, 1987) defines
350 Sustainability as utilizing resources to meet the 'needs of the present without compromising
351 future generations' ability to meet their own needs'. The close link between CSR and
352 sustainability has long been confirmed by numerous studies (Carroll and Shabana, 2010;
353 Christensen et al., 2021; Kang et al., 2015; Meseguer-Sánchez et al., 2021). A bibliometric

354 analysis from 2003 - 2021 conducted by Sánchez-Teba (2021) found that the main topics driving
355 CSR research between 2003 and 2021 were sustainability and the environment. The strong link
356 between the concepts is particularly clear in Europe, where for the European Union CSR is the
357 basic means of supporting sustainable development (Yıldız and Ozerim, 2014).
358
359 Environmental, Social and Governance (ESG) can be seen as the three non-financial dimensions
360 of business, which take into account the impact on the environment, respect for social values and
361 the quality of company management (DeGennaro and Barry, 2020). ESG developed from the
362 CSR concept (MacNeil and Esser, 2022) and represents an evaluable result regarding a
363 company's overall sustainability performance (Polley, 2022). ESG offers quantitative metrics and
364 thus enables a shift away from qualitative descriptions of CSR (Cini and Ricci, 2018). The
365 importance of ESG has risen particularly in recent years, in connection with the new EU
366 directive on corporate sustainability reporting, which from 2024 obliges enterprises with 250 or
367 more employees to report non-financial information (European Commission, 2021), thus greatly
368 increasing the number of businesses that will be obliged to file non-financial reports.
369
370 The concepts of CSR, ESG and Sustainability have a lot in common; certain (Fatemi et al., 2018;
371 Gillan et al., 2021) even consider them to be equivalent. However, despite their apparent
372 similarity, these are separate concepts with fundamental differences (MacNeil and Esser, 2022).
373
374 The hashtag #SDGS, which analysis has shown to be the 5th most frequently posted hashtag in
375 connection with CSR, refers to the 17 Sustainable Development Goals adopted by all UN
376 Member States in 2015. SDGs represent a plan to protect the environment, eradicate extreme
377 poverty, and combat injustice and inequality (UN – United Nations, 2015).
378
379 Table 1. The 30 most frequently used hashtags related to CSR on Twitter.
380 Source: own elaboration
381
382 **Topic analysis**
383 Topics analysis allows us to better understand the dynamics of the entire communication through
384 the identification of links between individual hashtags. The results of the topic analysis are
385 shown in Table 2.
386
387 Table 2: Topics related to #CSR
388 Source: own elaboration
389
390 The largest topic identified is Charity which includes aspects relating to volunteer and
391 philanthropic activities: charity, volunteer, donate, philanthropy, etc. These results are in
392 accordance with the research conducted by Kvasničková et al. (2020), which drew on data from
393 Instagram from 2019 to identify philanthropic responsibility as the biggest topic in both

394 developing and developed countries. The same conclusion was also drawn by a study carried out
395 by Ngai and Singh (2021), which analysed the CSR communication of Chinese companies on the
396 Sina Weibo social network. Charity and philanthropic activities have formed a basic part of the
397 CSR concept since its very beginning (Carroll, 1991); our results show that despite the fact that
398 CSR has seen a major shift towards sustainability, these still have their place in the concept.
399
400 The second largest topic identified is Company Government. This topic involves
401 communications relating to the management of a company, such as a strategy, work, business,
402 value, etc.
403
404 A significant proportion of CSR communication on Twitter is devoted to sustainability. As Pilař
405 et al. (2019) state, as evidence of environmental risks mounts up, sustainability is being included
406 into the agendas of legislators and organisations, as well as company objectives. The results of a
407 cluster analysis identified this area in the topics Sustainability, Climate Change and Waste,
408 which together make up 19.38% of CSR communication on Twitter. The dominance of
409 sustainability in CSR communication is also highlighted by a hashtag frequency analysis (Table
410 1). Our findings can be explained as the importance that environmental issues have taken on in
411 the eyes of the public, as also confirmed by studies by Connor (2022), Jakučionytė-Skodienė
412 (2022) and Wassman (2023). Companies are recognised as sustainability leaders and use
413 communication about sustainability to attract public attention and to increase pressure on key
414 (Abeydeera et al., 2016).
415
416 Another topic identified is Education, which includes terms such as school, student, child,
417 project, and skill. Support for education within the framework of CSR activities is a routine part
418 of CSR and is of fundamental significance particularly in developing markets, where companies
419 often use CSR programs to take up the role of the state, where it fails to act itself (Valente and
420 Crane, 2010), although they are still used in western countries, too (del Baldo, 2018; Chuah et
421 al., 2022). According to Roy et al. (2022), investment in education and health care within the
422 framework of CSR programmes gives companies higher stock market liquidity than investment
423 in sustainability or social justice. A visual analysis (see Fig 2) has identified that communication
424 in the field of CSR and Education is closely linked to the field of CSR and Charity.
425
426 The topic Marketing communicates content aimed at promoting sales, such as purpose, brand,
427 customer, market, etc. Okazaki et al. (2020) found that certain companies use CSR
428 communication on Twitter solely as another advertising channel and do not make the most of the
429 potential of dialogue with stakeholders for creating value. However, according to Jahdi and
430 Acikdilli (2009), focusing excessively on boosting sales entails the risk of the company losing
431 consumer trust in its CSR communication as a whole.
432

433   The last topic identified is Human resources management (HRM), which includes terms such as
434   job, employee, workplace, career, etc. HRM can be classed as part of the internal social pillar
435   within the Triple Bottom Line concept defined by Elkington (Elkington, 1994). There are also
436   current studies focusing on CSR and HRM (Podgorodnichenko et al., 2022; Stahl et al., 2020;
437   Turner et al., 2019; Yin et al., 2021) although previous research analysing CSR on social media
438   had not identified HRM prior to then. This could therefore be a new trend, with the CSR concept
439   gaining strength in HRM.
440
441   Figure 2 Visual analysis
442   Source: own elaboration
443
444   A visual analysis enabled us to identify the link between Charity and Education together with
445   CSR HRM. Topics polarised from this group are those focusing on the environment and
446   sustainability (Sustainability, Climate Change a Waste). These poles then include the topic
447   Company Government, which overlaps into both groups. These results are in accordance with
448   the partial results achieved by individual studies (Karagiannis et al., 2022; Khan et al., 2021;
449   Ndubuka and Rey-Marmonier, 2019).
450
451   **Sentiment analysis**
452   Sentiment analysis is used to identify the emotions that are represented in the monitored tweets
453   (Shamoi, et al. 2022). Our results (Fig 3) shows that the greatest negative sentiment is generated
454   by communication on the topics of Waste (10.9%), Marketing (9.5%), and Climate Change
455   (8.1%). Negative sentiment communicated in relation to the topics of Waste and Climate Change
456   is not necessarily the result of public opposition to communicated CSR activities in these areas
457   but is generally a consequence of negative emotions - such as the sadness and fear that
458   environmental problems elicit in certain parts of the population (Gago and Sá, 2021; Hickman et
459   al., 2021). In contrast, negative sentiment occurring the Marketing topic is probably related to
460   consumer distrust and their concerns that CSR activities will be misused for companies'
461   marketing purposes and for so-called greenwashing (Ginder and Byun, 2022; Martínez et al.,
462   2020).
463
464   In contrast, the highest positive sentiment can be identified with the topics of Charity (56.9%)
465   and Education (41.8%). Neutral sentiment was most frequently elicited by topics communicated
466   in connection with HRM (71.3%) and CSR Reporting (70%).
467
468   Figure 3 Sentiment analysis
469   Source: own elaboration
470
471   The results of the sentiment analysis indicate that companies focusing on topics related to
472   charitable activities or supporting education on Twitter have a high potential to generate positive

