

Exploring the challenges of remote work on Twitter users' sentiments: From digital technology development to a post-pandemic era

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ABSTRACT

The boost in the use and development of technology, spurred by COVID-19 pandemic and its consequences, has sped up the adoption of new technologies and digital platforms in companies. Specifically, companies have been forced to change their organizational and work structures. In this context, the present study aims to identify the main opportunities and challenges for remote work through the use of digital technologies and platforms based on the analysis of user-generated content (UGC) in Twitter. Using computer-aided text analysis (CATA) and natural language processing (NLP), in this study, we conduct a sentiment analysis developed with Textblob, which works with machine learning. We then apply a mathematical algorithm for topic modeling known as Latent Dirichlet allocation (LDA) model. Based on the results obtained from these data-mining techniques, we identify 11 topics, of which 3 are negative (Virtual Health, Privacy Concerns and Stress), 4 positive (Work-life balance, Less stress, Future and Engagement), and 3 neutral (New Technologies, Sustainability, and Technology Issues). In addition, we also identify and discussed 6 opportunities and 5 challenges in relation to the use and adoption of digital technologies and platforms for teleworking. Finally, theoretical and practical implications of the study are presented for companies that develop strategies based on teleworking and the adoption of new technologies in which stress management is configured as one of the most relevant indicators for further research on remote work. From the applied perspective, executives and policymakers can use the results of the present study to re-evaluate the benefits of remote work for employees.

1. Introduction

In recent years, the development of technology has led to the global emergence of new business models and business organization strategies (Cairncross, 1997). This impulse towards a greater technology use (Mariani et al., 2021), linked to the consequences of COVID-19 pandemic, has forced many companies to change their organizational structure (Daniels et al., 2001), adopt the use of new platforms and digital technologies (Davis, 1989), as well as other processes and challenges (Mariani & Nambisan, 2021).

Among other digital technologies enabling communication through the Internet, telework has become a way to protect workers against COVID-19 infection. In this context, companies have been forced to make dramatic decisions in favor of adopting new technologies to work

(Venkatesh & Davis, 2000). Accordingly, new technologies and digital platforms have become mandatory to use (Scandura & Lankau, 1997).

Telework is a phenomenon when organizations and their employees agree to work and perform their professional duties outside of the company's offices (Staples et al., 1999; Wellman et al., 1996). In order to enable the performance of work tasks when teleworking (Majchrzak et al., 2000; Olson, 1983), companies provide their workers with digital platforms, including both software and specialize hardware (Song et al., 2020). This development has been forced during the lockdowns caused by the COVID-19 pandemic (Wang et al., 2021).

Before the outbreak of the COVID-19 pandemic, telework did not raise the interest among academics (Rocco, 1998), as the need of technological development and communication through the Internet (Arpaci, 2017) and workers' having sufficient knowledge to perform

Abbreviations: UGC, User-Generated Content; UGD, User-Generated Data; CATA, Computer-Aided Text Analysis; NLP, Natural Language Processing; LDA, Latent Dirichlet Allocation; NLTK, Natural Language Toolkit.

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their work duties online (Olson & Olson, 2000; Spreitzer et al., 2017) has not occurred yet. However, as a consequence of the COVID-19 pandemic, there has been a growing interest in understanding the opportunities and challenges of the adoption of new digital platforms and technologies for teleworking. Some examples that have already been studied in the literature include work-life balance (Fenner & Renn, 2010) and employee motivation or privacy issues (Acquisti & Grossklags, 2005; Allen et al., 2015; Awad & Krishnan, 2006; Barsness et al., 2005).

Some authors have expected the analysis of these technologies (Castaldo et al., 2010; Davis et al., 1989), as well as the consequences of telework in the COVID-19 pandemic (Iglesias-Pradas et al., 2021; Lau et al., 2020). In addition, several authors highlighted the main disciplines that should be attended to analyze telework through digital platforms and corresponding technologies (Palos-Sánchez, Saura, & Velicia-Martin, 2019).

Similarly, several previous studies focused on understanding strategies, marketing (Haapio et al., 2021), innovation management (Mariani & Wamba, 2020; Metiu, 2006), entrepreneurship (Nambisan, 2017), privacy concerns (Barth & de Jong, 2017; Xu et al., 2011), and information management (Acquisti et al., 2015) in this pandemic era (Hodgson & Wigglesworth, 2020).

In this context, the originality of the present study is that, bridging a gap in previous research, we analyze user-generated content (UGC) to better understand the main opportunities and challenges of teleworking in the COVID-19 era. The UGC analyzed in the present study was collected from Twitter ($n = 167.394$) to extract insights in an original and novel way. Our main goal was to understand the main opportunities and challenges of teleworking when using technologies and platforms. This was done through the analysis of users' sentiments and the main topics in this research area. The main research question (RQ) addressed in the present study is as follows: "What are the main opportunities and challenges of using digital technologies and platforms in telework, according to Twitter-based UGC?" Our specific research aims were as follows:

- To create knowledge about the opportunities and challenges for the future of teleworking.
- To identify analytical perspectives to understand the use of digital platforms in teleworking.
- To explore different digital platforms and technologies used for the development of telework during the current pandemic and future pandemics.

In order to answer the research question and to accomplish the aims listed above, we used data-mining techniques focused on computer-aided text analysis (CATA) and natural language processing (NLP). These techniques were applied to analyze a UGC sample extracted from Twitter. Specifically, we first used a sentiment analysis developed with Textblob and then applied a mathematical algorithm for topic modeling known as Latent Dirichlet allocation (LDA) model.

The remainder of this paper is structured as follows. Upon the literature review, we describe the methodology used in the present study. This is followed by the presentation of the results. The paper concludes with a discussion of the results and conclusions where we discuss theoretical and practical implications of our findings, as well as limitations and future lines of research.

2. Literature review

2.1. Remote work: organizations and COVID-19

As discussed previously, the rapid growth of digitalization has led to dramatic changes in companies and organizations not only in terms of their business models, but also as concerns the actual organization of workplaces (Bowen & Pennaforte, 2017). Therefore, digital platforms

and tools have led to the emergence of a new working model where people can work away from their offices. Indeed, due to the COVID-19 crisis, companies have consistently introduced measures to facilitate remote work in order to better cope with the pandemic situation (Belzunegui-Eraso & Erro-Garcés, 2020). Corresponding measures included promoting the use of digital devices that are considered to be an essential factor in telework (Baruch & Nicholson, 1997).

