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Using Twitter for foresight: An opportunity?

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ABSTRACT

Twitter is a popular micro-blogging service and platform for public real-time communication. Concerning foresight, the value of Twitter has not been discussed or examined yet. Here this article concentrates on and considers different applications to examine how to use Twitter in foresight exercises. First, Twitter is discussed as a data source for retrieving input to roadmapping or scenarios. Therefore, an analysis framework is introduced and illustrated for the case of *#quantifiedself*. Second, options are outlined how to interact with a global network of people using Twitter as communication platform, e.g., for being used during foresight workshops or receiving input for scenario development. As the results show, both, the monitoring of topics and technologies, but also the active user engagement, are supported. In summary, Twitter is an opportunity to extend the considered data sources and to increase the number of involved stakeholder views. While the reliability of Twitter data still requires critical reflection, this article implies many new research opportunities.

1. Introduction

Today, there exist many different social media platforms which vary in functionalities, user groups and scope, but are an important source for real-time access to public opinion (e.g., Kietzmann, Hermken, McCarth, & Silvestre, 2011). On these platforms, users share their personal views and opinions and thereby might be an option in foresight exercises to emphasize societal developments and discussions. Therefore, aim of this article is to examine internet sources and social media for their use in foresight. This work concentrates on the platform Twitter owing to its diversity of contributing actors (e.g. individuals, associations or firms) and elaborates possible applications in the context of foresight. In contrast to blogs, tweets are much shorter (140 characters), contain hashtags that can be used for further analysis, and often contain links that direct to additional content.

Twitter has established as a worldwide micro-blogging service and platform for public communication (Bruns & Burgess, 2012; Java, Song, Xiaodan, Finin, & Tseng, 2007). As both a social network and an information-sharing platform, Twitter offers real-time news and covers a broad spectrum of topics. Twitter thereby aggregates many opportunities for conducting scholarly research, and so has attracted rising attention in recent years. Obviously, each scientific discipline has diverging interests. Whereas some study human communication behavior and social networks (e.g., Marwick & Boyd, 2011), others perform trend predictions (e.g., Asur & Huberman, 2010) or observe the online communication during crisis and natural disasters (e.g., Terpstra, de Vries, Stronkman, & Paradies, 2012). A lot of promising work from other disciplines has been

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published, but the potential of Twitter for foresight has been rarely discussed so far. In general, the use of Web 2.0 and social media is addressed in a range of articles on future policy planning or trend recognition (e.g., Cachia, Compañó, Ramón, & Da Costa, 2007; Grubmülle, Götsch, & Krieger, 2013; Haegeman, Cagnin, Könnölä, Dimitrov, & Collins, 2012). However, the use of Twitter as an information source or platform for foresight exercises is rarely considered, although a lot of options actually exist. Furthermore, foresight addresses social change (e.g., Salo & Cuhls, 2003), but there are no established data sources for the automatic analysis. Here, Twitter might be an option, especially with regard to establishing *social indicators* to measure the public discussion or opinion within a systemic perspective of analysis.

These observations lead to the research question addressed in this article: Does Twitter have any potential to be used in foresight? This relates, on the one hand, to Twitter as a data source and what can be (automatically) retrieved from it. Therefore, a framework is developed to illustrate the benefit. On the other hand, Twitter as a social media platform enables active engagement and user interaction; some examples are described.

This article begins with introducing Twitter and its basic principles in Section 2. After describing the scientific discourse about foresight and Web 2.0 in general, this article examines the opportunities that arise from Twitter in Section 3 related to Twitter as information source or platform in foresight. Then, applications are outlined for scenario development or roadmapping in Section 4. Finally, the results are discussed and conclusions are drawn in Section 5.

2. Twitter: an overview

The following introduces Twitter and its key characteristics and the principles of Twitter analysis. Then, an overview on Twitter as a research field is given.

2.1. Key characteristics

Twitter was launched in October 2006 and has become the largest micro-blogging service since then with currently 500 million tweets per day (Twitter, 2015). According to a recent statistic, around 22% of the worldwide internet users are active on Twitter (Globalwebindex, 2014). This article concentrates on Twitter because of its broad spectrum of covered aspects, the contained web links to additional content, the global spread and because it provides real-time access to user-generated content. Compared to other services Twitter is not only designed for disseminating news but also for active user engagement and an exchange of messages as tweets.

In particular, Twitter has five functionalities: tweets, hashtags, @-messages, retweets, and follower relations (see Table 1 for an overview). Each user can publish tweets and subscribe to the tweets of other users by f*ollowing* them. This creates a social network of users and follower relationships as a directed friendship model (Marwick & Boyd, 2011). This is in contrast to the undirected models of other social media platforms as, for example, Facebook. Each tweet can be forwarded as a retweet, be directed to other users by *@-messages*, or annotated by a *#hashtag*. Additionally, the tweets can contain web links referring to, for example, news articles, press releases, or reports.

The main types of interaction on Twitter are daily chatter and conversations, news reporting and information sharing (Java et al., 2007). Bruns and Burgess (2012) emphasize the role of social media channels such as Twitter in today's public communication as being used first primary in private communication, but this has changed within the last years. Social media and Twitter are meanwhile increasingly used by politicians and organizations for communicating with their consumers or citizens. Moreover, Twitter developed from sharing mostly personal information to sharing diverse information (see, e.g. Risse, Peters, Senellart, & Maynard, 2014).

To access this debate is most interesting for foresight, in particular to engage with different groups and stakeholders. So, in recent years, Twitter has established and a wide range of applications evolved as, for example, in enterprise-related communication (e.g., Stieglitz & Krüger, 2014), during crises and disasters (e.g., Terpstra et al., 2012), or in scholarly communication (e.g., Holmberg & Thelwall, 2014). Especially, Twitter plays an increasing role in political communication and has 'become a medium for talking and fighting about politics, organizing collective action, and showing support for, or critique of politicians and political issues (Jungherr, 2015)'. So Twitter is used for predicting the outcome of elections or as a communication platform during political protests (Gayo-Avello, 2012; Larsson & Moe, 2012; Mueller & van Huellen, 2012). Therefore, Twitter and its potential, especially for foresight, will be examined in the following.

Table 1
Overview on basic functionalities of Twitter.

Tweet	As a message of 140 characters, tweets can contain @-messages, links and #hashtags. The tweets can be answered and retweeted by other users.
@-message	To mention other Twitter users in a tweet, their username is tagged with @.
#hashtag	By the #-symbol, terms are tagged and connected with tweets using that same term.
Retweet	By retweeting a message, it is forwarded to the user's followers and can be shared within its network.
Follower	A follower *follows* other users on Twitter and thereby subscribe to the tweets of other users. Follower networks can be built up.