473   discussion. On the contrary, posts that deal with environmental topics such as waste
474   management, the effects of climate change, etc., are dangerous to evoke more negative emotions
475   in stakeholders than other topics. It is therefore crucial for companies to be aware of what kind of
476   communication can generate positive reactions and what kind can have a negative impact on
477   customer and public relations when publishing posts.
478
479

480   **Trend analysis**
481   Trend analysis was created for the 9 most frequent hashtags that are used in connection with
482   CSR (for more, see Table 3) * Hashtag #corporatesocial was eliminated from the analysis - it is a
483   synonym. These are relative values that are related to the #CSR hashtag. Based on this, it is
484   possible to identify the trend of individual hashtags in connection with the hashtag #CSR
485   independently of the trend of the entire topic #CSR.
486
487   Table 3: Trend analysis
488   Source: own elaboration
489

490   **Growing trend**
491   Based on the trend analysis, it was possible to identify three hashtags that have a growing trend.
492   1) #ESG - this hashtag expresses „Environmental, Social and Corporate Governance", (see
493   Figure 4), 2) #Socialimpact – this hashtag expresses „significant or positive changes that solve or
494   at least address social injustice and challenges. Businesses or organisations achieve these goals
495   through conscious and deliberate efforts or activities in their operations and
496   administrations"(Rice, 2021) (see Figure 5), and 3) #Charity – this hashtag expresses "form of
497   money, given freely to people who are in need, for example because they are ill, poor, or have no
498   home" (English Cambridge Dictionary, 2022) (see Figure 6).
499

500   Figure 4 Trend of #ESG hashtag on Twitter social network in connection with CSR
501   Source: own elaboration
502

503   Figure 5 Trend of #Socialimpact hashtag on Twitter social network in connection with CSR
504   Source: own elaboration
505

506   Figure 6 Trend of #Charity hashtag on Twitter social network in connection with CSR
507   Source: own elaboration
508

509   Our results confirm the growing popularity of ESG, which is mentioned for example in studies
510   Zainullin and Zainullina (2021), Clément et al. (2022), and Dmuchowski et al. (2022). One of the
511   reasons for this trend may be that ESG represents the best available tool for evaluating CSR
512   (Cini and Ricci, 2018). According to Sætra (2021), the concept of ESG even replaces the concept

513   of CSR. For these reasons, companies should pay considerable attention to ESG in their social
514   media communications to keep up with current trends.
515

The trend has not been proven

517   The four hashtags have not been proven a trend. 1) #sustainability (see Figure 7), 2) #sgds - This
518   hashtag expresses the Sustainable Development Goals (see Figure 8), 3) #business - expressing
519   the connection of CSR with the business environment (see Figure 9) and 4) #leadership -
520   connecting CSR and Leadership. Leadership is not about leaders, but about CSR processes that
521   need to be supported (Lythreatis et al., 2021; Phillips et al., 2019) (see Figure 10).
522

523   Figure 7 Trend of #Sustainability hashtag on Twitter social network in connection with CSR
524   Source: own elaboration
525

526   Figure 8 Trend of #SGDs hashtag on Twitter social network in connection with CSR
527   Source: own elaboration
528

529   Figure 9 Trend of #Business hashtag on Twitter social network in connection with CSR
530   Source: own elaboration
531

532   Figure 10 Trend of #Leadership hashtag on Twitter social network in connection with CSR
533   Source: own elaboration
534

Decreasing trend

536   As decreasing, the following two hashtags 1) #green and 2) #philanthropy, were identified. This
537   is a surprising finding because (Shiri and Jafari-Sadeghi, 2022) research identifies the
538   interconnection of Green and Philanthropy with CSR. A possible cause of this result is the shift
539   of CSR towards sustainability.
540

Cluster analysis of time series

542   The similarity in the development of the monitored time series was evaluated. The aim was to
543   identify which time series show the most similar development and at the same time to explore
544   whether some time series show a different trend development. Based on this analysis August
545   2020 was identified as a turning point where ESG values grew more faster than other time series.
546   The most similar are the time series Charity and Leadership, to which the Socialimpact time
547   series joined. Another similar pair is Philanthropy and Business. ESG was the only value that
548   showed significantly different behaviour (see fig. 11). On the basis of this analysis, the ESG
549   values were performed more detailed to the break using the Chow's test. The development of the
550   time series is then very different for the Sustainability time series, which contained the highest
551   shares of all monitored time series throughout the time series.
552

553   Fig. 11 Dendrogram for all input variables
554   Source: own elaboration in SAS
555
556   **ESG time series analysis**

557   Prerequisite:
558   From August 2020, values grow faster. There is a Chow test that tests the match of the models to
559   the turning point (January 2017 - August 2020) with the model from the break to the end (August
560   2020 - September 2022).
561   ***Trend function for the entire time series (January 2017 – September 2022)***
562    $y' = 0.041 + 0.23t$
563    $ESS_P = 380.75$
564   ***Trend function for the first part - (January 2017 – August 2020)***
565    $y' = 2.381 + 0.09985t$
566    $ESS_A = 28.84$
567   ***Trend function for the second part - (August 2020 – September 2022)***
568    $y' = -2.59 + 0.29926t$
569    $ESS_B = 180.09$
570
571   **Null hypothesis for Chow test:**
572   H_0: regression coefficients are equal
573   H_1: non H_0
574
575   **Calculation of the F-test statistics:**
576    $F = \dfrac{\frac{(380,75 - 28,84 - 180,09)}{2}}{\frac{(28,84 + 180,09)}{62}} = 25.49$

577   **p-value < 0.001**
578
579   **Null hypothesis can be rejected.** We have enough evidence to claim that the slope is in both
580   time series models different. That is the significantly faster growth in the second part of the time
581   series.
582
583   **The theoretical and practical implications**
584   The theoretical contributions of this study are manifold. First, as previously mentioned, a holistic
585   view of CSR communication on Twitter needs to be added to the current literature. Although
586   some studies identified some topics in CSR communication on Twitter (e.g., Chae and Park,
587   2018; Okazaki et al., 2020), analysing factors in detail has contributed to this study. Second, this
588   study introduces an automated machine learning approach to automatically analyse the content in
589   CSR communication on Twitter instead of using the manual coding techniques commonly used

590   in mainstream CSR communication research, thus, contributing from the methodological point of
591   view.
592
593   There are some critical practical implications of this study. As Hassani and Mosconi (2022) state,
594   a business can use social media to monitor trends in its business and as a source of competitive
595   intelligence. In the context of our results, companies should emphasize the communication of
596   activities from the environmental area, as this area is the strongest in the structure of the
597   identified topics. Communication in connection with charitable activities within the CSR policy
598   of the company evokes positive sentiment. ESG has clearly become a trend in CSR
599   communication on Twitter in recent years. These results could be used for the strategic
600   management of CSR for planning marketing communication.
601

Conclusions

603   In the current competitive era, communicating CSR activities is essential to a company's CSR
604   strategy. By social media analysis with a focus on hashtags and tweets, the present study
605   determined the method by which companies communicate CSR on the Twitter social network
606   worldwide. Analysis of this communication has identified a high proportion of environment-
607   related terms in CSR communication. Of the 9 topics extrapolated, 3 relate to the environment:
608   1) Sustainability, 2) Climate Change, and 3) Waste. The environment also features strongly in
609   CSR communication according to the results of an analysis of the frequency of the individual
610   hashtags, specifically #sustainability, #esg, #green, #sustainable, and #environment. The results
611   also indicate that meeting sustainable development requirements is a high priority for the
612   business sector, which is in line with the results of studies conducted by Tsalis (Tsalis et al.,
613   2020) and Bose and Khan (Bose and Khan, 2022). When examining the detection of
614   characteristics of CSR communication on Twitter, the article uses an automated machine
615   learning approach to automatically analyse content in tweets instead of using the manual coding
616   techniques commonly used in mainstream CSR communication research.
617   The results of the study show that CSR is a topic that is frequently communicated on Twitter. As
618   pointed out by Sharma (2019), well-communicated CSR campaigns on social media are
619   enormously beneficial to companies. Our results aid enterprises in developing communication
620   strategies that support the company's existence as a socially responsible subject and promote the
621   management of the company's reputation in accordance with the CSR philosophy.
622
623   This research brings new challenges for future studies. In connection with the results, in future
624   research, it would be advisable to ascertain whether the topics communicated vary over time.
625   This research used the Modified Louvain algorithm to extract the individual topics. In follow-up
626   studies, it would be appropriate to make use of other methods, such as Latent Dirichlet
627   Allocation (Blei et al., 2003), or structural topic models (Roberts et al., 2016).
628   In future studies, expanding the analysis by the local context of individual CSR activities, such
629   as in the study focusing on Italy (Patuelli et al., 2021) would provide the identification of

