The reconstruction of L'Aquila in people's emotions: using Artificial Intelligence to investigate post-disaster recovery in the long term

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Abstract

In recent years, the attention towards sentiments expressed on social media in disaster scenarios has increased. The role of social platforms in disaster management has traditionally been focused on the function that microblogs take for real-time data or in the early stages of recovery. Relatively less attention has been devoted to the sentiment expressed in the longer term. Using an Artificial Intelligence classification model on Twitter data collected for over a decade, this paper examines the sentiments towards the city of L'Aquila and its recovery after the 2009 earthquake. It emerges a close interconnection between the reconstruction progress and public sentiment. Timing, inclusiveness, and coherent communication proved to be critical in the post-disaster management. The study shows that mismanagement in a crisis can have lasting effects due to the perduring distrust in post-shock governance. Sentiment analysis in times of crisis permits interpreting the causes of distrust in a community's socio-economic reconstruction, and it is crucial for strengthening recovery management in successive and unrelated crises.

Keywords: Artificial Intelligence; Sentiment analysis; Disasters; Long-term impact

1. Introduction

The role of social media in public debate is increasing in popularity and relevance. Social platforms are used to express views on various topics, from product reviews to political opinions, from general issues and complaints to day-to-day activities. The increasing amount of publicly available data is used in many ways. Private companies and public institutions have used the analysis of people's opinions for more than a decade to detect public sentiment in order to increase the value and standards of their services or products (B. Liu & Zhang, 2012). Liu and Zhang (2012) define opinion mining as a technically challenging and practically very useful task consisting in the computational study of people's opinions, appraisals, attitudes, and emotions toward entities, individuals, issues, events, topics, and their attributes. For the analysis, this study uses Twitter, a micro-blogging social media on which users can post short messages. Twitter is considered the most useful social media for sentiment analysis in disaster contexts (B. F. Liu et al., 2012; Vera-Burgos & Griffin Padgett, 2020). Since its creation in 2006, this social media has gained increasing popularity becoming among the most widespread social platforms. Besides social content, Twitter is also used to diffuse news and real-time events, such as disasters, emergencies, and hazards. These contents include official communications, broadcast news, distress calls, and first-hand information. Researchers are increasing their attention towards these microblogs, facing the challenge of detecting and summarising the overall sentiment. The most recent developments in Twitter-related data analysis applied to disaster management focus mainly on the crucial role of microblogs for real-time data (e.g., Detera et al., 2021; Kersten & Klan, 2020). Much of the research using these data, to date, has focused on the very early stages of recovery, but there is a need for research in longer-term disaster recovery (Ogie et al., 2022). Sentiment Analysis (SA) can be critical in understanding sentiments toward a specific topic over a long period of time. Ogie et al. (2022) highlight a need for research exploring the use of social media data to monitor the effects of government grants, concessional rate loans to small businesses, and other stimulus packages, on the economic recovery of disaster-impacted communities. To do so, SA can be considered a crucial technique to detect two temporal dimensions of the phenomenon: the spot circumstances that

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happened in specific moments of the reconstruction process (and the emotions towards those events), together with the long-term trends that drive the recovery path. The combination of different Natural Language Processing (NLP) techniques also permits the reconstruction of what happened at a specific moment of the post-disaster and which were the emotional consequences of those events. After the 2009 earthquake, the recovery of L'Aquila has been anything but linear or without controversies (Imperiale & Vanclay, 2019, 2020). The reconstruction process has been severely and largely criticised for many reasons. Even if it is in an advanced phase, twelve years after the earthquake, the city's rebuilding still must be totally completed. The process has been characterised by different stages of development, from an initial prolonged stagnation up to the investments in culture and innovation of the latest years. This study retraces the phases of the reconstruction process, examining how public opinion has perceived them. Besides the opportunity to use social media in monitoring the effects of government aids for disaster recovery, in the literature it is highlighted the need to investigate also on (Ogie et al., 2022): 1) the various dimensions and phases of disaster recovery, 2) the use of social media in understanding different cultural contexts because of an important geographical bias, 3) the politicisation of disasters through social media conversations and how this impacts community recovery, particularly in relation to the government inaction that affects solidarity and social cohesion during the disaster recovery phase. In order to do so, the paper is organised as follows: the second section examines the literature on sentiment analysis and its use for the study of disasters; the third section provides information on L'Aquila earthquake and the reconstruction process as the background for the empirical assessment, explaining why the case of L'Aquila is ideal for addressing these issues; the fourth section presents the data sources and the research design; the fifth section presents and discusses the results of the analysis, and the sixth section offers the conclusions.