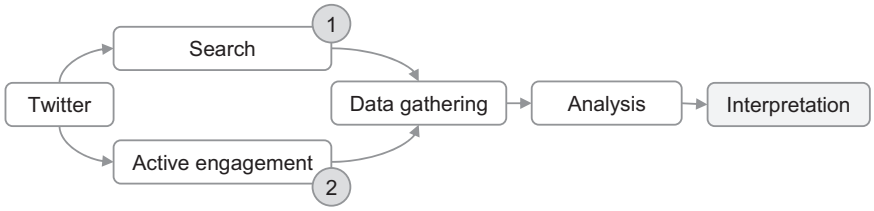

Fig. 1. Twitter analysis – static search or active engagement.

2.2. Twitter data analysis

No common way has prevailed how to conduct Twitter data analysis while there are qualitative and quantitative endeavors (see, e.g., Bruns & Burgess, 2012). In the course of this article, two strategies for getting data are distinguished as denoted in Fig. 1: searching data (1) or active engagement (2). The former depends on a search strategy (as described below) while the latter depends on launching a discussion (see Section 3.3 for examples). This is followed by data gathering and data analysis while an interpretation of the results is generally the last step.

Twitter can be searched for terms, hashtags or (groups of) users. The complexity of this search depends on the individual field characteristics and how well the field can be delimited. For example, to search emerging technologies in general is more complex than searching for specific technologies such as *#quantifiedself* or *#bioeconomy* where certain hashtags are repeatedly used.

Several commercial and non-commercial tools exists for gathering and analyzing Twitter data (see for an overview e.g., Gaffney and Puschmann, 2014). Which tool to apply depends on the individual process requirements. Furthermore, it is possible to implement an own analysis framework using the Twitter API. Primarily, the Twitter API was designed for integrating Twitter in other web services and applications but is now also used for data gathering. Among the different options to reveal data are term-based searches (e.g., a search for *#quantifiedself*) or retrieving follower networks. In principal, Twitter asserts the monopoly right on its data because its business model relies on selling this data; naturally resulting in a conflict of interests (see, e.g., Puschmann and Burgess, 2014). So by most tools data can only be retrieved from now on no historic data is available. But there are commercial services as GNIP that allow historic data retrieval. This makes retrospective data subject to a charge. In addition, there are rate limits on retrieving Twitter data in large scale. In contrast to many other social media platforms as, for example, Facebook, Twitter does not have private accounts and all tweets are public.

The analysis of Twitter data reveals aspects as communication patterns, recent trends, user statistics, or follower networks. Apart from the tweet, metadata as tweet ID, geo coordinates of sender and the user ID are included in the data retrieved by the Twitter API. A qualitative tweet analysis delivers first insights, but with an automated approach more data can be processed. When analyzing Twitter data the handling and interpretation of retweets needs to be clarified. According to Metaxas, Mustafaraj, Wong, and Zeng (2014) retweets express interest, trust or agreement. Boyd, Golder, and Lotan (2010) describe retweets as form of validation and engagement with other users. This implies a certain relevance, but tools that automatically retweet on certain terms or hashtags reduce the expressivity of the received retweets. So for the course of this paper, tweets and retweets were distinguished and retweets were interpreted as *received attention*.

2.3. Twitter research

There is an ongoing scientific discourse on Twitter and its analysis in different scientific disciplines as indicated by the following bibliometric analysis. Based on data from Web of Science, this analysis examines which scientific disciplines are involved, what they specifically address and how they are interconnected.

Publication data (both articles and proceedings) related to Twitter[1] was extracted from the *Web of Science*-database (2.581 results). Fig. 2 depicts an increasing publication activity within the last 9 years. For a comparison, data on the related social media-platforms *Facebook* (3609 results in total) and *YouTube* (1431 results) and for the term *social media* (5359 results) was additionally retrieved. As this overview shows, *social media* as generalization has the highest number of publications while *Facebook* has more and *YouTube* less publications than *Twitter*.

The data on the search for *Twitter* was retrieved for a more detailed analysis. Fig. 3 contains the network of research areas active in the field of Twitter research. This network results from the mentioning of different disciplines related to a publication. Links denote connections between two disciplines and the size of the node depends on the number of linkages (node degree) and thereby the connectivity. The most active discipline is *computer science* involved in 47% of the considered articles and a focus on developing algorithms and improving data analysis methods. *Computer science* is strongly linked to *engineering* with an equal focus. While the bottom half of the network has a technical and engineering focus (e.g., chemistry,

[1] Search string: TS = "Twitter" AND DOCUMENT TYPES: (Article OR Proceedings Paper); Timespan: 2006–2014.

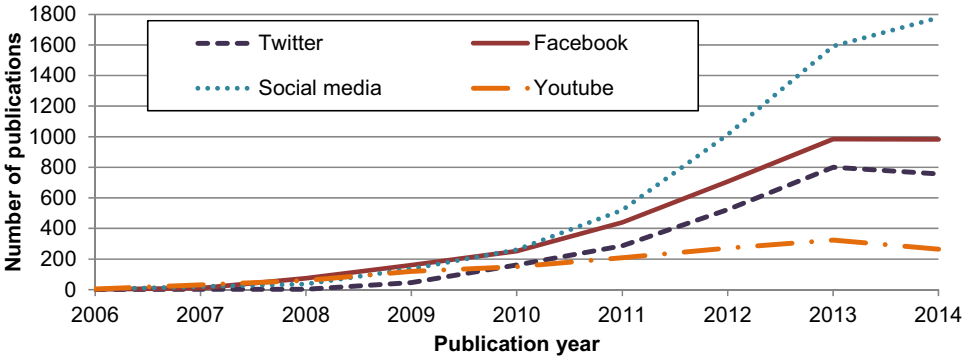

Fig. 2. Data on Twitter and related platforms.
Source: Web of Science; time interval: 2006–2014.

environmental sciences & ecology), other disciplines contribute to the field of Twitter research as well such as *business and economics* (e.g., trend prediction or brand communication) or the *social sciences* (focus on social networks and communication behavior). Furthermore, *psychology*,*neurosciences*, *pharmacology*, or *educational science* are active in the field of Twitter research.