630   differences between individual countries in comparison with the global context and the overall
631   trend of globalization.
632
633   Our study identified the trends of unique hashtags in connection with the hashtag #CSR. Further
634   research is needed to learn more about the attributes that lead to these trends.
635
636   Limitation of this research, similar to earlier research (Dong and Rim, 2019; Ngai and Singh,
637   2021) that focused on the analysis of social networks, this study was focused on a single social
638   network, namely Twitter, which opens up possibilities for further research for other social media,
639   such as Instagram or LinkedIn.
640

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Figure 1

Four steps of social media analysis based on the framework for hashtag research (SMAHR).

Figure 1 depicts the diagram showing the individual steps of the analysis.

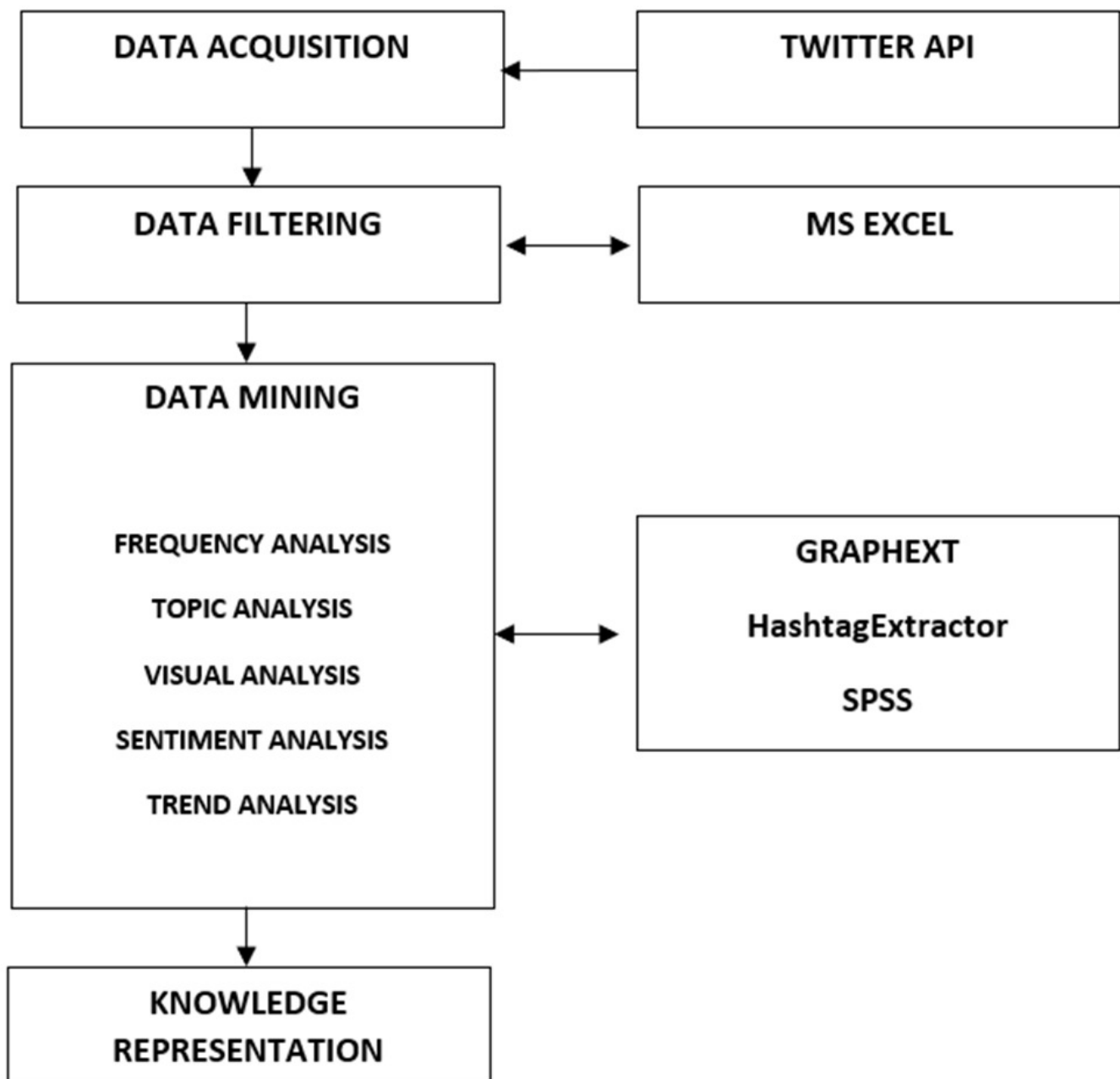



Figure 2

Visual analysis

Figure 2 shows the individual colors representing the extracted clusters in the ForceAtlas2

view.

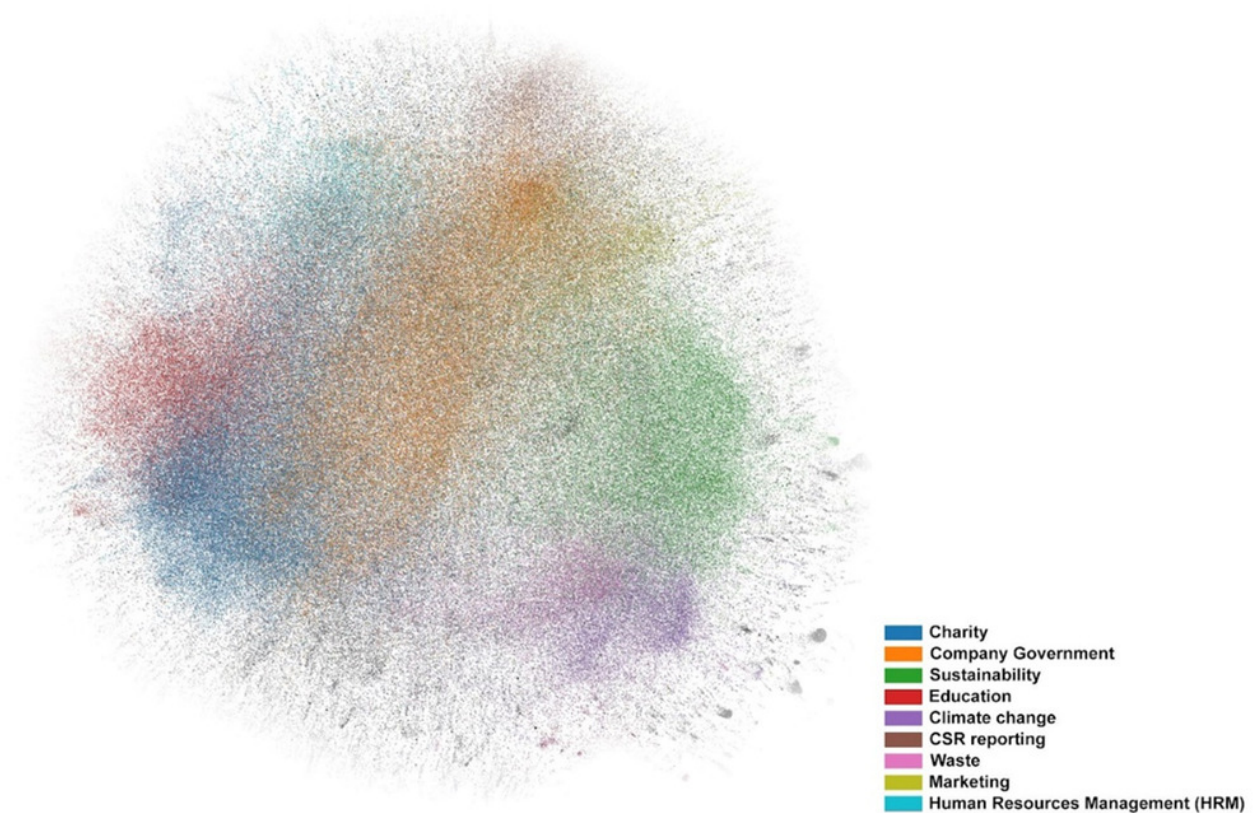



Figure 3

Sentiment analysis

Figure 3 shows the percentage representation of individual sentiments in the extracted topics.