2. Artificial Intelligence, sentiment analysis and disasters

Together with the increasing diffusion of social media in the last decade, Artificial Intelligence (AI) has gained a crucial role in disaster preparedness and response. Many studies highlight the importance of social networks such as Twitter (Song & Huang, 2021; Yin et al., 2015) in disaster management for their real-time characteristics. In addition to its original social function, Twitter is becoming a real-time platform to monitor events such as accidents, shocks, disasters and other emergencies. It is the most used social network in disaster studies (Ogie et al., 2022), and its use is strongly correlated with the per-capita economic damage caused by a large-scale disaster (Kryvasheyeu et al., 2016). Public bodies and disaster relief organisations are increasingly using this social media to respond promptly (Kankanamge et al., 2020; Yuan et al., 2020). Besides the benefits deriving from the real-timeliness of social media, the development of studies on social platform data gives the advantage of relying on a high volume, variety and variability of datasets. In disaster studies, a common strategy is to investigate social media data to analyse facts from the expressions of people that are considered as "sensors" (Laituri & Kodrich, 2008; Shibuya, 2017). To date, the bulk of research on the use of social media in disaster recovery has prioritised the analysis of management and early phases of disaster response, particularly focusing on the role of social media communication in improving situational awareness (Luna & Pennock, 2018). Even if these data have been less used to explore the mid and long-term recovery process, scholars highlight the role of social media in the whole post-disaster phase (Abedin et al., 2014; D. Alexander, 2014; Houston et al., 2015). Moreover, Ogie et al. (2022) argue that a clear geographical bias is reflected in the current body of literature, with much of the research on social media used for disaster recovery concentrating on the North American context. Despite being a risk-prone area, very few studies focus on Italy. One is from Contreras et al. (2022), which used SA to assess post-disaster recovery on the 10th anniversary of L'Aquila's earthquake using tweets from April 4 to 10, 2019. They use a supervised classification based on experts' rules on post-disaster reconstruction. While

feasible for a short period of time, this research needs AI to look at thirteen years. Investigating sentiment for a long-term post-disaster allows to: 1) carry out a yearly reconstruction of the fundamental stages of the post-disaster recovery; 2) understand the dynamics that accompanied, pushed, and stopped the reconstruction after the earthquake, 3) understand the medium to long-term reconstruction policies' effect on the population sentiment.

3. L'Aquila Earthquake, the reconstruction policy and social media

On the 6th of April 2009, a 6.3 Mw earthquake hit the city of L'Aquila, the capital of the Abruzzo region and the historic centres of more than 80 villages (across 57 municipalities) in Central Italy. Several buildings were destroyed, 309 people lost their lives, and more than a thousand people were injured. More than 70 000 people were displaced. The public expenditure for the reconstruction is estimated at 12.2 billion €, financing more than 24 000 projects[2]. More than 9.8 billion € of public expenditure is dedicated to 22 726 projects for financing private reconstruction. In April 2022, more than 19 500 construction sites completed their works (more than 86% of these projects). In terms of public financing, at the date of April 2022 were distributed more than 7.4 billion euros (69% of the funds requested). As shown in Figure 1, most funds requests arrived in the first phase from 2009 to 2013. Most of the financing occurred from 2012 to 2015 (Figure 2), and the effective payments started in 2013 (Figure 3), continuing significantly until 2018. These data could represent decent progress (compared to the disaster's magnitude), but the path toward recovery has not been linear. L'Aquila's context is ideal for analysing the multifaced effects of the post-disaster reconstruction management. Aside from the considerable financing, the process has been characterised by the protagonism of the national government, providing an optimal case study for understanding the effects of the politicisation of disasters. On the other side, especially from the halfway of the reconstruction process, it has been a lab also for innovation, knowledge, and culture-led policies. This scenario provides a unique setting for investigating the effects of social and cultural events such as sports, recreation, arts and cultural programmes that are emphasised in the literature as key for social recovery (Baumann et al., 2021; Mannakkara & Wilkinson, 2015). Starting with the controversies, Prime Minister Silvio Berlusconi declared a state of emergency immediately after the earthquake, giving the Department of Civil Protection a critical amount of power. As a common procedure for disaster recovery in Italy (Özerdem & Rufini, 2013), the government has opted for extraordinary powers and procedures with the appointment of Special Commissioners and "fast tracks". All centres of devastated villages and L'Aquila's historical city centre were declared "red zones", from which all civilians were excluded, initially by military personnel and later by the construction of fences together with military patrols. With the decree of the 22nd of June, 2012 (no. 83), the National Government stated the end of the state of emergency on the 31st of August, 2012. Under the state of emergency and the so-called "miracle narrative" (Ciccaglione, 2019) were taken controversial decisions without considering financial, environmental, or social issues that led to unwelcome consequences, including economic stagnation, stalled reconstruction, alienation of the local population, fiscal deprivation and corruption (D. Alexander, 2019). The so-called CASE plan, an acronym for "Complessi Antisismici Sostenibili Ecocompatibili" (earthquake-resistant residential buildings for a sustainable reconstruction), is an example of this controversial reconstruction (D. Alexander, 2013). These are new settlements for households displaced by the earthquake that, despite being presented at the beginning as constructed in the proximity of existing built-up areas and the places of origin of the displaced people, have been located in the periphery of the city contributing to strengthening the already dispersed urban tissue of L'Aquila (Falco et al., 2018).