This analysis supports the assumption of an (interdisciplinary) scientific discussion with regard to Twitter. For getting a rapid overview on the research interests addressed in these articles, author keywords are analyzed. The 100 most frequent author keywords were analyzed and visualized as a term network (see Fig. 4) using the method as described in, for example, Kayser, Goluchowicz, and Bierwisch (2014). Terms are represented as nodes and the node size depends on the co-mentioning with other terms (illustrated as links). Obviously, central and well-connected nodes are *Twitter*, *social network* and *social media* because they are covered in many abstracts. A cluster on analyzing Twitter data is located in the bottom of the network

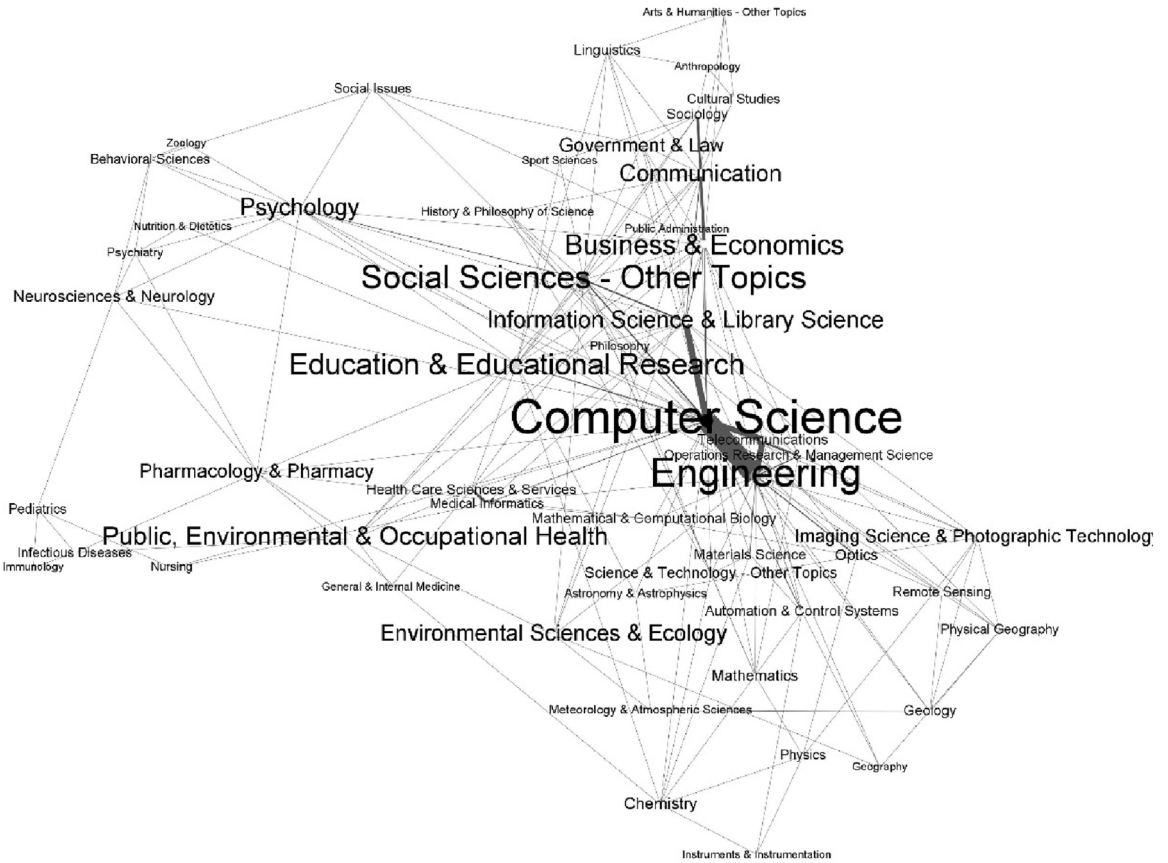

Fig. 3. Network of scientific research areas related to Twitter (node degree > = 4).

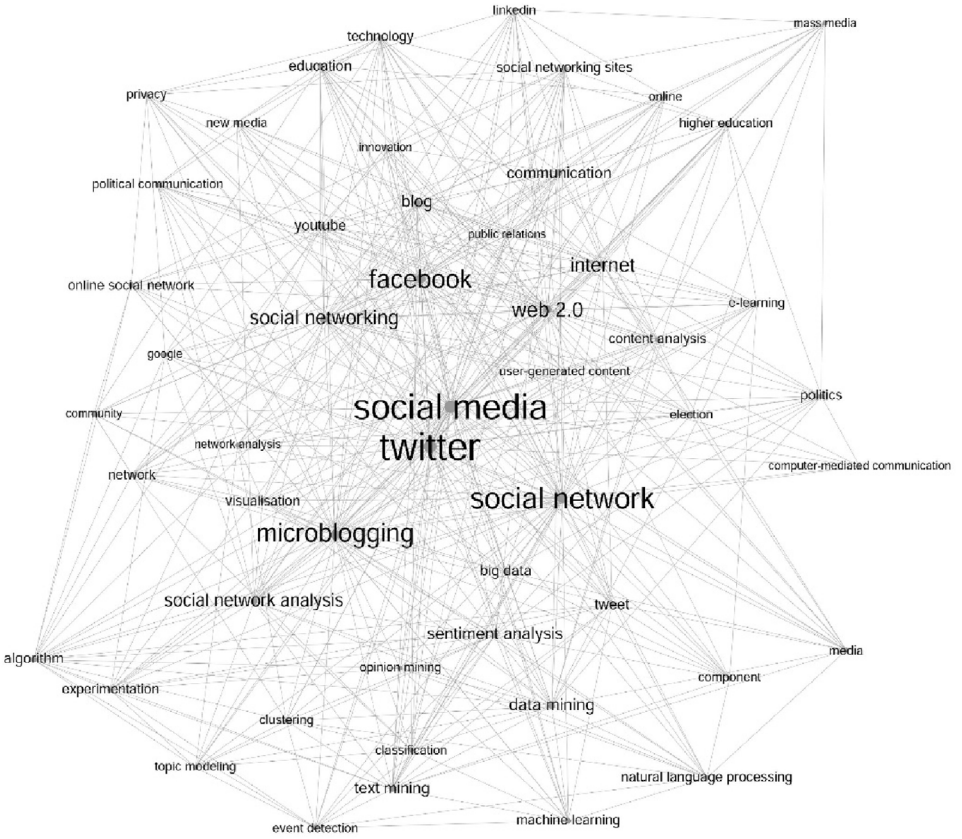

Fig. 4. Network of author keywords (node degree > 15).

(e.g., *sentiment analysis*, *classification*, and *algorithm*). Furthermore, *politics*, *e-learning,* and *election* are contained in the network. This underlines that a breadth of research interests of technical and non-technical character can be addressed using Twitter as a basis.

A deeper look into the results shows that foresight issues and future planning do not occur in this analysis. As a consequence, possible applications will be a focus of this article and outlined in the next section

3. Opportunities with Twitter for foresight

According to the understanding underlying this article, foresight is a structured dialogue about possible future developments among relevant stakeholders. This integrates qualitative and quantitative approaches where to build on with Twitter very well. The context where foresight is conducted (e.g., policy planning, corporate strategy) is not further distinguished in the course of this article because general options are discussed that do not require an exact foresight research framework.