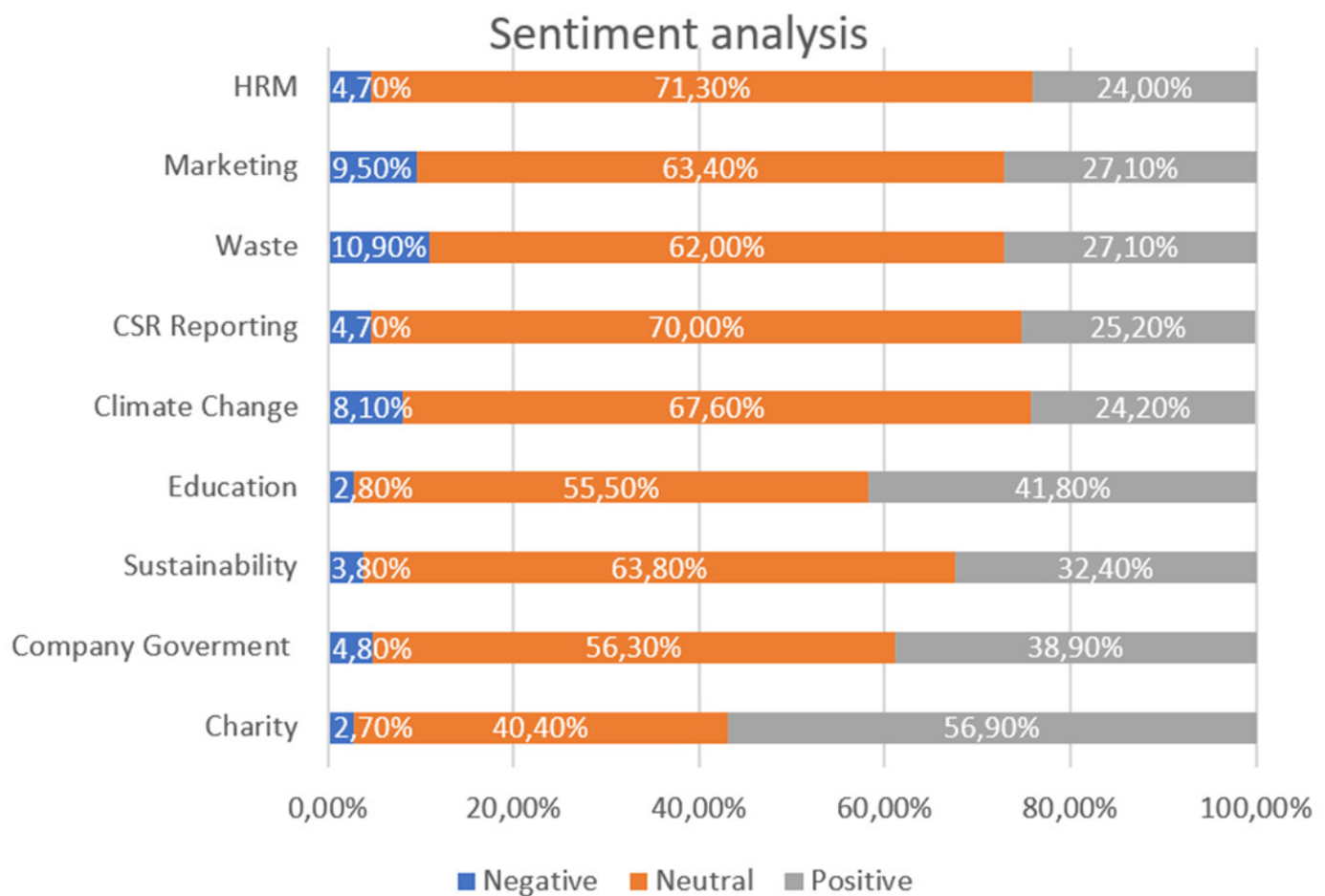



Figure 4

Trend of #ESG hashtag on Twitter social network in connection with CSR

Figure 4 depicts the diagram showing the Trend of #ESG hashtag on Twitter social network in connection with CSR

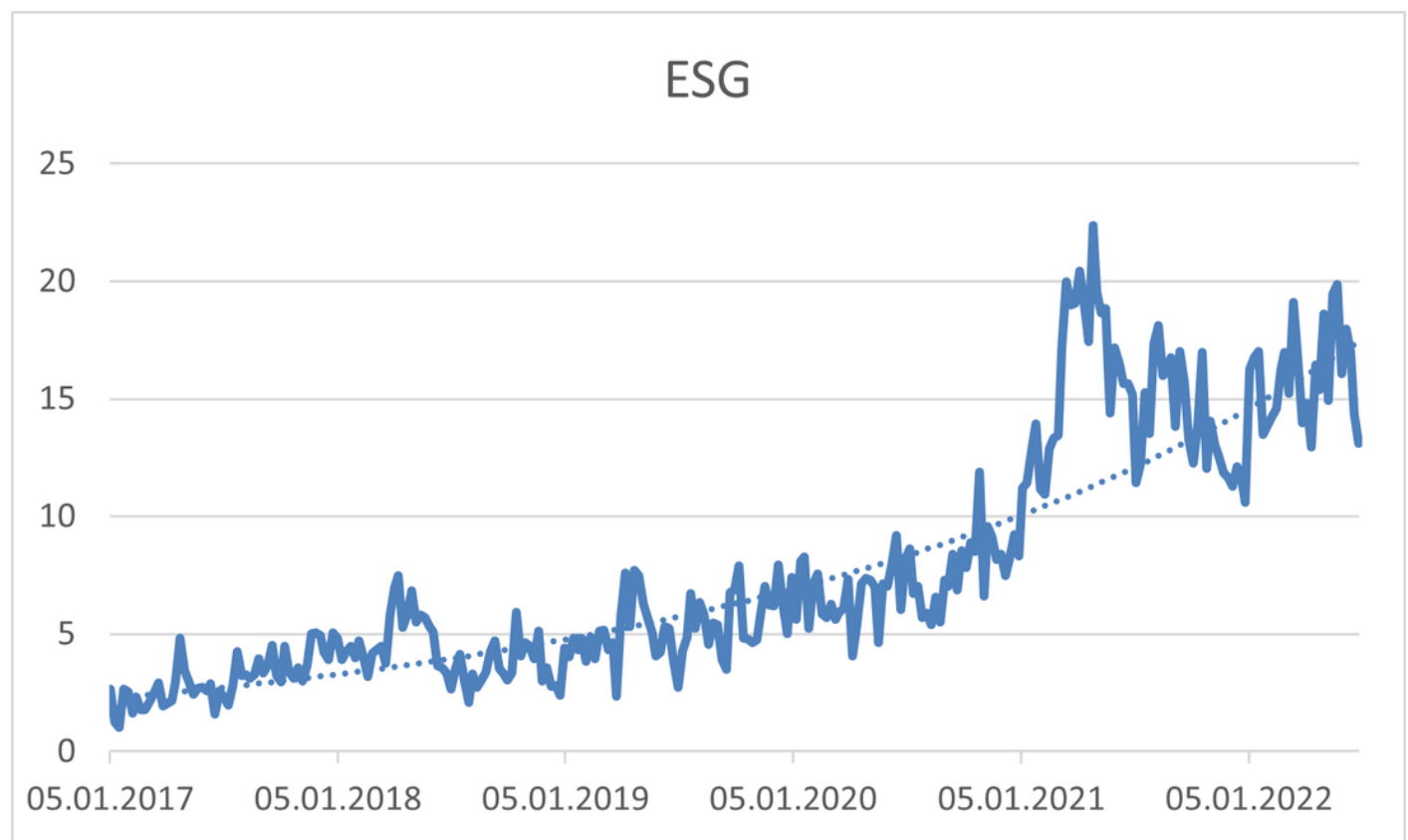



Figure 5

Trend of #Socialimpact hashtag on Twitter social network in connection with CSR

Figure 5 depicts the diagram showing the Trend of #Socialimpact hashtag on Twitter social network in connection with CSR