Telework is conventionally defined as a practice of work from different places—mainly out of the office—using different information and communication technologies (Belzunegui-Eraso & Erro-Garcés, 2020). As highlighted by Nilles (1975) and Baruch (2001), such technologies may improve workers' performance in terms of productivity. Accordingly, companies should consider these technologies as a new way towards business success. Furthermore, through telework, companies may have a better access to talent (Haddud & McAllen, 2018), which enhances companies' recruiting potential while improving their organizational structure and flexibility (Illegems et al., 2001).

In terms of efficiency, telework can reduce energy expenditure in the workplace, as well as emissions from employees' daily journeys to and from work. Therefore, remote work is considered as an eco-strategy that, through reducing pollution, traffic jams, congestion, and accidents (Baruch, 2001), reduces the adverse environmental impact (Belzunegui-Eraso & Erro-Garcés, 2020). In terms of social benefits, several authors have introduced online communication platforms, such as Slack or FlipGrid, in which members post a short video to present their current progress (Rysavy & Michalak, 2020).

All these recent changes have allowed workers to achieve better collaboration and communication in order to face daily business issues during lockdown. Furthermore, several other authors have insisted on the use of these technologies as a way of employees' interacting with their colleagues (Richardson & Benbunan-Fich, 2011). Overall, as compared to office-based workers, telework has been reported to promote labor and family conciliation (Baruch, 2001; Belzunegui-Eraso & Erro-Garcés, 2020).

At the same time, there is also evidence showing that text-based management and chat tools can negatively affect workers' mental health, although this effect was not reported for videoconferencing (Schmitt et al., 2021). Similarly, Chadee et al. (2021) found that digital platforms can exhaust users. Moreover, there are also reports showing that, although companies implement digital communication, workers can feel isolated due to the lack of face-to-face exchange (Harris, 2003). Finally, there is also evidence that telework may provoke health issues such as stress or even cholesterol increases.

A critical issue discussed by Fairweather (1999) is surveillance in employment, whereby managers can remotely monitor their employees by reading email messages, as well as through telephone calls. In the last months, due to COVID-19 pandemic, remote work has enabled employees to safely work from home in order to keep the economy moving. In this lockdown context, users have shared large amounts of information on their social media, especially on Twitter (Fenwick et al., 2021). In this context, there has been growing academic research on the impact of COVID-19 on people and their lives (Wrycza & Maślankowski, 2020).

2.2. User-generated content and remote work

With regard to user-generated content and remote work, in a study on digital nomads, Nash et al. (2021) analyzed UGC from digital nomad's Twitter accounts. Several other scholars also investigated how social media and Twitter were used in the beginning of the pandemic and COVID-19 lockdowns. For instance, Fenwick et al. (2021) found that, while social networks have played an important role in the decision making of governments, work from home was perceived as a controversial topic in many corporations (Fenwick et al., 2021). Another relevant study that analyzed Twitter-based UGC using sentiment analysis and thematic analysis was conducted by Bojja et al. (2020).

In a study that explored teleworking by analyzing tweets, Wrycza

and Maślankowski (2020) used text-mining analysis to identify new topics. Furthermore, through the analysis of data from social media, Zhang et al. (2020) highlighted several issues and major topics during COVID-19, such as domestic violence, public health, or how businesses transformed their structures and work. Several studies that compared a pre-pandemic year and 2020 were also conducted (Alshaabi et al., 2020). For instance, based on the analysis of large amounts of tweets (range: from 1,000 to 5,000), Kleinberg et al. (2020) found that the population's concerns were linked to family safety and economic stability.

Regarding how citizens felt along the pandemic while working from home, Min et al. (2021) applied discontinuous growth modelling to analyze over 1.56 million tweets. Based on the results, the authors argued that remote work has both advantages; therefore, companies should provide continuous support to their remote employees. Similarly, based on the results of sentiment analysis of tweets with the hashtag #TGIF (“thank god it’s Friday”), Zhang et al. (2021) concluded that positive tweets were posted at the end of the work week, while negative tweets were linked to users that worked during weekends. Among the most common topics identified in this study were teleconferencing, cybersecurity, and work–life balance.

Furthermore, Zhang et al. (2021) also noted that, overall, there were positive attitudes linked to remote work, except on weekends. As mentioned above, among the most tweeted topics were work-life balance, cybersecurity, and teamwork. In addition, this positive outlook was confirmed the analysis of a small portion of negative emotions as compared to the positive ones on tweets; “good” and “hope” were two most frequently used words when referring to remote work (Dubey & Tripathi, 2020).

Finally, in a study that investigated virtual work meetings during COVID-19 through the analysis of comments on LinkedIn, Karl et al. (2021) found that themes such as camera or microphone issues came up, as well as work-from-home disadvantages where employees showed their dissatisfaction about working in their households where distractions and noise were very common. Table 1 summarizes major previous studies conducted to date that analyzed UGC to explore the topic of remote work.

Table 1
Topics in UGC related to remote work.

Authors	Relevant topics
Zhang et al. (2021)	Users linked remote work to benefits such as productivity, flexible work; challenges included work-from-home difficulties (distractions in the home environment or poor internet connections).
Saks (2021)	Employees were concerned about occupational safety and health, flexible working organization, performance management, employee engagement, and social inclusion.
Dubey and Tripathi (2020)	Users had positive sentiments about trust and anticipation in telework during lockdown.
Zhang et al. (2020)	Topics such as home office, cybersecurity, mental health, work–life balance, teamwork, and leadership were discussed on social networks, without revealing important changes through several months.
Karl et al. (2021)	During COVID-19 pandemic, employees stated that the use of videoconferences was complicated by work-from-home issues, such as frequent distractions.
Min et al. (2021)	Stay-at-home orders during COVID-19 provoked mainly six emotions (anger, disgust, joy, fear, and sadness), of which five had different trajectories over four months.
Wrycza and Maślankowski (2020)	IT companies increased their use of social media to promote their products for remote working, while remote skills and webinars linked to telework were also discussed on Twitter.

Source: The authors

3. Methodology development

In recent years, owing to the improvement of CATA and NLP techniques, the use of content shared by users on social media has considerably expanded (Srinivas & Reddy, 2021). In addition, the continued use of social networks as the two-way information channel between companies, on the one hand, and employees, customers, or users, on the other hand, has consolidated social networks as a reliable source of information for the extraction of insights that help to understand emerging research topics (Schivinski & Dabrowski, 2016).