The following section describes opportunities of Twitter for foresight – as a data source and as a platform for conducting foresight exercises. After summarizing the state-of-the-art, use cases are outlined and first experiments are conducted.

3.1. Related work on foresight and social media

Related to the usage of Twitter in the context of foresight, little work was done so far. More research exists on the general application of Web 2.0 and social media in foresight and future-oriented planning. For example, Cachia et al. (2007) describe the potential role of online communities for foresight. They conclude that these communities hint towards changes and trends in sentiment and social behavior. Additionally, they encourage creativity and collective intelligence, serve for brainstorming and enable the collaborative development and debate of different future developments. As Gheorghiou, Curaj, Paunica, and Holeab (2009) state, Web 2.0 enable new types of foresight exercise that are more interactive, make better use of online resources and develop content. In their work, they propose a Web 2.0 platform as extension of the Delphi method.

While companies use social media and Twitter monitoring for some years (e.g., Stieglitz & Krüger, 2014), policy planning has just started. For example, Haegeman et al. (2012) emphasize the still limited use of Web 2.0 tools in policy planning. They

tested a Web 2.0 framework for R&I priority setting. Grubmüller et al. (2013) examine social media (analysis) for future-oriented policy planning. They state that governments increasingly recognize the benefit of social media as information source and additionally as an instrument for receiving feedback and detecting future trends. In their project, they gathered citizen opinions to adapt future policy development. Apart from challenges as legal and ethical issues that need to be resolved, they conclude that social media are an ideal instrument to support policy planning.

Pang (2010) describes how to harvest online content produced by futurists and foresight practioners for a *social scanning* framework for trend detection where Twitter may be one part. He suggests to gather tweets annotated with #future, harvest content published by futurists and futures-oriented lists on Twitter. A practical application is missing. Amanatidou et al. (2012) use Twitter in a horizon scanning framework for collecting web links on relevant issues. They further state that Twitter may be a source for identifying signals and examining their spread, but additionally the uptake by different communities. In addition, they see an interactive component in the use of Twitter. As their work already underlines, a set of different information sources needs to be combined in order to receive reliable results as each source has its bias. So, among others, they worked with Twitter, conducted a survey, processed foresight reports, and attended conferences. Schatzmann, Schäfer, and Eichelbaum (2013) outline applications summarized under the term *foresight 2.0* using web content and online environments. Concerning Twitter, they describe an application storing tweets containing the term *future* or the hashtag *#prediction* for automatic monitoring.

Recently, altmetrics evolved at the intersection of scientometrics and social media trying to measure scientific activity apart from scientific publication behavior. Rather, altmetrics focuses on Twitter or other social media formats (Priem, Piwowar, & Hemminger, 2012; Thelwall, Haustein, Larivière, & Sugimoto, 2013). For example, the scholarly communication of different disciplines on Twitter is examined (Holmberg & Thelwall, 2014). This of course requires that the community is online and contributes (tweets) together with the (reliable) identification of researchers on Twitter.

As this literature overview shows, few work addresses the use of Twitter in foresight as also the overview in Section 2.3 has shown. Especially, a comprehensive overview on which foresight specific aspects can be addressed with Twitter, possible use cases and applications is missing so far. Therefore, this article concentrates on these points and outlines first ideas.

3.2. Twitter as a data source for foresight

140 characters as for a tweet are small space – however, they can contain valuable information. Twitter cannot only be used for information-sharing but additional for searching information (e.g.,Teevan, Ramage, & Morris, 2011) and may deliver valuable input to examine societal change and concerns. Principally, most foresight exercises start with desk research to get an overview on current developments and previous activities regarding the topic. Here, Twitter as a platform can facilitate the search process, help to check *if* there is a public debate or any attention at all, *how* intense or emotional this debate is, which actors contribute and *what* is discussed.

In the following, a case study underlines the use of Twitter as a data source for foresight activities. Data was retrieved using the Twitter API and a framework for processing Twitter data was implemented based on Python and SQL. Tweets on a certain topic are read in together with the sender (as username), the number of retweets the tweet received, the date and the number of @mentions per user. This data is processed and the tweet is split into single words, @mentions, hashtags and web links. After cleaning the terms (e.g., matching word variants) and hashtag (e.g., merging plural and singular form), the data is stored in the database for being analyzed further.

The following describes the functionalities of this framework using the example of the topic *quantified self*. In short, *quantified self* (e.g., Swan, 2012) is to incorporate technology, especially sensors and IT, into everyday life for self-monitoring of different parameters such as vital signs or nutrition. Table 2 summarizes descriptive parameters of the dataset restricted on English tweets (4.762 out of 6.284 tweets in total).

Often, their remains the question of who the main actors are engaged with a topic. Principally, Twitter enables the observation of concurring actors, the classic competitors. In a more science oriented context, the research landscape can be observed by following other research institutes or conference news feeds. The number of followers and received @messages can indicate influential actors. Twitter-accounts with high follower numbers might be important organizations or users. For example, Table 3 shows the five most active users in the dataset on *#quantifiedself*. This table lists the number of followers an user has, the number of its tweets and retweets and the number of received @mentions. Thereby, this table indicates whom to follow if monitoring a topic. Additionally, their profiles can be checked for further information, regardless if they are organizations or private actors. As a further point, this analysis supports identifying relevant actors that are sooner or later needed in most foresight exercises (e.g., workshops, interviews). Frequently mentioned users with a high number of tweets

Table 2
Key parameters of the dataset.

Search for	#quantifiedself
Time	2015-03-02–2015-04-14
Number of retweets	3.040
Number of tweets	1.722
Number of different users that tweet or retweet	1.657

Table 3
Top 5 users for #quantifiedself.

Username	Followers	Retweet	Tweet	@mentions (no RT)
eramirez	2960	53	78	34
jayfader	2173	2	27	3
mchiaviello	8313	0	23	1
quantifiedself	12709	4	24	20
agaricus	3884	3	16	3

have a certain influence or meaning and might be contacted for the following foresight exercise for interviews, workshops, or surveys. Due to the real-time character of Twitter and its high actuality, this might reveal different actors than searching information elsewhere. So, one option is to analyze structural aspects of Twitter and identify relevant organizations or people tweeting on a certain topic.

Concerning the tweets, the most retweeted messages can be considered as a first orientation indicating aspects that get much attention. Further on, web links, hashtags and the messages' content give an overview about the ongoing debates and the content shared. To begin with, hashtags contained in the tweets were analyzed. Retweets were excluded for this analysis. The tweets are visualized as wordclouds (size of word depends on its frequency) and as networks (underlines which hashtags are frequently mentioned together and therefore connected).