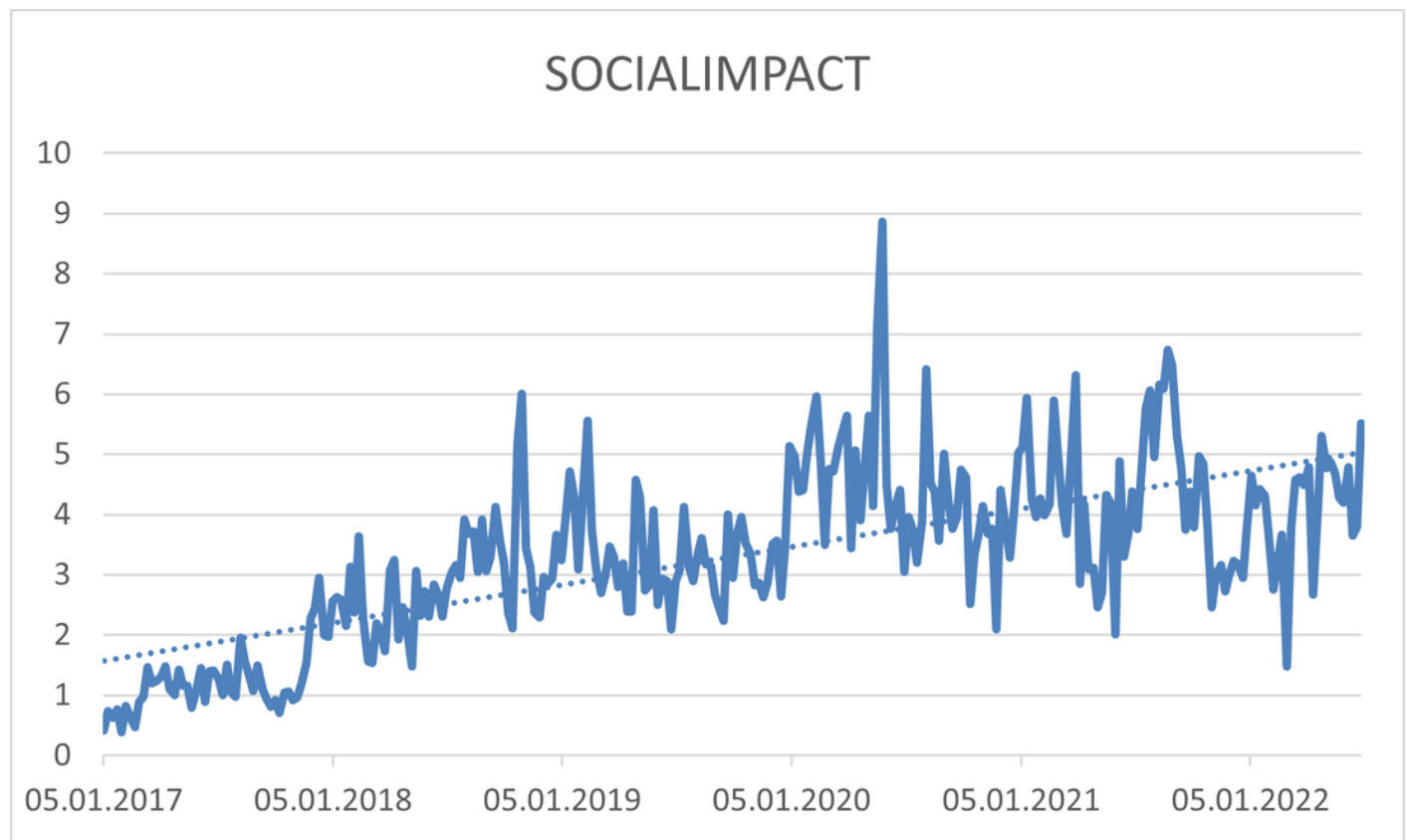



Figure 6

Trend of #Charity hashtag on Twitter social network in connection with CSR

Figure 6 depicts the diagram showing the Trend of #Charity hashtag on Twitter social network in connection with CSR

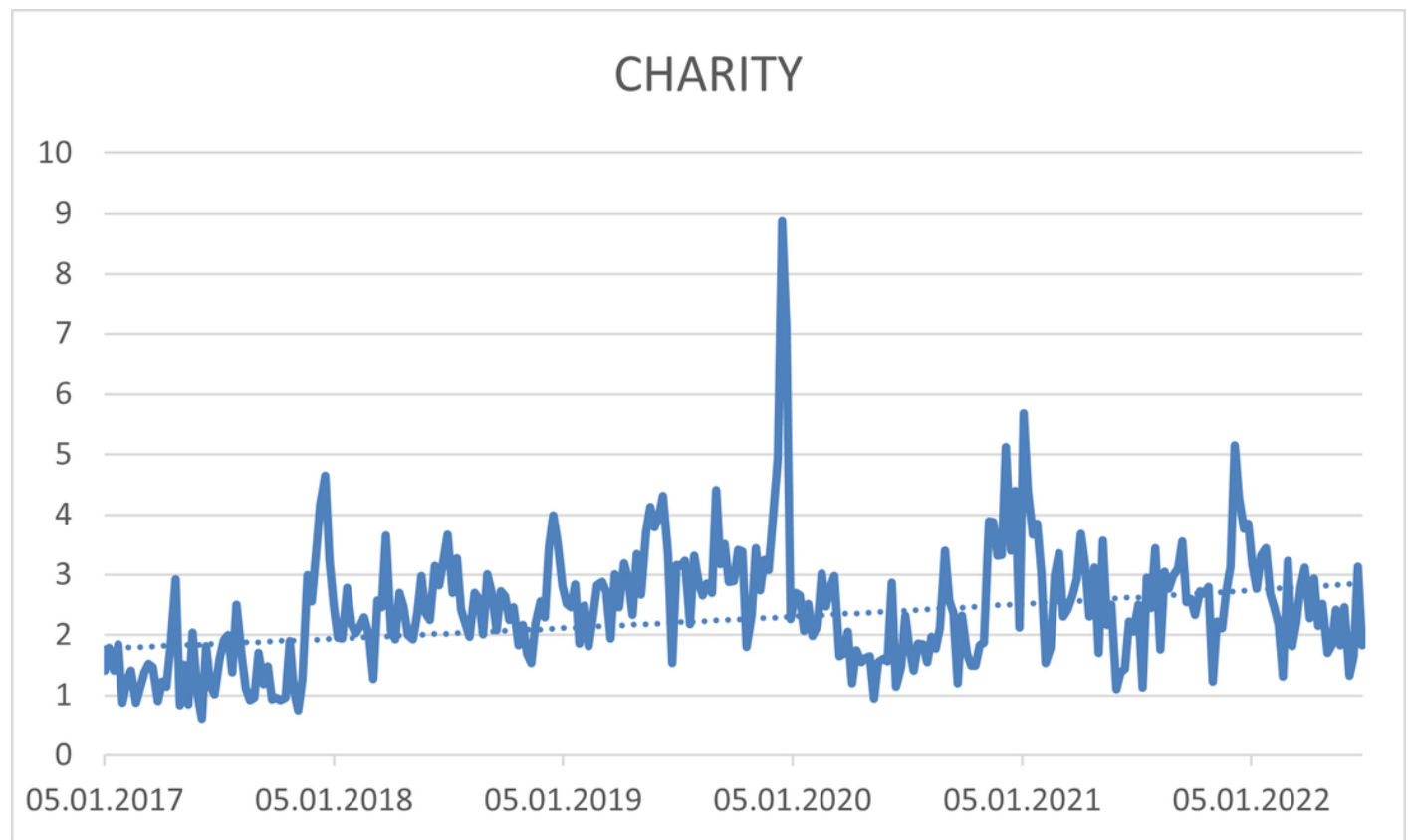



Figure 7

Trend of #Sustainability hashtag on Twitter social network in connection with CSR
Source: own elaboration