In this context, Twitter has become a key social network to understand several industries, such as IoT (Sinha et al., 2019), digital marketing (Taecharungroj, 2017), or data and sociology (Lin et al., 2013; Ribeiro-Navarrete et al., 2021), among several others. Therefore, user-generated data (UGD) or UGC (Saura, Palacios-Marqués, & Ribeiro-Soriano, 2021) are becoming primary data sources for researchers to model theory and, hence, to formulate hypotheses that can be further validated in empirical research (Park & Park, 2016). The UGC sample is understood as small text fragments that are then analyzed using machine learning to meet the objectives of the study, identify topics, and classify their sentiments. Accordingly, following Vijayarani and Janani (2016) and Kunal et al. (2018) we developed a sentiment analysis with TextBlob using data-mining approaches (Vijayarani & Janani, 2016) such as vector classifier, multinomial naïve Bayes (MNB), logistic regression (LG), and random forest classifier (RFC). Then, based on the database of UGC tweets subdivided into sentiments, we performed an LDA to obtain themes according to positive, negative or neutral sentiments expressed in the tweets. Finally, following the indications of the CATA (Brunzel, 2021) conceptual framework, in order to extract additional insights and to create knowledge and theory regarding technologies and digital platforms for remote work, we analyzed the data using textual analysis based on content analysis and n-grams.

3.1. Data sampling

In order to gather information related to telework, a total of 205.204 tweets containing the hashtags #remotework, #remoteworking, and #telework were downloaded from the Twitter application programming interface (API) between April, 4 and August, 6, 2021. To increase the quality of the sample, filtering processes were performed using Python with Pandas libraries (McKinney, 2012). Specifically, the dataset was cleaned by excluding tweets shorter than 50 characters; the tweets with URLs and symbols were also eliminated (Piña-García et al., 2016). Additionally, duplicate tweets and retweets (RTs), as well as duplicate tweets shared by other users were removed. Since the present study does not focus on multimedia elements, all graphic icons, images, and videos attached to tweets were also removed. The final sample ($n = 167.394$ tweets related to telework) was analyzed to extract insights about opportunities and challenges of remote work.

3.2. Sentiment analysis

Sentiment analysis is a method based on NLP and CATA that aims to divide a sample of text pieces into different sentiments. In the present study, UGC collected from the social network Twitter was analyzed. As indicated by Cui et al. (2016), algorithm and machine learning models trained to perform sentiment analysis can be set to identify different sentiments. However, in the present study, we focused only on positive, negative and neutral sentiment factors, thus disregarding more specific emotions (e.g., sadness, surprise, or frustration). In this decision, we followed several previous studies (Fan et al., 2017; Zhu et al., 2020).

While there are several data-mining models that can be used to classify textual data based on the sentiments expressed in those data, we used TextBlob, a well-known approach developed in Natural Language Toolkit (NLTK) and Patterns (Kunal et al., 2018). In order to extract quality results, we followed the considerations provided by Bermingham

and Smeaton (2011). In our analysis, polarity was classified from -1 to 1, while the subjectivity values ranged from 0 to 1. To train the algorithm, a set of 621 manually classified text inputs were developed and extracted from the sample of tweets. This allowed the algorithm to understand the sentiments and perform the machine-learning process to classify the rest of the sample. We performed this algorithm classification and training independently, without comparing the results. Then, the final sample was divided in equal parts. Classification experiments were run with the results of the 621 inputs to avoid bias and increase accuracy of sentiment analysis. Prior to the final accuracy identification, we also established a protocol for the classification of inputs in lexical terms considering the characteristics of the NLP and CATA software. These processes were previously developed in-depth by Robach et al. (1984) and Mathieu et al. (2021).

As indicated by Reis et al. (2020), the more times an algorithm working with the machines learning is trained, the greater become its predictive capacity and accuracy. Accordingly, we trained the algorithm a total of 621 times. This number of samples was previously reported to be sufficient for research that uses machine learning (Bzdok et al., 2018). After training, different experiments were performed to select the best results using SVC, MNB, LR, and RFC models. To validate the results, the variables of precision, recall, f1-score, and support were also defined in terms of macro average and weighted average (Hiremath & Patil, 2020). These experiments were based on classification algorithms and were tested to improve sentiment analysis results with TextBlob. It is a standard procedure in machine learning studies where several classification algorithms are used to increase precision of the results. Accordingly, the greater the number of experiments performed, the greater the probability of selecting accuracy results with greater precision for the sentiment analysis (Reis et al., 2020; Saura, Ribeiro-Soriano, & Palacios-Marqués, 2021a).

3.3. Topic modeling using LDA

In recent years, LDA has been among most frequently used data-mining methodological approaches to extract topics from a sample composed of documents, pieces of text, or other components (Moro et al., 2015). LDA is a mathematical algorithm based on a probabilistic assumption to identify topics in a sample (Slof et al., 2021). Here, a sample that consists of documents would be divided into sentiments as a result of the sentiment analysis developed in the previous step. In the present study, we used Gibbs sampling in the Mac version.

The LDA model allows researchers to statistically identify the number and location of words and their frequency in the database. Said differently, LDA provides a list of the most relevant words in a database based on their position and usage (Hagen, 2018; Park & Oh, 2017). When a set of linked keywords is identified, the topic modeling algorithm statistically calculates their connections to offer a topic that characterizes their content. In this way, researchers can identify topics in the analyzed sample (Maier et al., 2018). In the present study, LDA was applied to each of the three databases previously divided according to the sentiments expressed in them (i.e., positive, negative, and neutral) to obtain topics related to the use of technology and digital platforms. In order to identify and classify the themes, 10 most relevant words in the LDA results were analyzed for each theme. Based on this analysis, a name of each theme was established. Whenever the first 10 words were not sufficient to define the topic, we analyzed 20 most frequent words, which is common procedure in this type of studies (Hagen, 2018; Slof et al., 2021). To the best of our knowledge, none of the previous studies has used LDA to analyze Twitter-based UGC and to explore the topics related to opportunities and challenges of remote work (Saura, Ribeiro-Soriano, & Palacios-Marqués, 2021b).

3.4. Textual analysis

Textual analysis developed in the present study was based on the

indications and theoretical conceptualizations proposed by Krippendorff (2018). In general, data-mining techniques focused on the use of textual analysis are based on the assumption that the weight and word opposition in a database can determine the relevance of certain topics in a database. Based on these findings, it is then possible to identify patterns in the data based on content analysis (Harrison, 2013).

Textual analysis makes it possible to measure the relevance of keywords found in a database and thus link the insights to the topics classified by sentiment analysis. In this context, an important variable that represents the weight and relevance of words is the weighted percentage (WP) (Feng & Behar-Horenstein, 2019).

Another common approach along with textual analysis is the identification of n-grams (Sidorov et al., 2014). This analysis makes it possible to understand how the lexicon of words and the position of each word can determine the meaning and relevance of the ideas or insights linked to each word. The n-gram analysis is a process that makes it possible to identify and measure the keyness and p-value factors of a word in the database in relation to other words, word nodes, or topics, as explained in the mutual information theory (Laneman, 2006). In this way, the probability of a word's occurrence is measured as a key factor to identify correlations between different variables, measure the relevance in terms of total weight of the database, or make comparisons in relation to frequency (Krippendorff, 2018).