As both illustrations in Fig. 5 indicate, much in the field of *quantified self* is about wearables or health and its digital monitoring. The wordcloud as the representation of the hashtag frequencies gives a first idea about the structure and focus of the topic and underlines key points in the discourse. Wearables are central here and products as the *apple watch* or *fitbit* are covered as well. Looking at the hashtags in their interconnectedness further highlights that *#health* is highly connected to *#wearable*, *#digitalhealth* or *#bigdata*. Additionally, *#digitalhealth* and *#wearabletech* or *#mhealth* and *#wearabletech* are strongly linked.

Next, the terms contained in the tweets were analyzed for further insights on the discussion on quantified self (see Fig. 6). Compared to analyzing hashtags only, analyzing the full tweet enables to examine the content on a more detailed level, not

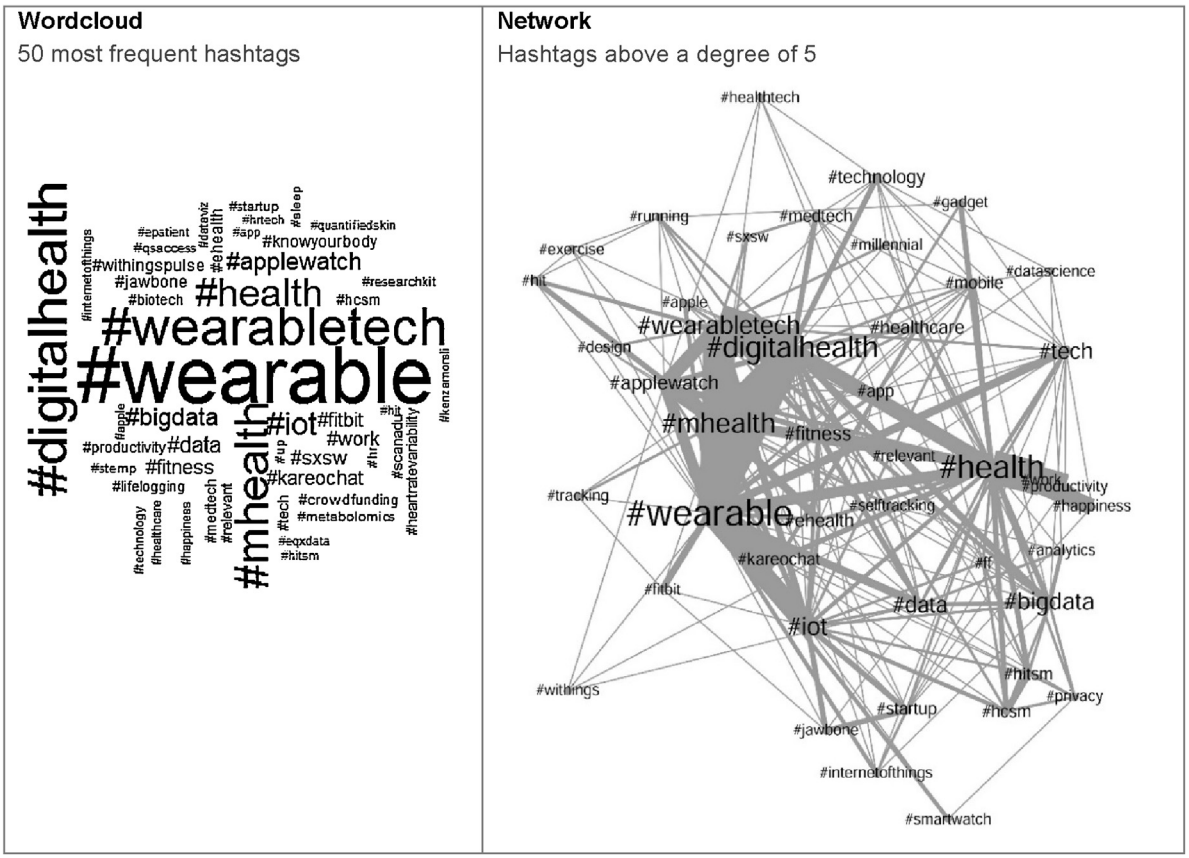

Fig. 5. Most frequent Hashtags contained in the tweets on #quantifiedself and network representation.

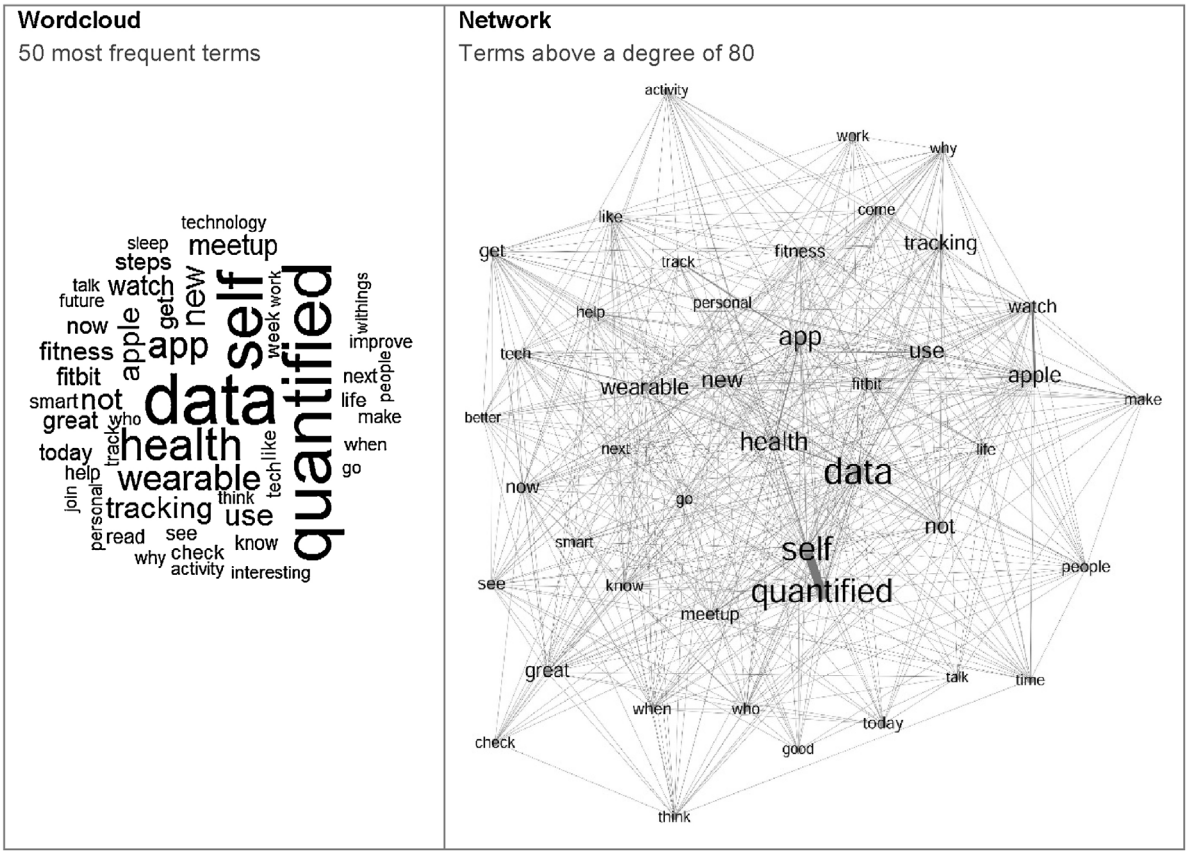

Fig. 6. Tweets on #quantifiedself.