[2] opendataricostruzione.gssi.it, retrieved in February 2023

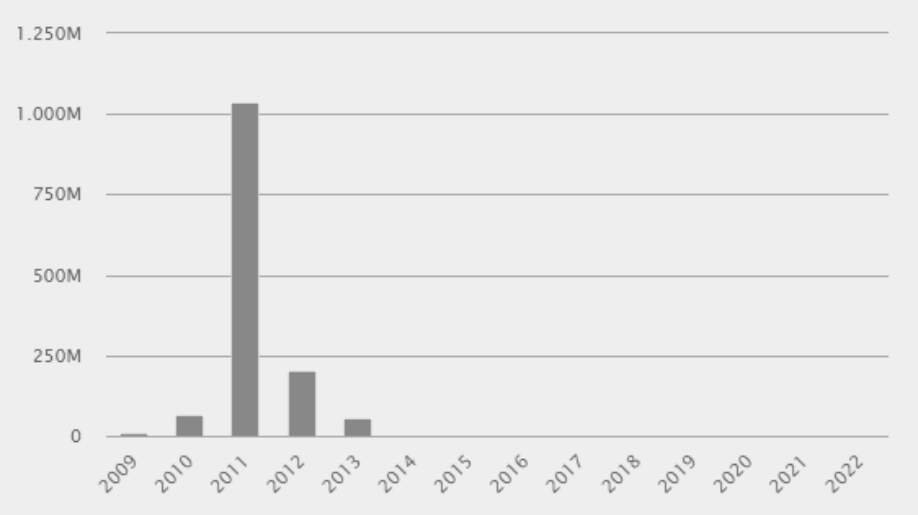

Figure 1. Amount of funds requested to the government for the private reconstruction in million euros. Source: opendataricostruzione.gssi.it

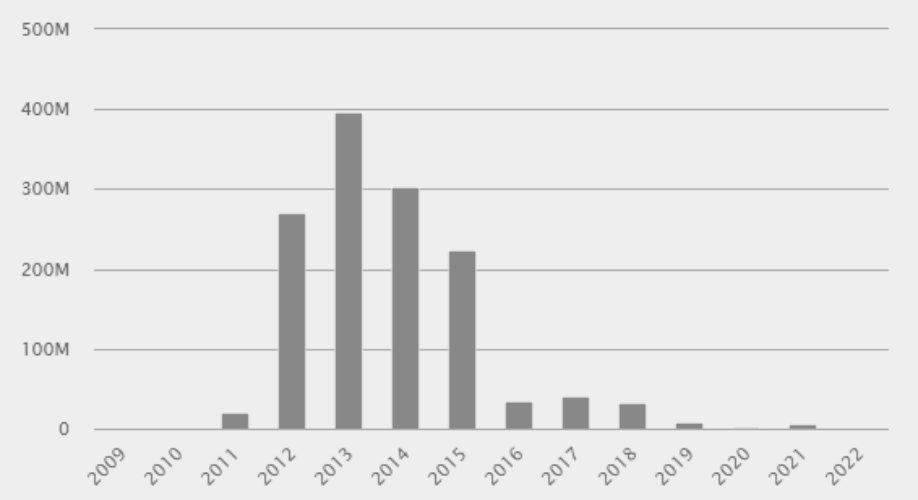

Figure 2. Amount of funds financed by the government for the private reconstruction in million euros. Source: opendataricostruzione.gssi.it