Figure 7 depicts the diagram showing the Trend of #Sustainability hashtag on Twitter social

network in connection with CSR

Figure 8

Trend of #SGDs hashtag on Twitter social network in connection with CSR Source: own elaboration

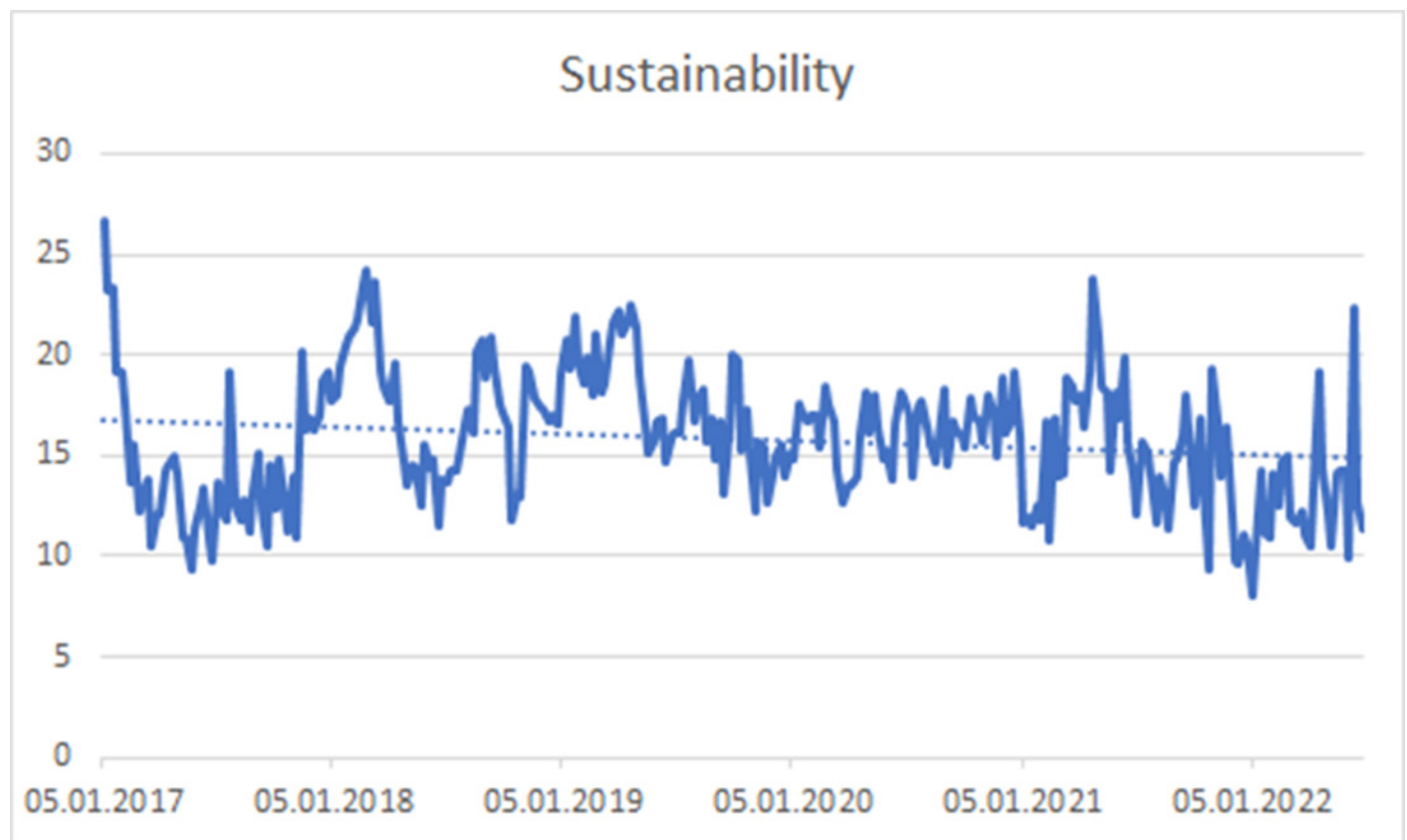



Figure 8 depicts the diagram showing the Trend of #SDGs hashtag on Twitter social network in connection with CSR

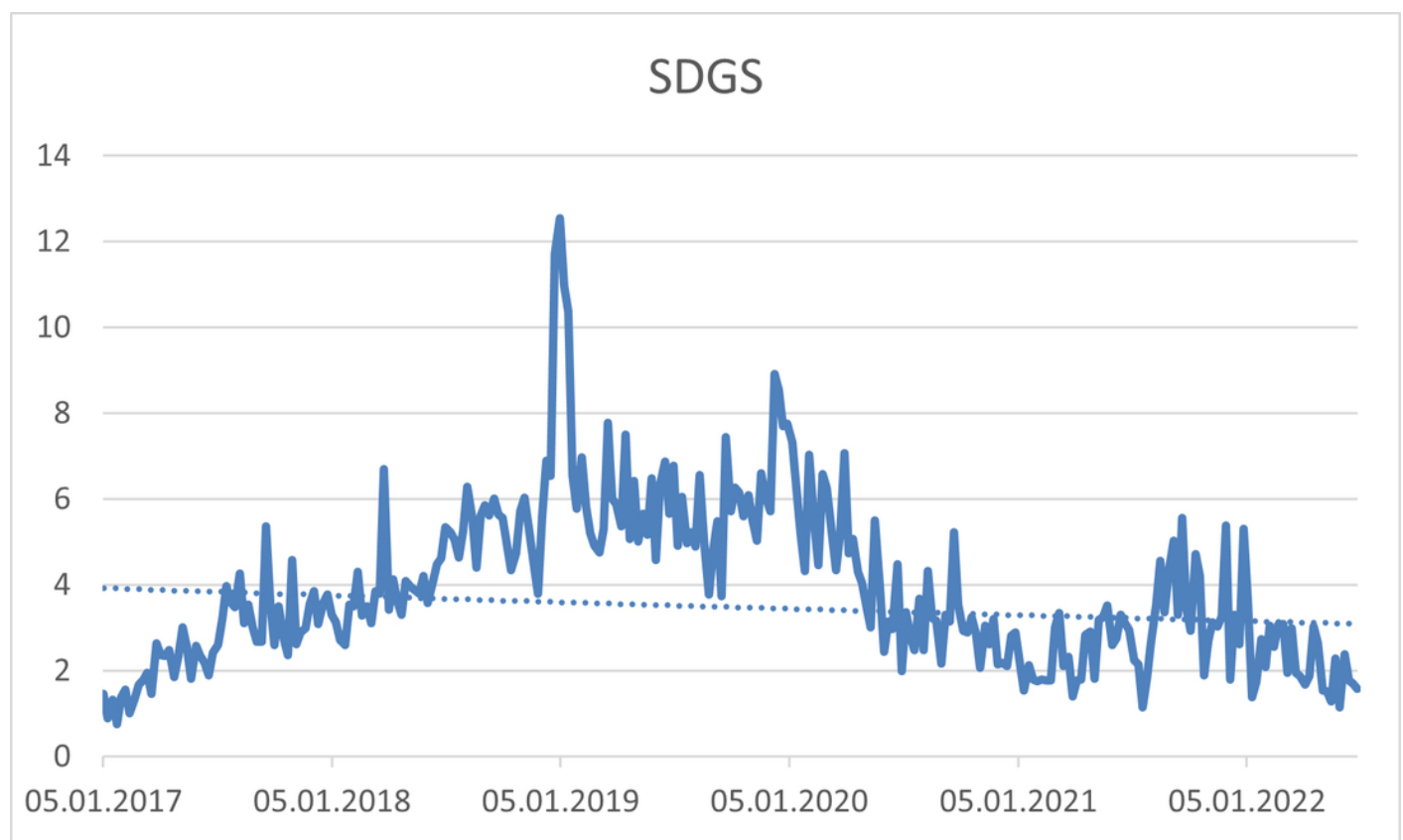



Figure 9

Trend of #Business hashtag on Twitter social network in connection with CSR Source:
own elaboration