4. Results

4.1. Sentiment analysis results

In this section, we report the results obtained using TextBlob with SPC, MNB, LG, and RFC. As argued by Hiremath and Patil (2020), accuracy is an indicator that measures the success of a machine-learning model or, as in our case, of a model trained to perform sentiment analysis. In the literature, the analysis of accuracy is used in models that work with artificial intelligence (AI) (Conant et al., 2019). Therefore, the higher is the accuracy score, the higher is the statistical validity of the results of the developed sentiment analysis model.

In the present study, the highest accuracy was found in relation to a Linear SVC Sl. No. 7 (0.869218) and No. 8 (0.872900). For random forest classifier, the two highest accuracy values were 0.551041 and 0.550024. As concerns Naïve Bayes, the corresponding highest accuracy results were 0.720701 and 0.757501. Finally, for logistic regression, the two highest accuracy values were 0.848378 and 0.830057. Table 2 presents a summary of the results obtained in the experiments.

Table 2
TextBlob analysis by experiment.

Sl. No.	Model Name	Fold_idx	Accuracy - TextBlob
0	RandomForestClassifier	0	0.501468
1	RandomForestClassifier	1	0.551041
2	RandomForestClassifier	2	0.542402
3	RandomForestClassifier	3	0.546253
4	RandomForestClassifier	4	0.550024
5	LinearSVC	0	0.814773
6	LinearSVC	1	0.842851
7	LinearSVC	2	0.869218
8	LinearSVC	3	0.872900
9	LinearSVC	4	0.861341
10	Multinomial Naïve Bayes	0	0.703122
11	Multinomial Naïve Bayes	1	0.713414
12	Multinomial Naïve Bayes	2	0.720701
13	Multinomial Naïve Bayes	3	0.757501
14	Multinomial Naïve Bayes	4	0.701341
15	LogisticRegression	0	0.810790
16	LogisticRegression	1	0.821022
17	LogisticRegression	2	0.848378
18	LogisticRegression	3	0.830057
19	LogisticRegression	4	0.821058

Source: The authors.

Furthermore, Table 3 summarizes the brief scores in relation to the model based on the results of our sentiment analysis. In research, it is a standard procedure to compare the results of different statistical models to increase the efficiency of the results. Table 3 shows the names of the methods and the corresponding scores. As can be seen in Table 3, the highest scores were obtained for linear SVC and logistic regression (0.87 and 0.84, respectively).

Following the considerations of Liu et al. (2017) who underscored the importance of data visualization in machine learning-centered approaches, Fig. 1 (a) shows the results of the experiments with 5 cross-validations results (see also Hiremath & Patil, 2020). Fig. 1 (b) shows the highest scores of TextBlob sentiment analysis results. On the X-axis, both figures reflect a maximum total accuracy of 1, represented up to 0.90. The Y-axis shows the numbers related to the experiments carried out with LSVC, RFC, LG and MNB in a total of 20 experiments. Fig. 2.

Furthermore, as concerns the classification of the sentiments, Table 4 presents the key indicators that measure the standard efficiency of the computed classification. the classification reports are presented for each of the sentiments subdivided into the accuracy, recall, f1-score, and support variables. Following Li and Liu (2014), accuracy is a variable that measures and represents the quality of the machine-learning model regarding the assigned tasks. Furthermore, as argued by Trofimovich (2016), variable f1-score is used as a metric that combines the recall and precision variables into a single value that identifies both variables. The f1-score variable helps researchers to understand the comparison of two metrics in order to identify suitable combinations. As reported by Hiremath and Patil (2020), the support variable shows the predictive ability of a computed model. Furthermore, following Bermingham and Smeaton (2011), the macro average represents the total average of the model according to the results of each variable, while weighted average measures relativity in relation to weight of a set of variables.

4.2. Topic-modeling results

The aim of applying LDA in the present study was to identify topics that can explain the main opportunities and challenges of remote work through the use of technologies and platforms. Overall, a total of 11 topics were identified. Then, the identified topics were classified into opportunities (6 topics) or challenges (5 topics). Following Hong and Davison (2010), and as explained previously, we analyzed the most frequently used words in each of the identified topics (previously divided into positive, negative, or neutral). Based on this analysis, each of the topics was named and classified (see Table 5 and 6).

Of note, while the LDA application and analysis process is automated, meaning that the researchers work on the results classified by the computation of the model, the process of naming the topics is manual and thus exploratory. The classification and naming of the topics are linked to the sentiments of each topic previously divided by the application of sentiment analysis. The results of the classification of the topics by sentiment are shown in Table 5 and 6.

According to Gabrielatos and Marchi (2011) and Gabrielatos (2018), the keyness value measures the relevance of each topic. Keyness is a metric used in studies focused on data mining and linguistics to measure lexical relevance of words, their position in a database, as well as the strength of the link between the topics linked to the log-likelihood score values. By using keyness, a log-likelihood value of > 3.8 was found to be

Table 3
Brief scores of TextBlob analysis.

	Model Name	Scores of TextBlob analysis
1	LinearSVC	0.872900
2	LogisticRegression	0.838378
3	MultinomialNB	0.757501
4	RandomForestClassifier	0.551041

Source: The authors.

statistically significant when p -value < 0.05. Additionally, the relevance of each topic and its classification into sentiments allow one to understand and link the results to the objectives of the study. This approach is commonly used in linguistic and textual analysis studies that use mutual information (Church & Hanks, 1990).

In the present study, we selected only those topics that were immediately relevant to the subject of our investigation; all other topics were discarded. Tables 5 and 6 list the identified topics, with their corresponding descriptions, sentiments, as well as keyness and p -values. With regard to the topics that could be understood as opportunities, within the contextualization proposed in the research objectives, Table 5 identifies and describes those topics categorized as opportunities in relation to remote work using digital technologies and platforms.

Of note, the topic with the highest p -value (0.046) is related to New technologies, characterized by the use and adoption of new technologies by companies. The next topic is Virtual health ($p = 0.033$), which is focused on opportunities related to employees' mental health and stress. The third topic is Work-life balance ($p = 0.023$), which concerns maintaining the balance of remote work and family conciliation. Next come the topics of Less stress ($p = 0.022$), which is related to opportunities in relation to saving commutes in large cities and Sustainability ($p = 0.019$), which refers to a great opportunity for remote workers to reduce pollution and fuel consumption. The sixth and final topic is Future of remote work ($p = 0.018$), which refers to an opportunity for this industry to consolidate in the use of new platforms and digital technologies.