only on keyword level as implied by hashtags. Here, stopwords were removed (e.g., *and*, *the*, *we*). For example, the term *data* is very frequent and, as the term network illustrates, *data* is a highly connected term, closely linked to *app* and *health*. Furthermore, aspects like *tracking* or *work* occur with a high frequency and go beyond the general description of the technological functions or tools.

Then, the tweets are analyzed for their sentiment, particularly with regard to examine technology acceptance or gather opinions on technologies and related aspects. Therefore, a classifier is applied that distinguishes between neutral, positive and negative tweets. Lists of positive respectively negative words are used to classify the tweets in an automatic process. As the results show, most tweets are neutral in the dataset on #*quantifiedself*, few are positive, and nearly none are negative (see Table 4 for examples). This implies that the discussions are more a neutral exchange of facts and information or technology hype but negligible on critical issues (e.g., ethics, privacy). This observation is consistent with the qualitative content analysis of the tweets.

However, one challenge with sentiment analysis is the inability to recognize irony or consider the context. For example, the tweet "*The unexamined life is not worth living*" ~ *#Socrates #quantifiedself*" contains the words *not worth*. These are on the list for negative classification. In another tweet, this might really be used in a negative intonation. However, in this context this tweet is not necessarily a negative one but could also be interpreted as a non-negative statement, an aspect that cannot be finally assessed with an automatic analysis, of course. However, these challenges should be kept in mind when using sentiment analysis together with short sentences as tweets.

Table 4
Sentiment analysis – classified tweets.

Positive	Neutral	Negative
Anyone used this? It sounds like a fantastic app for some #QuantifiedSelf action.oggr: My Favorite Free Health App http://t.co/mOafyf5xlX	*Meetups This Week* http://t.co/Nujsuk9jUC *#quantifiedself*	*"The unexamined life is not worth living" ~ #Socrates #quantifiedself*
Nice little piece of hardware; pretty reliable so far #scanadu #health #quantifiedself http://t.co/6oFS7RGTix	*"What is a step anyway?" – @grapealope talking about #quantifiedself device accuracy at #SXSW*	*Exhaustion, obsession, self-tracking #quantifiedself* http://t.co/QsykNvgA2i

Table 5
Overview on retrieved web links [excerpt].

Contained link	*Website header*
http://t.co/6XuUGkqrIo	Is peer-reviewed science too slow to track wearable accuracy? | mobihealthnews
http://t.co/7Bv6SDkhC9	Defining a new indicator of cardiovascular endurance and fitness – Marco Altini
http://t.co/7KuN01teRR	Yasmin Lucero on Baby Tracking Quantified Self

The tweets on *#quantifiedself* contain 1.118 web links that can be checked for further input by applying web scraping (e.g., Russell, 2011). In this case, the website headers are retrieved and can be manually screened for relevant content (see Table 5). This content can contribute further insights, timely issues and broaden the information base of the foresight exercise related to the subject of investigation like "quantified self".

As outlined by this use case on *quantified self*, Twitter data analysis gives a first overview on the topic and captures the ongoing debate – in general – what the people or civil society expressed related to the topic. Especially the societal discourse can be faster examined than by using classical methods as surveys or interviews and much more people (and thereby opinions) can be considered than otherwise. So the results deliver valuable input for the foresight exercise, especially in the phase of diagnosis and exploration of the research topic and support the foresight process as such.

3.3. Twitter for user engagement

In principal, Twitter is not only designed for one-way communication but can be used for user interaction to reach and involve the public in future planning processes. This can be transferred to foresight as illustrated in the following.

3.3.1. Using Twitter during foresight workshops

Since a while, Twitter has been used during events and conferences to announce talks or other advertisements. Moreover, Twitter might be used during larger workshops to gather additional input and ideas or give administrative information. Kelliher and Byrne (2015) use an online platform in their participatory foresight work for process documentation and additional discussions where Twitter was a small part of a larger framework. They see opportunities of their event-centered documentation in facilitating the dissemination of the content and the resulting community discourse. What is already common for conferences might be used during larger foresight workshops (more than 50 participants). Marked with an own workshop hashtag (e.g., the acronym of the project), additional comments can be given, instant feedback can be received, suggestions and discussion can take place, and the participants can stay informed after the workshop finished. Of course working only with Twitter offers less opportunities than a framework as in Kelliher and Byrne (2015). However, implementing Twitter is easier and it can be integrated in other online platforms.

3.3.2. Using Twitter for story creation

For example, scenario development is a common method in foresight (e.g., Reibnitz, 1991; van der Heijden, 2005). Different factors and future developments are taken into consideration to illustrate possible futures. Therefore, different methods are applied, but in most cases the input is aggregated to short stories each describing one future. Platforms as Twitter can be used to gather relevant issues and ideas on how things might evolve (future paths). For example, Raford (2012) describes a pilot project in which he asked four questions on the future of public services using a specialized software platform. Participants from all over the world were invited to contribute brief stories or opinions tagged with keywords. Finally, the input was aggregated to three short scenarios. In a later article, Raford (2015) discusses the application of Web 2.0 in the context of scenario planning and criticizes the still limited use in foresight. He concludes that, principally, the advantages lay in (1) the huge sample of participants providing a greater data source and, thereby, delivering more input for the scenario process, (2) real-time monitoring of opinions and comparison to a common base and (3) the rapid testing of scenario spaces in online communities.

Furthermore, Twitter can be used as alternative to survey tools. Instead of keywords as in Raford (2012), hashtags annotate the answers. Among those participating, the user data can be retrieved for sending a survey or getting interview contacts. In a first attempt, the following tweets were sent (see Fig. 7). When initiating a discussion, the tweet should be marked with a unique hashtag that the respondents can tag their tweets (such as *#futureQS* or *#Quantfut*). By using relevant

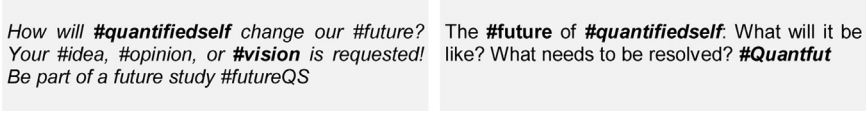

Fig. 7. Tweets on the future of quantified self.

existing hashtags such as *#quantifiedself,* related communities are notified. Moreover, by adding key organizations or foundations (@message), the tweet can be spread further if the organization retweets the message (multiplicator function).