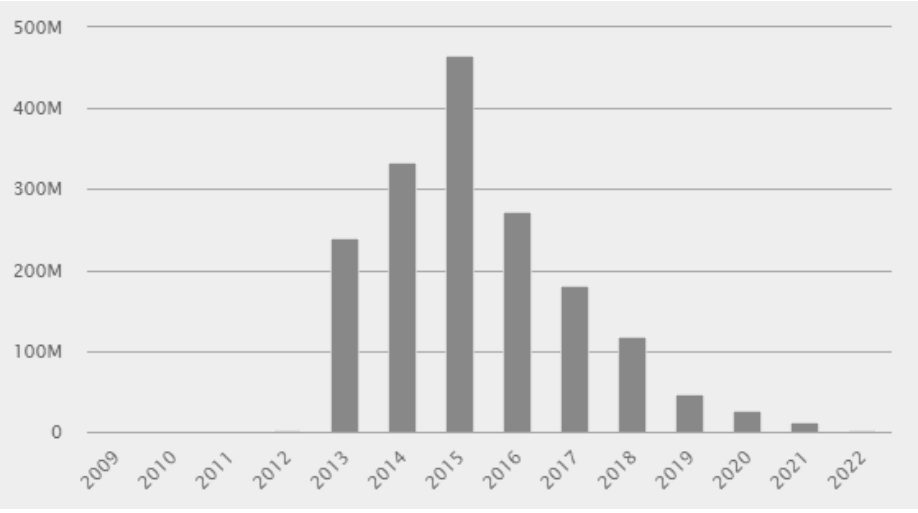

Figure 3. Amount of funds financed by the government deployed for the private reconstruction in million euros. Source: opendataricostruzione.gssi.it

The CASE plan ended up being a clear example of the politicisation of the reconstruction process. The aim for Berlusconi was two-fold: to expand urban development areas to benefit the construction industry (an important business sector for the former Prime Minister) and to be recognised as a politician that did "things better than others" by providing real houses instead of containers or prefabricated units (Özerdem & Rufini, 2013). Nevertheless, the whole process of reconstructing L'Aquila and its satellite towns was characterised by inertia and delay, and these buildings ended up in failure becoming permanent "new towns" around L'Aquila (D. Alexander, 2019). In examining the disaster cycle, Alexander (2019) pointed out that the CASE project represented a vast social, political and architectural experiment, conducted at an enormous cost undermined by corruption and poor decision-making. Besides the high cost of the new settlements, these apartments proved their poor construction quality with the collapse of three balconies in 2014, problems with water infiltration and approximately 200 anti-seismic isolators were judged defective (D. Alexander, 2010, 2013). In this context, many protests against the top-down decisions were organised by L'Aquila's residents in the first part of the stagnant recovery process, and social media played an important role in the organisation of riots (Farinosi & Treré, 2011). On these occasions, the citizens forced the "red zone" and, while putting in place different kinds of protests, took pictures and videos that were shared on several online platforms such as Facebook, Flickr, blogs, and Twitter (Farinosi & Treré, 2014; Micalizzi, 2010). Furthermore, a series of judicial consequences of the quake have captured the public debate in the first part of the recovery process. A notorious case is the so-called "L'Aquila Seven", the controversial trial that in October 2012 sentenced to six years in prison seven members of the National Major Risks Commission (*Commissione Grandi Rischi*), six scientists and one public official for manslaughter, bodily harm and conspiracy in connection with the victims of the earthquake (D. Alexander, 2014; Benessia & De Marchi, 2017; Imperiale & Vanclay, 2019). The entire legal process concluded in November 2015 with the Supreme Court of Cassation decision that recognised as innocent the six scientists and sentenced the government official to two years of jail (Imperiale & Vanclay, 2019). After controversies and delays, the reconstruction process gained momentum. The number of reconstructed buildings for residential and commercial use has increased concretely along the city centre's main roads since 2016 (Contreras et al., 2018). Despite showing a mixture of reconstructed and occupied buildings accompanied by edifices under repair and ruins (mostly public buildings), the centre of L'Aquila started showing healthy signs of reconstruction activity seven years after the earthquake. Together with the above-mentioned problems, several efforts were put in place to reconstruct the social and economic spheres of the city. Since the first community meetings, developing L'Aquila as a city of knowledge has been a guiding principle for local actors (OECD, 2012), and it has been transformed into a pillar of socio-economic reconstruction (OECD, 2013). Since the beginning, a series of specific measures were taken towards the university, the city's leading enterprise (D. Alexander, 2019; Magni et al., 2017), resulting in the fact that the earthquake had no statistically significant effect on first-year enrolment at the University of L'Aquila in the three academic years after the disaster (Cerqua & Di Pietro, 2017). In the longer term, consistently with L'Aquila being a university town, the increase in the enrolments at the University of L'Aquila is a tangible fact related to post-disaster recovery (Contreras et al., 2022). It represents, together with the institution of the Gran Sasso Science Institute (GSSI) and the presence of the National Institute for Nuclear Physics, a shift towards developing a knowledge city. Following another strategic pillar of the OECD (2013) aimed at improving the use of cultural heritage, many efforts have also been made to pursue L'Aquila as a cultural and creative city. Cultural events, in fact, can increase trust, optimism and social cohesion after disasters (Aldrich & Meyer, 2014; Vale & Campanella, 2005). A first example is the construction of the Auditorium del Parco in 2012, a Renzo Piano Building Workshop project. Since 2012, in the old town, there has been an increasing propensity towards the organisation of cultural events (Pasquinelli et al., 2019). In the beginning