Similarly, with regard to possible challenges for remote work using digital technologies and platforms, Table 6 presents the corresponding identified topics, their descriptions in relation to the objectives of the study, and the sentiments of each topic. Specifically, the most relevant topic was Technology issues ($p = 0.037$), whereby technology and its adoption by employees highlights the need to increase training and technical knowledge. The second topic was Privacy concerns ($p = 0.028$) that arise due to the difficulty of creating secure digital ecosystems for employees when adopting new platforms for remote work due to the complexity of cyberattacks and possible gaps of security. The third topic was Equipment ($p = 0.016$), which describes the challenges related to the software and hardware necessary for employees to correctly perform their remote work activities. The fourth in ranking was the topic of Engagement ($p = 0.015$), which focuses on the analysis of the relationship between companies and employees as compared to work in the office. Finally, the last topic was Stress ($p = 0.015$), which is linked to family conciliation and the stress generated by the demand for using new software.

4.3. Textual analysis results

According to Krippendorff (2018), textual analysis can be used to identify insights and knowledge in UGC databases. In this way, based on the relevance, frequency, and positions of words in a database, one can derive necessary for the definition and creation of theory related to the research objectives. In the present study, the textual analysis was the last step of the methodological process developed and applied to a database of 167.394 tweets. In order to extract valid insights, we measured the frequency (Fq) of the words, as well as their weight (WP) in the total UGC database. Depending on the process and software used, words can be grouped into nodes, i.e., sets of word groupings that make it easier for a researcher to understand their linkages (Loughran & McDonald, 2016). These groupings make it possible to thoroughly investigate the ideas and connotations of each node. A node refers to a grouping of words that derive an explanation towards a study topic. The same study can have different nodes in which the different ideas and keywords obtained from the sample are grouped and classified. Based on these results, knowledge will finally be created by theorizing the insights in connection with the existing theory (Saura, Ribeiro-Soriano, & Palacios-Marqués, 2021b). In the present study we used Pandas GroupBy in

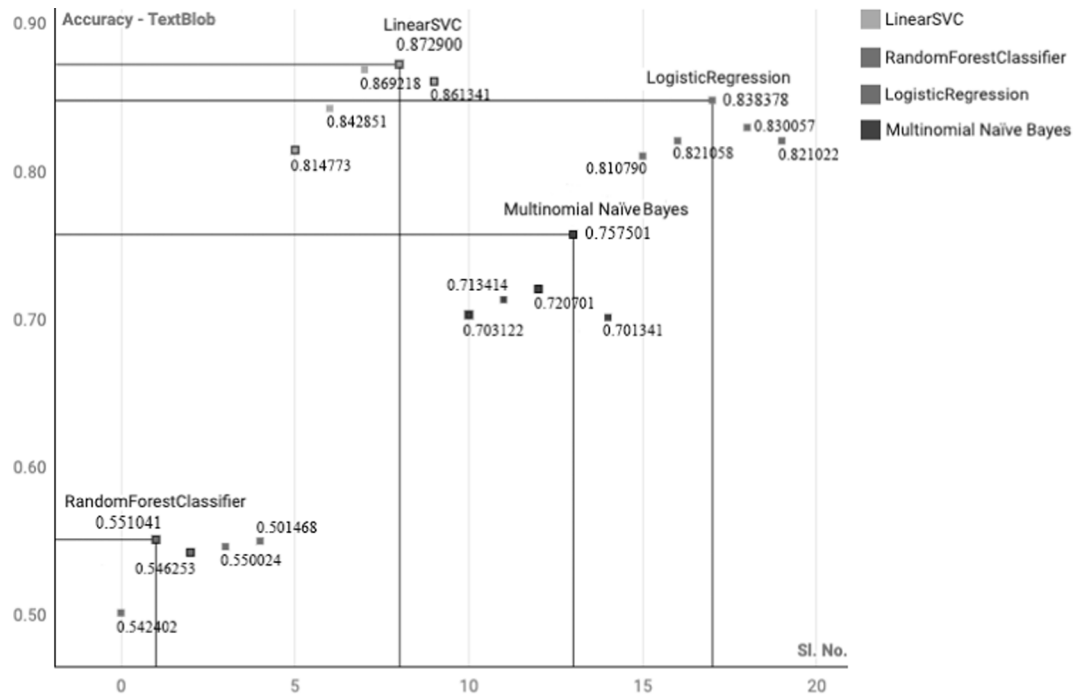


Fig. 1. Main brief scores of TextBlob Analysis in the 5 cross-validations experiments.

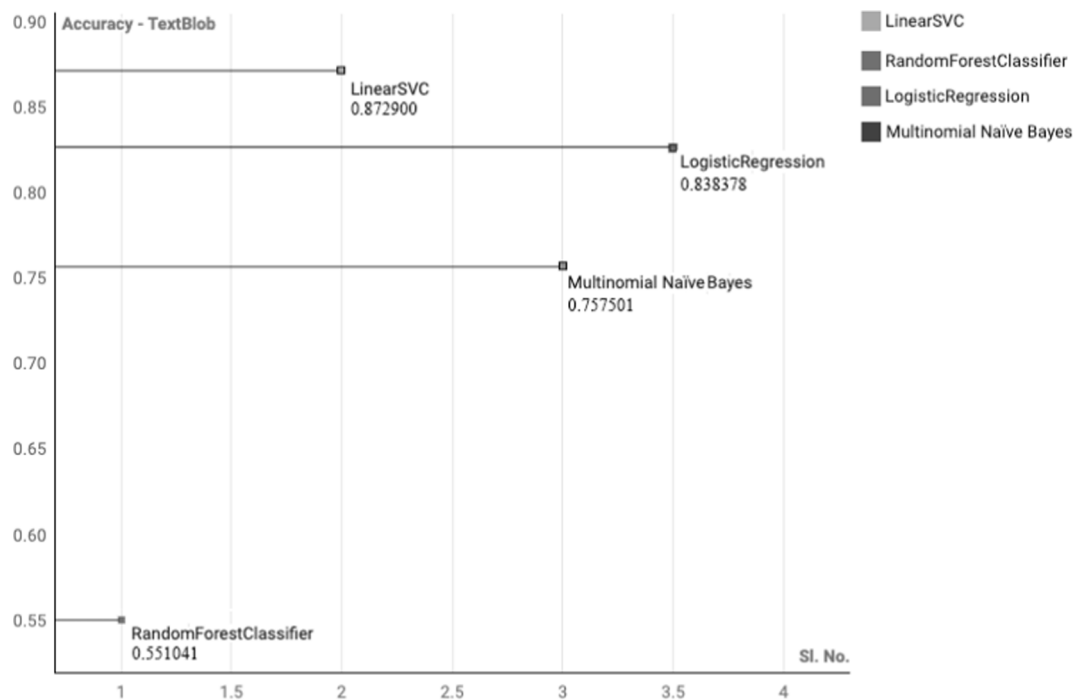


Fig. 2. Highest accuracy results in the 5 cross-validations experiments in TextBlob.