Additionally, the Twitter community can deliver key points for drawing the scenario stories and Twitter is applicable for interactive story writing. For example, in 2012, The Guardian run an experiment with known authors on Twitter fiction writing (The Guardian, 2012). This might be linked to future visions. Guillo (2013) describes how he used an online survey embedded in an online platform for evaluating images of the future. He worked with young people (university students from Spain and Finland). Besides really interesting experiences and testing new ways of online engagement, one conclusion is that the participants missed interactive components. This may be resolved by using Twitter where images of the future can be published online for discussion and receiving feedback. This leads not only to an increased interaction in the community but also a rapid feedback on scenario spaces by the online community, as Raford (2015) describes. So input for or discussions about visions or scenarios can be tried to gather by initiating a discussion (see Fig. 8).

The second part on Twitter user engagement and interaction (Section 3.3) was more on showcasing the idea and illustrating possible realizations. The faint response emphasizes that more advertisement (over different channels) is necessary. Another important point is network building. It is central to be connected within the relevant communities or with many interested people for being recognized and getting attention. This of course needs some time and effort but increases the likelihood of success. Nevertheless, the variety and breadth of participants (e.g., age, social background) reached over Twitter cannot be reached over *classic* methods. Therefore, more effort and research should be conducted to get Twitter working for participatory foresight in future. Principally, it worked very well in other applications, see, e.g., on Twitter chats (Budak & Agrawal, 2013), for conducting surveys (Marwick & Boyd, 2011) or for *twitterviews* (interviews on Twitter).

4. Foresight applications using twitter

As shown in Section 3, the main functions of Twitter are data source or platform of exchange. The following outlines three possible applications using Twitter (data) together with foresight methods such as trend detection, scenario development or technology roadmapping.

4.1. Using Twitter for trend detection

The recognition of trends deals with the analysis and interpretation of economic, technological, social or cultural developments with systemic implications. In a general understanding, a trend describes a significant and constant development with possibly high impact on the future. With respect to weak signals and trend recognition (Ansoff, 1975), Twitter as an information source might reveal aspects that summarize societal aspects not considered otherwise. Trends are relevant for foresight, especially together with environmental scanning and analyzing the state of the art. For example, trending topics are analyzed based on Twitter (Benhardus & Kalita, 2013) or Twitter is used for the prediction of box revenues (Asur & Huberman, 2010). However, when using Twitter for trend recognition and prediction in the context of foresight, among others the following aspects should be kept in mind.

To begin with, in the context of foresight, the requirements for trend detection vary together with the abstraction level of foresight. As Liebl and Schwarz (2010) criticize, there are numerous examples for missing or unclear definitions of trends in foresight work. Furthermore, trends have a long duration (at least 5 years), opposed to social movements as hypes and fashions, which in the short term get much attention, but soon subside and disappear (Müller, 2009). Therefore, detecting trends requires historic data retrieval. However, Twitter data is, in most cases, retrieved retrospectively and, therefore, developments cannot be analyzed backwards. And for example, Cozzens et al. (2010) give an overview about definitions of emerging technologies and recent techniques for their identification while their results show that they are in most cases identified qualitatively by expert assessments. Also first practical examinations by the authors showed that Twitter for trend recognition remains a qualitative endeavor.

However, as the literature overview in Section 2.1 shows, Twitter is no established data source in the context of foresight and futures studies. Due to the reasons described in this section, trend detection with Twitter in the context of foresight is an excellent point for future research, but will not be further covered in this article. Therefore, the focus of this article lays only contingent on trend recognition but on other possible applications such as idea generation and monitoring, information exchange and participatory approaches as comprehensive stakeholder engagement. Rather it examines the general meaning of Twitter for foresight to capture developments (roadmapping) or to summarize topics (scenarios).

What do you imagine the #future of ***#quantifiedself*** *will be like? Come up with your* ***#vision*** *or story!* ***#QSfiction***

Fig. 8. Future Visions on quantified self.

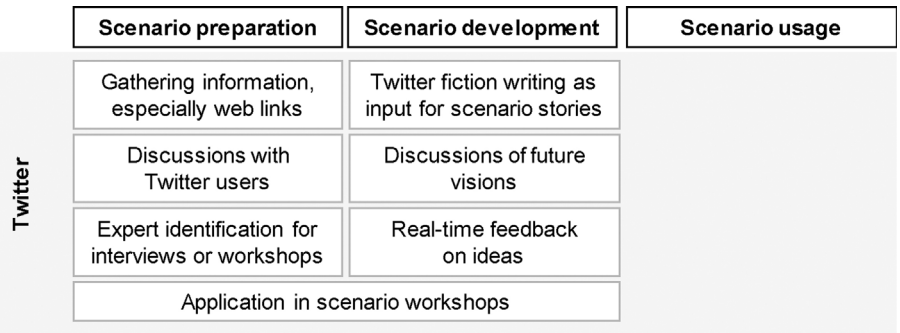

Fig. 9. Twitter in the context of scenario development.

4.2. Twitter for scenario development

Twitter data analysis and engagement with the Twitter community might be linked to scenario development (see e.g., O'Brien & Meadows, 2013; Reibnitz, 1991) as illustrated in Fig. 9. First, the initial step of information gathering may be facilitated by an automatic summary of the considered topic. Especially the web links contained in the tweets direct towards additional information, reports or websites and might deliver valuable input. In addition, expert search and discussions on Twitter may further enhance the preparation phase. As outlined above, workshop participants can contribute additional insights using Twitter as communication channel. Furthermore, the discussion and identification of influence factors (e.g., tracking, privacy, products) and their possible influence on future developments is an option. In the second step, when the input is processed to scenario stories, Twitter fiction writing might support the development of the stories and the discussion of future visions. Apart from that, real-time feedback to questions and ideas from a global network can be received. However, the feedback to the scenarios and the implications might also be useful in the final step of scenario usage.

4.3. Twitter for technology roadmapping

Another attempt to use Twitter in the context of foresight (methods) is to test its applicability for technology roadmapping. Technology roadmapping is an established and frequently used method in the context of strategy development and foresight to map future paths Phaal, Farrukh, & Probert, 2004). However, in times of increasing volumes of data from heterogeneous sources, new forms for input generation arise, also for roadmapping. While there are established data sources to monitor science and technology (such as patents and publications), there are still few data sources that are used in foresight for a systematic monitoring of changing user preferences or non-technical developments in general.