were organised small and micro-events. Since 2014, a series of major cultural events such as "Sharper-The European Night of Researchers", the "Mountain Festival", and the "Jazz Festival" (since 2015) have been organised, bringing back to life the historic city centre. Events and festivals have been historically promoted for the socio-economic recovery after disasters for decades (e.g. Gotham, 2007; Richards & Palmer, 2010). Nevertheless, the effect of urban events in such contexts has not been widely addressed in the literature (Pasquinelli et al., 2019).

4. Data, methodology and research design

The data for the analysis are collected from the official Application Programming Interface (API) developer platform provided by Twitter to researchers with specific research objectives. It provides Twitter access in real-time and to historical public data. To process the tweets, the Bidirectional Encoder Representations from Transformers (BERT) has been used, which is a transformer-based machine learning technique for natural language processing (NLP) pre-training developed by Google (Devlin et al., 2019). BERT is designed to pre-train deep bidirectional representations from unlabelled texts by jointly conditioning on both the right and left context in every layer. As a result, the pre-trained BERT model can be fine-tuned with just one additional output layer to create state-of-the-art models for a wide range of assignments without task-specific modifications. As the dataset is in Italian, a version of BERT called UmBERTo has been used for the study. UmBERTo is a RoBERTa architecture-based Language Model trained on large Italian Corpora. The Robustly Optimized BERT Pretraining Approach (RoBERTa) is a development of BERT that improves the training of the original one and leads to better downstream task performance (Y. Liu et al., 2019). More specifically, for this research has been used the FEEL-IT open-source Python package (Bianchi et al., 2021), a RoBERTa-based language trained on large Italian Corpora (UmBERTo) fine-tuned on 2037 tweets marked with an emotion label. FEEL-IT is a novel benchmark corpus of Italian Twitter posts annotated with four basic emotions (anger, fear, joy, sadness) or binary sentiments (positive or negative). As a result, FEEL-IT can infer both sentiments and emotions. FEEL-IT has been tested with MultiEmotions-It (Sprugnoli, 2020), which accounts for both basic and complex emotions in Italian, resulting in an accuracy of 0.73. Together with the classification of sentiments, a keyword extraction per each emotion has been performed (Figure 4). To do so, the pre-processing of words that is typical for this kind of NLP analysis has been necessary. The analysis starts with the tokenization of the tweets, breaking them into words by removing punctuation marks, hashtags, and links. Then the stopwords (those words that are not useful for the analysis) were deleted with the Natural Language Toolkit (NLTK) in Python. After that, words are processed into stems (parts of words responsible for their lexical meaning) to obtain their root form. The study is performed on a dataset of tweets in Italian containing the word *L'Aquila* in a thirteen-year period, from January 1, 2009, to December 31, 2021. Retweets were excluded to avoid duplicates and work just on first-hand feelings. The entire dataset containing the word L'Aquila has 571 443 tweets. To keep the tweets related to the earthquake, the analysis is based on those that contain the stems related to the quake. These are the Italian stems *terremot*, *sism*, *scoss* and *ricost* that translate into earthquake, its synonyms and the word reconstruction in English. The resulting dataset is composed of 53 610 tweets related to the disaster. Of them, 16 868 contain the stem *ricost* (reconstruction). Since the entire dataset could be processed with a unique fine-tuned model, the research was limited to tweets in Italian. As tweets are not georeferenced, limiting to the Italian language facilitated to restrict the analysis of sentiments closer to the local community.