Python (McKinney, 2011) for the development of textual analysis. Tables 7 and 8 list the main keywords identified within each topic based on the words' frequency and relevance in the database.

Each of the topics was divided into word nodes, and then the total numbers of terms related to each topic and of times a keyword were categorized within each node. In this way, through the frequency (Freq) and WP variables, it is possible to assess the importance of each node or set of keywords in relation to the topics and the expressed sentiment. Of note, word nodes are composed of simple or compound words, in which synonyms can be valid keywords to explain and determine the

composition of the topic and its total average relevance in the database.

As mentioned in the methodology section, in addition to textual analysis, CATA and NLP studies would typically analyze n-grams to obtain additional insights. Accordingly, following Sapkota et al. (2015) and Kouloumpis et al. (2011), the main n-grams present in the text pieces subdivided by topics and sentiments were analyzed. In general, a n-gram model predicts the occurrence of a word given only its previous word (as $n - 1 = 1$). Following similar approaches (Sapkota et al., 2015), Table 9 presents main unigrams and bigrams in relation to the identified topics.

Table 4
Classification report of machine-learning model results.

Sl. No.	Parameters	Vader precision	recall	f1-score	support
1	Negative	0.76	0.81	0.74	20.499
2	Positive	0.84	0.74	0.81	2212
3	Neutral	0.88	0.91	0.90	20.451
4	Accuracy	–	–	0.82	43.640
5	Macro avg	0.80	0.73	0.73	43.640
6	Weighted avg	0.77	0.82	0.81	43.640

Source: The authors.

Table 5
Topic modeling results (Opportunities).

R	Topics	Description	Sent.*	Keyness	p-value
1	New technologies	Remote work causes remote workers and companies to be forced to use and adopt new technologies and platforms.	Neutral	643.29	0.046
2	Virtual health	To increase the mental health of employees by prioritizing routines with less stress and that generate less anxiety for workers.	Negative	430.67	0.033
3	Work-life balance	To maintain a balanced life between work and family reconciliation	Positive	405.81	0.023
4	Less stress	Saving commute in large cities thus increasing rest and work time.	Positive	405.21	0.022
5	Sustainability	Fuel savings by commuting to daily work.	Neutral	381.05	0.019
6	Future	A constantly changing industry driven by the adoption and development of new technologies and platforms to turn any location into an office.	Positive	380.91	0.018

Source: The authors.

5. Discussion

As shown by Wrycza and Maślankowski (2020), the use of new technologies for remote work has been an important concern for Twitter users during COVID-19 pandemic. Companies and workers have been forced to use new digital platforms to promote remote work. In addition, as argued by Alshaabi et al. (2020) and Zhang et al. (2021), COVID-19 pandemic has had a dramatic impact on users' behavior and mental health. Accordingly, some of these behavioral changes have been already investigated in the literature (Zhang et al., 2020).

As suggested by the results of the present study, the topic of work-life balance (keyness 405.81 and p-value 0.023) was positively evaluated by Twitter users. This highlights that remote workers' positive experiences linked to not only the work-family balance, but also to the process of adoption of new technologies as an opportunity to achieve a more efficient work routine. Similarly, Karl et al. (2021) pointed out that, during the current pandemic, it is essential to learn how schedule and organize videoconferences.

Furthermore, the topic of Less stress (keyness 405.21 and p-value 0.022) was also positively evaluated by Twitter users, suggesting that the adoption of new platforms and technologies has positively affected employees by reducing their need to commute to work (and thus reducing the adverse impact of other stressors, such as traffic jams, energy consumption, etc.). In line with our finding, Min et al. (2021) also

Table 6
Topic modeling results (Challenges).

R	Topics	Description	Sent.*	Keyness	p-value
1	Technology issues	Employees dealing with new platforms, technical issues, and managing teams online.	Neutral	631.97	0.037
2	Privacy concerns	To create safe environments for the privacy of employees in their homes with the use of new technologies and platforms.	Negative	520.15	0.028
3	Equipment	To obtain the necessary software and hardware for each remote worker is a challenge for companies and employee training.	Neutral	213.71	0.016
4	Engagement	Increase engagement between the company and workers with videoconferencing platforms and virtual meetings	Positive	208.10	0.015
5	Stress	Remote workers must reconcile with family life and take training courses to adapt to the use of new technologies and digital platforms	Negative	207.77	0.014

Source: The authors.

Table 7
Keywords by topic related to opportunities.

R	Topic	Words	Frq.	WP
1	New technologies	New platforms, video conferencing, cloud solutions, Zoom, apps, video conferencing software, software solutions, among others.	12.421	17.12
2	Virtual health	Virtual health insurance, frustration, screen freezing, emotional impact.	9.286	11.94
3	Work-life balance	Family time, work tasks, multitasking, schedule, meetings, home office.	5.026	8.02
4	Less stress	Pressure, location, vehicles, garden, mountains, motivational, among others.	3.012	3.41
5	Sustainability	Car's pollutions, commute, long commutes, cities, air quality, among others.	3.006	3.41
6	Future	Home offices, new companies, productivity, efficiency, rethinking environment.	2.935	3.39

Source: The authors.

Table 8
Keywords by topic related to challenges.

R	Topic	Words	Freq	WP
1	Privacy concerns	Vulnerabilities, data security, data governance, legal practices, among others.	4.169	4.12
2	Engagement	Complaints, communications, wrong strategies, expectations, flexibility, among others.	2.409	3.08
3	Equipment	Home office checklists, home office set up, internet connection, laptops, among others.	1.936	2.84
4	Stress	Family, children, ineffectively work office, videocalls, space, locations, among others.	1.638	2.78
5	Technology issues	Updates, technical problems, CRMs, implementation, technical department	1.079	2.42

Source: The authors.

Table 9
Main n-grams for the identified topics.