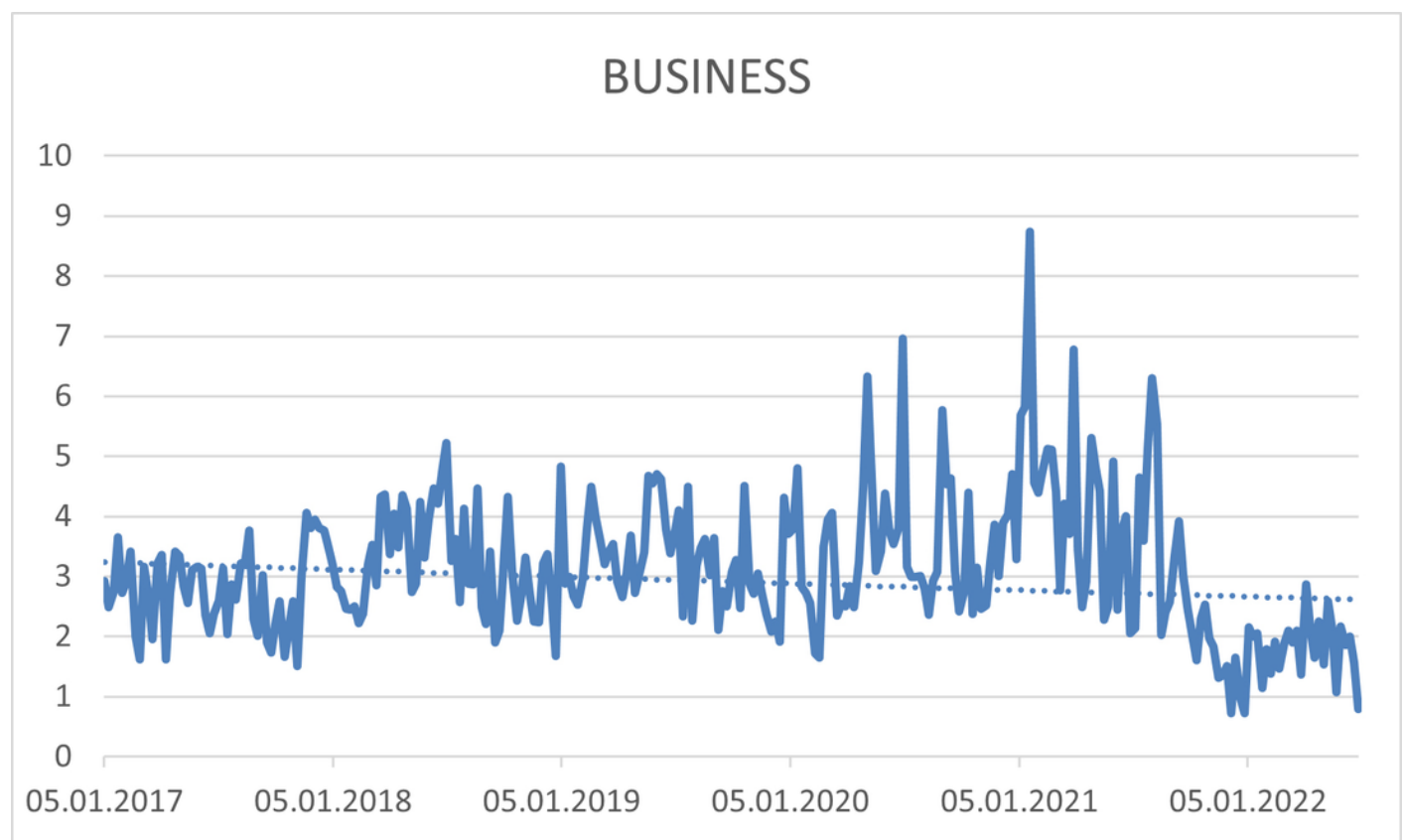
Figure 9 depicts the diagram showing the Trend of #Business hashtag on Twitter social

network in connection with CSR

Figure 10

Trend of #Leadership hashtag on Twitter social network in connection with CSR Source: own elaboration

Figure 10 depicts the diagram showing the Trend of #Leadership hashtag on Twitter social network in connection with CSR