One option for retrieving user data is social media. So, for example, Twitter allows insights in changing customer needs and trends. Based on the analysis conducted in this article, the following requirements as summarized in Fig. 10 can be

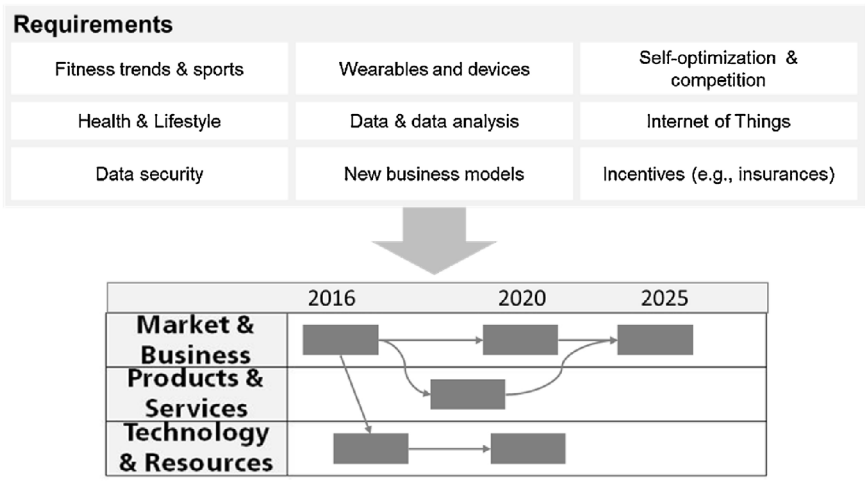

Fig. 10. User requirements with relevance for technology roadmapping.

identified such as data related issues, the emergence of new business models, or fitness applications. These requirements can be addressed in the roadmapping process to early integrate user aspects in strategy planning.

5. Conclusion and future work

On the example of Twitter, this article examines the contribution of social media data to foresight. First ideas on how to use Twitter for foresight are outlined. The research aim was to examine the potential of Twitter for monitoring and interactive purposes in the context of foresight exercises. As the previous sections showed, Twitter enables both monitoring and engagement. To quickly familiarize with a topic, the structures of Twitter but also data retrieval are most helpful. The content offers a broad picture reaching, for example, from science results, advertisement to news reporting and indicates *if* the topic gets any attention at all (number of tweets), *what* is discussed (e.g., used hashtags) and *how* (sentiment analysis). Twitter facilitates a fast access to user-generated content, a huge number of people and real-time feedback on ideas. So, working with Twitter as communication and exchange platform broadens the perspective of foresight activities and enables the involvement of further stakeholders or different groups of the society not considered by foresight otherwise. Compared to other applications, no own interactive framework needs to be set up. This has, among others, the advantage that people are addressed in their known social media environments.

Social media data as result of social interactions allows to observe human behavior and to interact with the society (see e.g., Zafarani et al., 2014). Techniques such as APIs provide fast access to large social data sets opposed to other methods in data collection (e.g., surveys) (Danneman & Heimann, 2014). However, social media research data is a relatively new field of study, so many questions are not fully clarified at the moment. For example, Twitter provides efficient data collection at large scale but has limitations as every method or data source. A critical reflection on Twitter data shows that there are no common standards in research with Twitter at the moment (Bruns & Burgess, 2012) and the scientific contribution of Twitter is not fully explored.

Generally, Twitter as a data source is accused for not being representative (see, e.g., Bruns & Stieglitz, 2014), to be no reliable scientific source and generally a product of marginal groups. Twitter analysis is not representative for society (see for a discussion e.g., Boyd and Crawford, 2012), but it reflects ongoing developments and changes. Limits to representativity are, for example, that the search strategy applied in this article builds on the assumption that certain hashtags or terms are included in the tweets, only certain groups are active on Twitter, and the number of active citizens differs between countries. However, for the case of this article, Twitter data is used as part of a larger framework and the data analysis has an illustrative character. Besides legal and ethical issues as described in Section 2, information credibility (e.g., spreading misinformation) (e.g., Castillo et al., 2011) and authenticity of the tweets can be questioned. Due to the volume of data that is retrieved and because it is summarized to identify topics in general, both aspects are less critical in the case of this article. There are many different actors as firms, political parties that produce heterogeneous input covering a broad spectrum of opinions. This spread of content cannot be captured by other foresight methods and is an interesting opportunity that should be further explored in future work. Moreover, the social structure and the knowledge structures of Twitter enable new research paths (see, e.g., Jungherr, 2015). In the context of foresight, this for example relates to the identification of influential users and stakeholders using follower networks and known network metrics.

Tweets that are sent not necessarily read (*sender receiver*-fallacy). This hinders interactive approaches as tried in this article. Therefore, in future wok, other platforms such as Facebook should be tested to set up discussions on a specific topic in (closed) groups. Many of the applications as outlined in this article (e.g., use of Twitter during workshops) do not require retrospective data. Furthermore, retrospective Twitter data can be bought from special vendors or recorded during the course of a foresight project.

When actively using Twitter as a supportive element in foresight as, e.g., in scenario development, biased user activity, expertise or representativity of the data are less critical. As a creative process, foresight requires possible, desirable, or provocative input regarding future developments. However, the observations from Twitter should be weighted up against other data and foresight methods or be part of a larger framework as illustrated in Section 4. Therefore, a mixed methods approach should be applied instead of building only on Twitter analysis. Finally, Twitter has offerings to the foresight community such as networking among researchers, the spread of information (invitations to conferences, workshops, project results, etc.), or triggering online discussions on certain issues.

Apart from the example of scenario development or roadmapping above, of course, many other possible applications combining Twitter and foresight methods exist. This relates, for example, to real-time Delphi or foresight gaming approaches, but also to the examination of organizational networks, technology acceptance, or the comparison to other frequently used data sources (e.g., patents, scientific publications). Furthermore, more research effort should be spent on linking Twitter or social media data to innovation indicators and the examination of social change. Hence, many options for future work related to methodological integration or combination evolve but also the applied context (e.g., policy planning, corporate strategy development). The added value needs to be individually examined. Much research effort is conducted at the moment to assess the contribution of social media platforms and also foresight and futures studies should do so. Of course, the approach and ideas developed in this article are transferable to other social media platforms such as, for example, LinkedIn to emphasize a business view. However, because the user groups addressed by each platform differ, the chances and limitations should be considered individually. As described above, the intention of this article was to gather first ideas and

create a starting point for detailed future research. This article points out a wide range of promising opportunities how to use Twitter in future foresight applications and it remains to be seen which will get realized.

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