*R	NewTechnologies				R	Virtual health			
	*Freq	*Freq L	*Freq R	Topic		Freq	Freq L	Freq R	Topic
1	1.200	782	418	NewTechnologies	1	982	474	508	VirtualHealth
2	391	190	201	Videoconferencing	2	701	394	307	Emotions
3	201	92	109	Videocalls	3	647	301	346	Frustration
4	198	105	93	Cloud	4	401	205	196	Panic
5	191	79	112	Apps	5	398	372	26	Expectations
R	Work-life balance				R	Less stress			
	Freq	Freq L	Freq R	Topic		Freq	Freq L	Freq R	Topic
1	762	371	391	Homeoffice	1	671	371	300	Pressure
2	501	239	262	Family	2	627	309	318	Locations
3	381	178	203	Meetings	3	291	104	187	Offices
4	290	130	160	Tasks	4	152	70	82	Cities
5	195	98	97	Calendar	5	149	120	29	Organize
R	Sustainability				R	Future			
	Freq	Freq L	Freq R	Topic		Freq	Freq L	Freq R	Topic
1	601	371	230	Sustainability	1	571	290	281	Future
2	548	390	158	Pollution	2	503	272	231	Innovation
3	401	238	163	Cars	3	496	268	228	Efficiency
4	374	167	207	Movements	4	262	132	130	Productivity
5	201	102	99	Commute	5	101	54	47	Rethinking
R	Privacy concerns				R	Engagement			
	Freq	Freq L	Freq R	Topic		Freq	Freq L	Freq R	Topic
1	402	281	121	Privacy	1	352	168	184	Engagement
2	372	167	205	Vulnerabilities	2	109	52	57	Communication
3	300	132	168	Breach	3	53	23	30	Interaction
4	238	103	235	Data	4	49	30	19	Flexibility
5	153	73	80	Blackmail	5	43	26	17	Complains
R	Equipment				R	Stress			
	Freq	Freq L	Freq R	Topic		Freq	Freq L	Freq R	Topic
1	350	179	171	Equipment	1	302	142	160	Stress
2	201	145	187	Laptop	2	290	139	151	Children
3	105	71	34	Setup	3	130	60	70	Ineffectively
4	91	42	49	HomeOffice	4	105	85	20	Space
5	86	38	48	Hardware	5	93	42	51	Child
R	Technology issues								
	Freq	Freq L	Freq R	Topic		Freq	Freq L	Freq R	Topic
1		206	103					103	Updates
2		174	82					92	Technical
3		60	26					34	Implementation
4		53	30					23	Problems
5		40	21					19	Knowledge

*Rank (R).

*Frequency (F).

*(F) of words on the left (FreqL).

*(F) on the right (FreqR).

noted that the stress and attitude towards these situations during COVID-19 pandemic has been positive, because no commuting was considered by many employees as an opportunity for a radical lifestyle change, even though alarms and extreme situations during the pandemic could still adversely affect employees. For instance, [Song and Gao \(2020\)](#) showed that workers can reduce their stress even more when adopting teleworking depending on the environmental factors, such as moving outside of the city, which promotes family conciliation and increases work pleasure. In addition, the COVID-19 pandemic not only caused radical changes in the life of remote workers but has also led to the development of new business models and technologies focused on generating less stress for remote workers. New business models include traditional business models adapted to remote work. However, executives, managers, and policymakers should propose internal research to re-evaluate the benefits of remote work for their employees.

Furthermore, the topic of sustainability in our data was valued as a

neutral topic (keyness 381.05 and p -value 0.019). In general, the use of digital platforms ([Michelini et al., 2018](#)), as well as personal software or hardware provided by companies, promotes sustainable actions. Accordingly, teleworking is generally an opportunity to reduce pollution in cities and encourage relocation to rural environments. Similarly, [Moos, Andrey and Johnson \(2006\)](#) argued that remote work and company strategies promote sustainable actions.

Next, health turned out to be a negative topic (keyness 430.67 and p -value 0.033) in our data, as the psychological pressure caused by the pandemic has negatively affected the global business ecosystem based on telework ([Kontoangelos et al., 2020](#)). This finding suggests that it is necessary to closely attend to the issues of remote employees' mental health, which, in turn, could improve the effectiveness and profitability of their work. Importantly, while there are opportunities to develop routines with less stress and anxiety for workers, several policies introduced by companies can cause negative feelings among employees. In

this respect, we agree with Larson et al. (2020) that, although telework offers many important benefits for businesses, companies should carefully consider the ways of making digital platforms user-friendly so that to avoid causing unnecessary pressure and stress among their employees (Saura, Palacios-Marqués, & Ribeiro-Soriano, 2021c).

Next, the topic of new technologies (keyness 643.29 and p -value 0.046) was neutrally evaluated in our data. During the current pandemic, companies have been forced to implement new technologies and platforms to enable their workers to effectively perform their functions. This opportunity has led to the extensive use of cloud technology, IoT, artificial intelligence, CRMs, digital marketing tools, or e-commerce, among other tools in the telework industry.

Furthermore, the topic of Future of remote work (keyness 380.91 and p -value 0.018) was positively evaluated by users, according to the results of our sentiment analysis. In line with this finding, Leonardi (2020) argued that those technologies such as artificial intelligence, as well as new tools and connected devices, will promote remote work in the medium and long term (Zhang et al., 2021). Offshoring and integration of new intelligent systems will consolidate telework as a genuine option for companies, thus breaking the traditional models of management and business organization (Wrycza & Maślankowski, 2020).

However, the topic of Privacy concerns (keyness 520.15 and p -value 0.028) emerged as a negatively evaluated topic. This suggests that the business industry must strengthen its systems and digital platforms to safeguard the data and actions performed by remote workers (Ribeiro-Navarrete et al., 2021). Accordingly, in the absence of firewalls and protection systems for employees' computers that are typically considered in offices, enterprise solutions for remote work must also be proposed. Overall, protecting remote workers from potential attacks and security breaches that can put their work at risk remains an important challenge of telework (Karl et al., 2021).

One challenge, as also argued by Pattnaik and Jena (2020), is how to improve engagement processes in the company (keyness 208.10 and p -value 0.015). Interaction with employees should be a key consideration for the development of both the organization and the planned strategies. The use of new technologies by teleworkers results in a higher need for training and more extensive use of processes that can affect communication, employees' comfort with business communication, as well as their engagement with customers. In this respect, it is important to consider business strategies to promote teleworking with digital platforms focused on an effective engagement between companies, managers, and customers (Prasad et al., 2021).

There has been some research on the adoption of new technologies and digital platforms for teleworking (Risi et al., 2020). However, in line with the findings previously reported by Borissova et al. (2020), in our data, the topic of Equipment (keyness 213.71 and p -value 0.016) was found to be neutral. Overall, at present, there is a general deficiency in companies in terms providing their employees with appropriate equipment. In this connection, Burri et al. (2011) argued that telework is associated with significant investments on part of the employer, since office equipment is usually fixed and not portable. In addition, timely and effective performance of work duties outside of the office remains a challenge for many businesses.