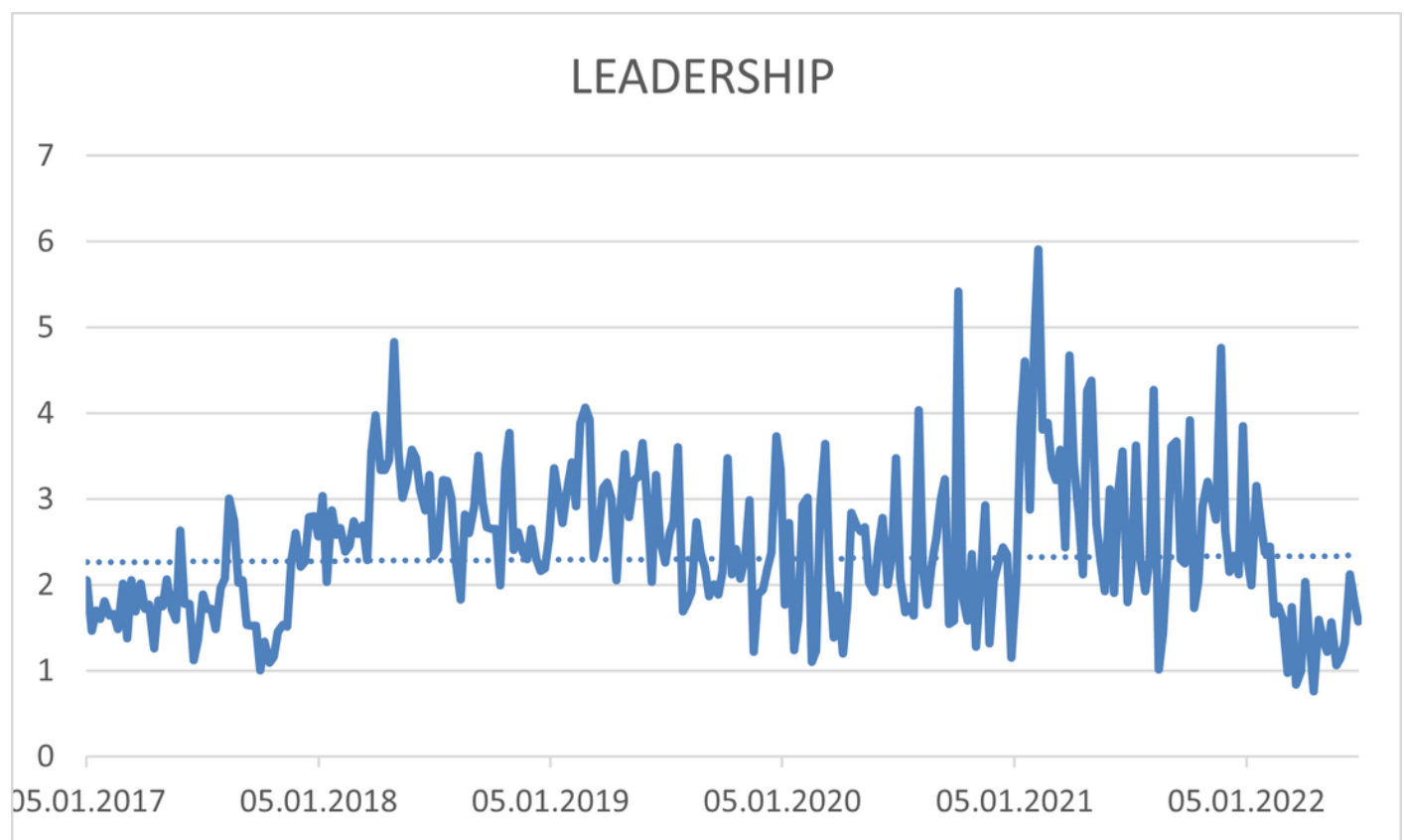



Figure 11

Dendrogram for all input variables

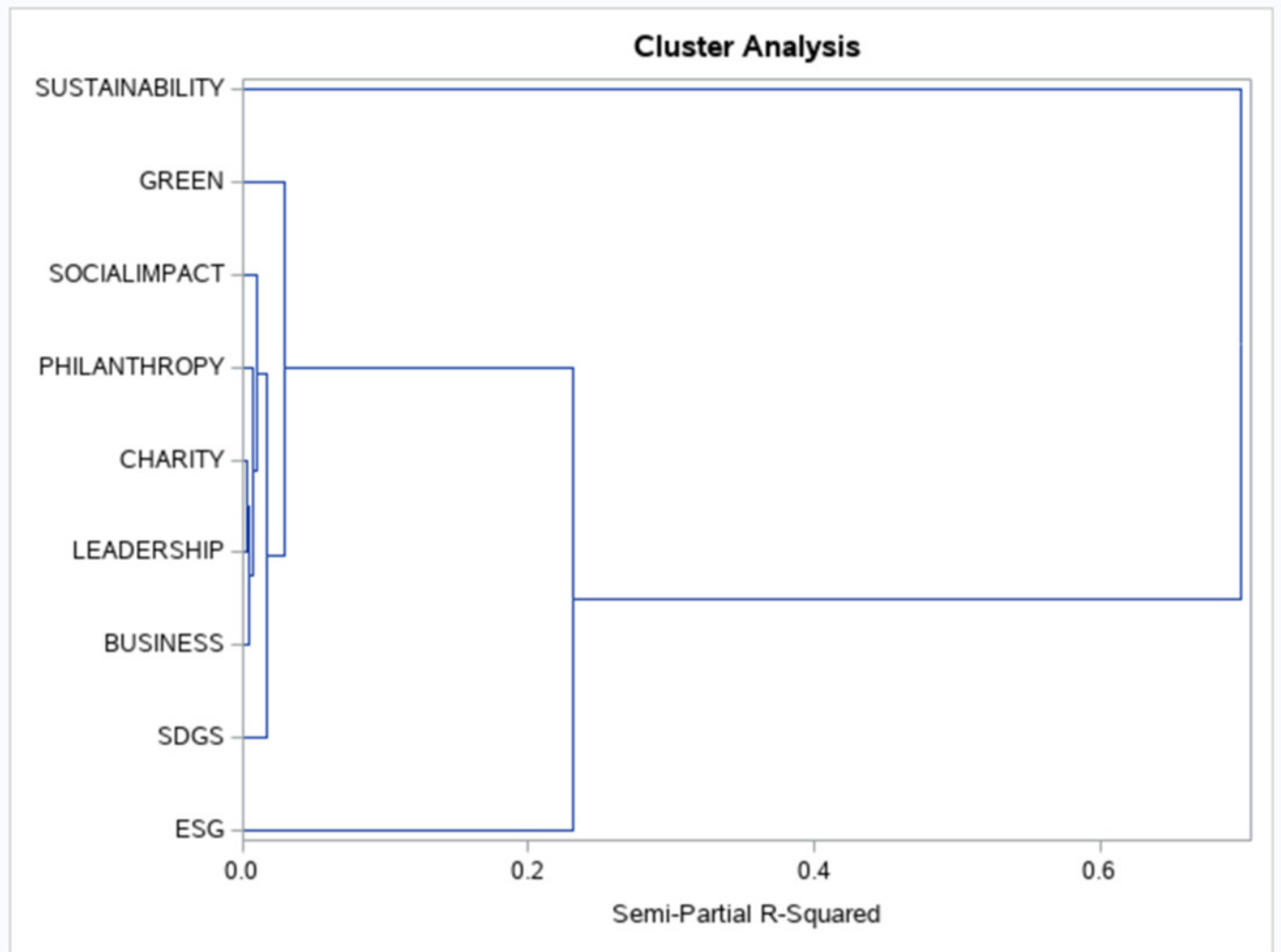
Figure 11 shows the cluster analysis of top 9 hashtags connected to CSR

The 30 most frequently used hashtags related to CSR on Twitter

Table 1 shows the 30 most frequently used hashtags related to CSR on Twitter sorted by frequence.

No.	Hashtag	Frequency	No.	Hashtag	Frequency
1	#csr	520638	16	# india	8502
2	#sustainability	100474	17	#socialresponsibility	8203
3	#esg	36347	18	#supplychain	8035
4	#sgds	19860	19	#sustainable	7927
5	#green	15488	20	# marketing	7111
6	#business	14442	21	#climatechange	6902
7	#socialimpact	13429	22	#socenet	6691
8	#leadership	12282	23	#community	6298
9	#charity	11076	24	#marketing	6291
10	# corporatesocialresponsibility	10840	25	#education	6278
11	#philanthropy	10373	26	#impact	6219
12	#health	10276	27	#mentalhealth	5934
13	#environment	9405	28	#colunteering	5895
14	#corpgov	9178	29	#psychology	5879

15	#ethics	9101	30	#innovation	5866

Topics related to #CSR

Table 2 shows the identified topics related to #CSR. Absolute and percentage size and key words are listed for each topic.

Topic	Size of the Topic		Key terms
	%	absolut	
Charity	16,06%	83 691	charity, support, volunteer, help, donate, donation, volunteering, community, philanthropy, nonprofit
Company Government	15,78%	82 203	business, company, corporate, impact, work, community, strategy, value, community, good
Sustainability	10,96%	51 383	sustainability, green, sustainable, esg, sdg, report, environmental, business, change, future
Education	7,06%	36 800	school, education, child, student, project, skill, young, support, initiative, program
Climate change	5,24%	27 305	climate, energy, carbon, climatechange, renewable, emission, green, sustainability, solar, environment
CSR reporting	3,60%	18 733	corporate social responsibility, csr reporting, social impact, report, company, business, read, impact, esg, responsible
Waste	3,18%	16 581	plastic, water, waste, recycle, food, circular economy, green, sustainability, packaging, reduce
Marketing	2,81%	14 633	brand, purpose, marketing, consumer, customer, business, company, profit, market, social impact
Human Resources Management (HRM)	2,78%	14 470	job, employee, hire, job opening, workplace, HR, employee management, career, manager, engagement

Trend analysis

Table 3 shows the trend analysis. The table shows the development of the trend of the top 9 hashtags.

Hashtag	Perameter Estimate - b	T Value	Pr>|t|	Trend
Esg	0.23033	14.61	<0.0001	Growing
SDGs	-0.01389	-1.3	0.1991	Has not been proven
Green	-0.06757	-4.06	0.0001	Decreasing
Business	-0.00312	-0.56	0.5788	Has not been proven
Socialimpact	0.05222	9.57	0.0001	Growing
Leadership	0.00351	0,83	0.4073	Has not been proven
Charity	0.01443	2.76	0.0075	Growing
Philanthropy	-0.02602	-7.97	0.0001	Decreasing