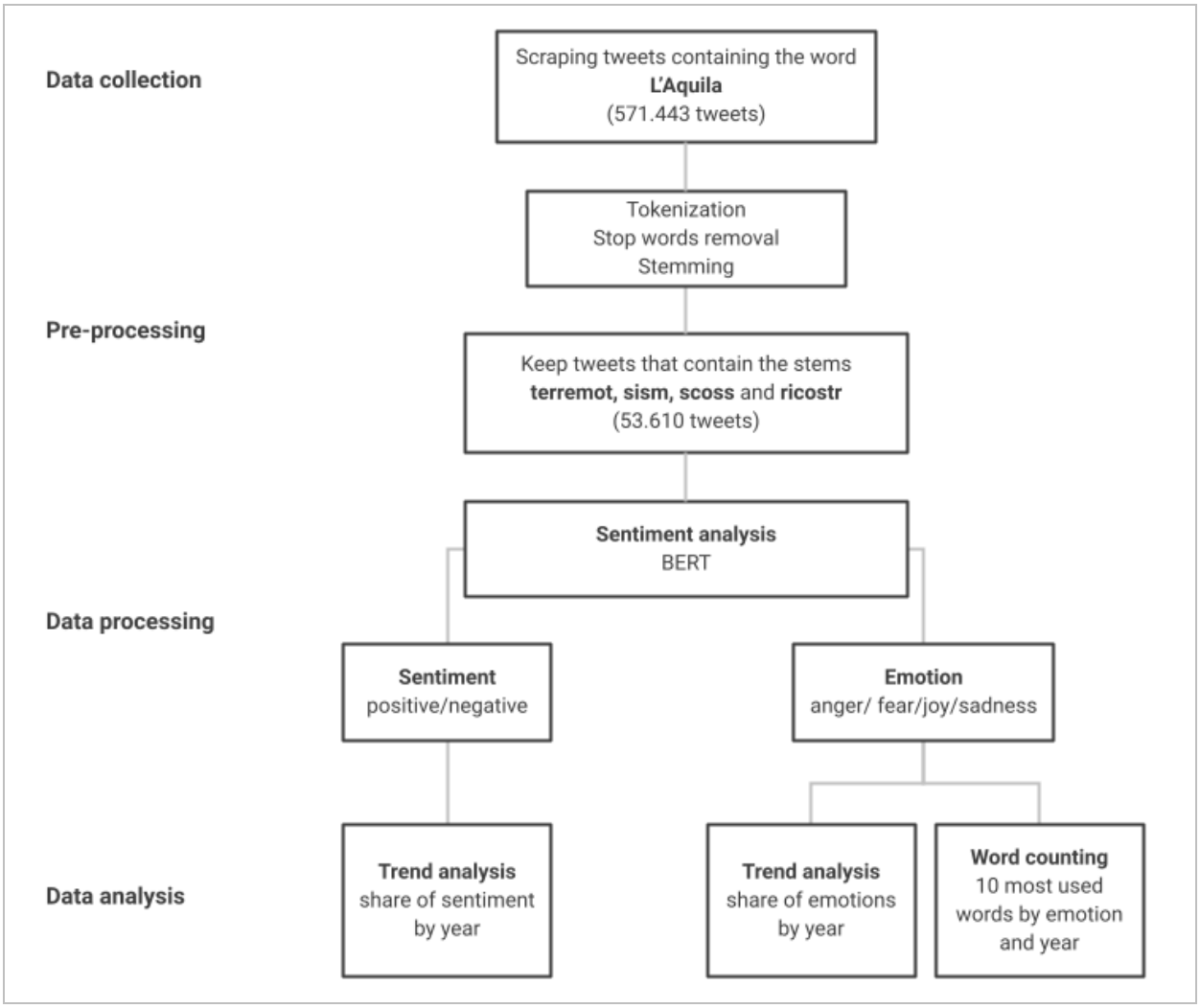

Figure 4. Summary of the steps implemented for the analysis of Twitter data

The debate on the L'Aquila quake grew from 1500 tweets in 2009 to 7500 tweets in 2013 (Figure 5). After the peak of 2013, the interest of the community on Twitter started decreasing with a consistent trend since 2015, apart from two peaks, one in 2016 (the year in which the memories of the tragedy reappeared