Furthermore, unlike the topic of Less stress discussed above, the topic of Negative stress (207.77 and p -value 0.014) also emerged in the data. This topic is more linked to challenges, rather than opportunities. Many users perceived it challenging to effectively combine business and family. In line with this finding, Dhawan and Chamorro-Premuzic (2018) and Davis et al. (2021) highlighted that many employees have doubts about the possibility to effectively work from home. In this connection, Adamovic (2022) identified the need to investigate behavior of employees when they adopt to new forms of remote work. Depending on the job and the implemented measures, negative stress among the employees can considerably increase, which can adversely affect employees' mental health. As argued by Mann and Holdsworth (2003), radical changes in work environments can be counterproductive

and generate anxiety and stress in workers. Therefore, stress is positioned as one of the variables composed of pros and cons, depending on the case analyzed.

Finally, the topic of Technology issues (keyness 631.97 and p -value 0.037) was neutrally evaluated by Twitter users. This topic encompasses users' opinions about the problems caused by the adoption of new technologies, additional or advanced configurations, as well as internal organization of meetings and other remote business issues.

6. Conclusion

In the present study, we used three data-mining techniques (sentiment analysis, topic modeling and textual analysis) to identify the main opportunities and challenges of remote work when using digital technologies and platforms. The data analyzed in the present study were the UGC from Twitter. Based on the results of our analysis, we identified six topics linked to opportunities and five topics linked to the use of technologies and digital platforms.

The identified topics were differently evaluated by Twitter users. Among the positive topics were work-life balance, less stress, and engagement. The negative topics were virtual health, privacy concerns, and stress. The neutral topics were sustainability, new technology, and equipment. Taken together, the identified topics respond to the main research question addressed in the present study ("What are the main opportunities and challenges of using digital technologies and platforms in telework, according to Twitter-based UGC?").

Regarding the main opportunities offered by the use of technologies and digital platforms, particularly important are business strategies that can help workers to improve their work-family balance. However, these strategies can also induce stress and anxiety in the home environment. However, the opportunity to telework allows users to avoid commuting to work, thereby increasing the time needed for family and stress reduction. New technologies make teleworking more efficient and boost sustainability by avoiding unnecessary travel and reducing pollution. However, the use of digital platforms that are not properly optimized to manage digital tasks and meetings may adversely influence remote workers' mental health.

New technologies have not only allowed the adoption of new digital platforms by workers but have also had a positive attitude on employees' learning how to use these technologies. At present, there is little doubt that the future of the industry will depend on the development of new technologies and digital platforms that will enable remote workers to increase their efficiency without compromising their mental health.

However, the newly emerging technological ecosystem has led many remote workers to start having privacy concerns regarding the software and hardware they use. The technology used in companies is more sophisticated than standard computers used by remote workers at home. Accordingly, security breaches or data leaks that can affect the privacy of users are an important concern that should be addressed.

Along with the increase in measures to protect user privacy, another challenge is improving employees' engagement. Effective telework requires a seamless flow of communication between the company and its remote employees. Another challenge is improving remote workers' equipment, which may require considerable investments on part of companies. Finally, one of the main challenges of remote work is the possible emergence of problems with the use of new technologies, as well as the need of employees' constant learning how to deal with technical problems. Therefore, if companies want to develop an effective remote work strategy in the long term, the aforementioned problems should be taken into account.

On the one hand, reducing stress through remote work (wherever the latter is possible) can be a great opportunity for companies to offer better working conditions, greater flexibility, as well as family conciliation for its employees. In cases where remote work through the use of new digital platforms allows employees to move outside the city can be considered as an opportunity promoting the well-being and health of

employees, as well as reducing pollution and driving sustainability.

On the other hand, the negative stress that remote work can cause must be seriously considered and evaluated. In fact, the adoption of new digital platforms, radical changes in habits, and family reconciliation at home while teleworking can cause mental health problems and results in radical increases in the stress level of remote workers. These factors can cause situations in which work performance decreases, adversely affecting companies' profitability. Accordingly, managers and executives must propose new forms of telework management to be re-evaluated in the medium and long term. New forms of work-life balance must be found to identify stress as a priority and to ensure that remote employees' comfort and effectiveness are not affected.

6.1. Theoretical implications

In recent years, telework has drawn a considerable scholarly attention in the academic community. The COVID-19 pandemic has accelerated research on the adoption of new technologies by both firms and remote workers. The results of the present study offer several theoretical implications for further research. For instance, the topics identified as opportunities can be used as variables for statistical models or future surveys that would seek to evaluate the empirical significance of the identified topics. Similarly, the topics identified as challenges can be employed in further surveys to identify their relevance for businesses and remote workers. Furthermore, future studies can use the original approach to extract insights from UGC on Twitter proposed in the present study to explore other issues related to the use of new technologies and digital platforms by remote workers.

Similarly, the results of the present study revealed that stress is one of the most complex variables to understand the main drives and conditioning factors of remote work. Accordingly, new studies on stress must be developed. The COVID-19 pandemic has elicited an increase in work-related mental health problems, and further research is needed in this area. Interviews and questionnaires with workers and managers must be developed to quantitatively measure and re-evaluate the main pros and cons of stress in remote work depending on the business model, the digital platform and technology used, and the remote worker family situation.

6.2. Practical implications

With regard to practical implications of our findings, companies can take into account both opportunities and challenges identified in the present study to improve their remote work strategies. In addition, our findings provide companies with a better understanding of how employees perceive the development of telework-related tactics from the perspective of workers' views on privacy concerns, use of better equipment, potential issues related to technology use, or managing a healthy psychological life. Companies can take these insights as part of their research plans to improve their communication, marketing, or human resources strategies.

At the same time, a recommended practice for companies, policy-makers, and managers is to propose in-company training through which employees can increase their knowledge and skills of stress management and work-life balance. New processes for managing work routines and meeting objectives must be established by executives so that the adoption of remote work remains flexible and durable over time. Company actions should focus on avoiding mental health problems and increasing work-life balance among remote workers.

6.3. Limitations and future research

The limitations of the present study are related to its exploratory nature. In the present study, Twitter data were assumed to be valid sources of UGC. Furthermore, sentiment analysis used in the present study has several limitations, particularly with regard to accurate

identification of connotations and irony, which are not always classified appropriately. Next, regarding LDA, the classification and naming of themes using LDA is a manual process, which can introduce some bias into the results. Accordingly, future research should cautiously interpret the results of the present study taking into account the limitations outlined above.

CRedit authorship contribution statement

Conceptualization: JRS, DRS and PZS. Data curation: JRS. Formal analysis: JRS, DRS and PZS. Funding acquisition: JRS, DRS and PZS. Investigation: JRS, DRS and PZS. Methodology: JRS, DRS and PZS. Supervision: DRS and PZS. Validation: PZS. Visualization: JRS. Roles/ Writing - original draft: JRS. Writing - review & editing: JRS, DRS and PZS.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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