due to another catastrophic earthquake that hit small towns in Central Italy) and in 2019 for the 10th anniversary of the earthquake. Even if the number of tweets related to the reconstruction follows a similar path, the highest peak was in 2014 (Figure 6).

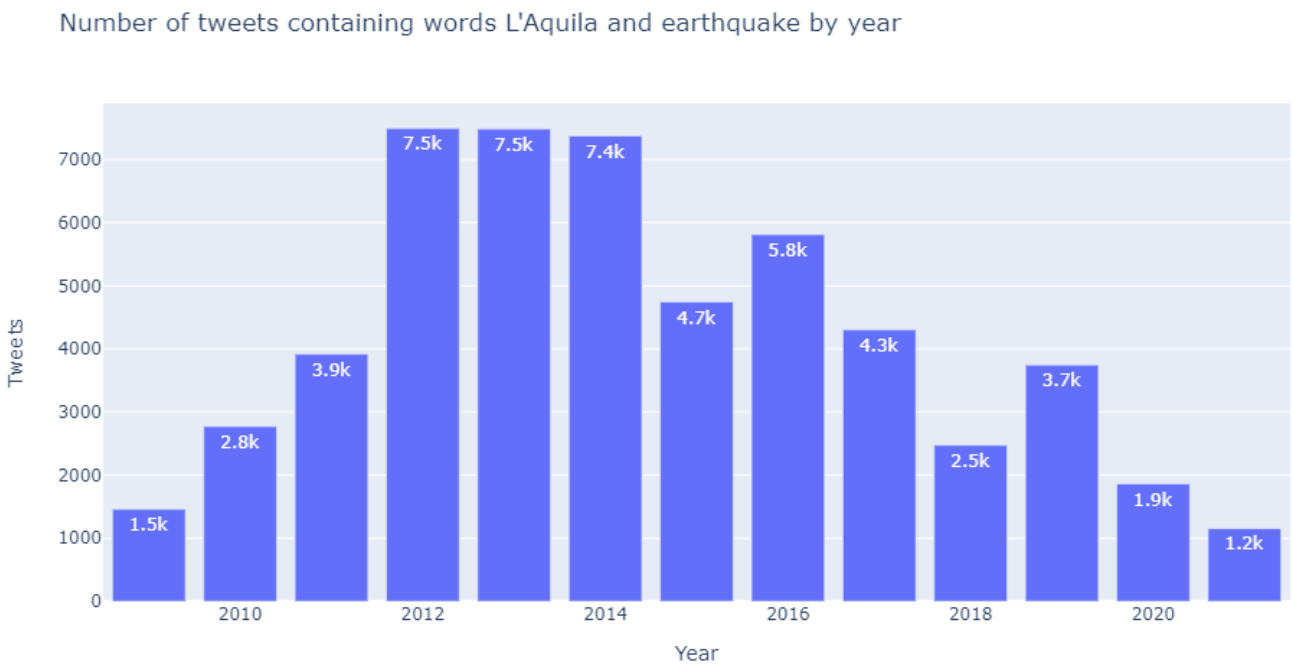

Figure 5. Total tweets containing the words L'Aquila and earthquake (or its synonyms). Own elaboration on Twitter data

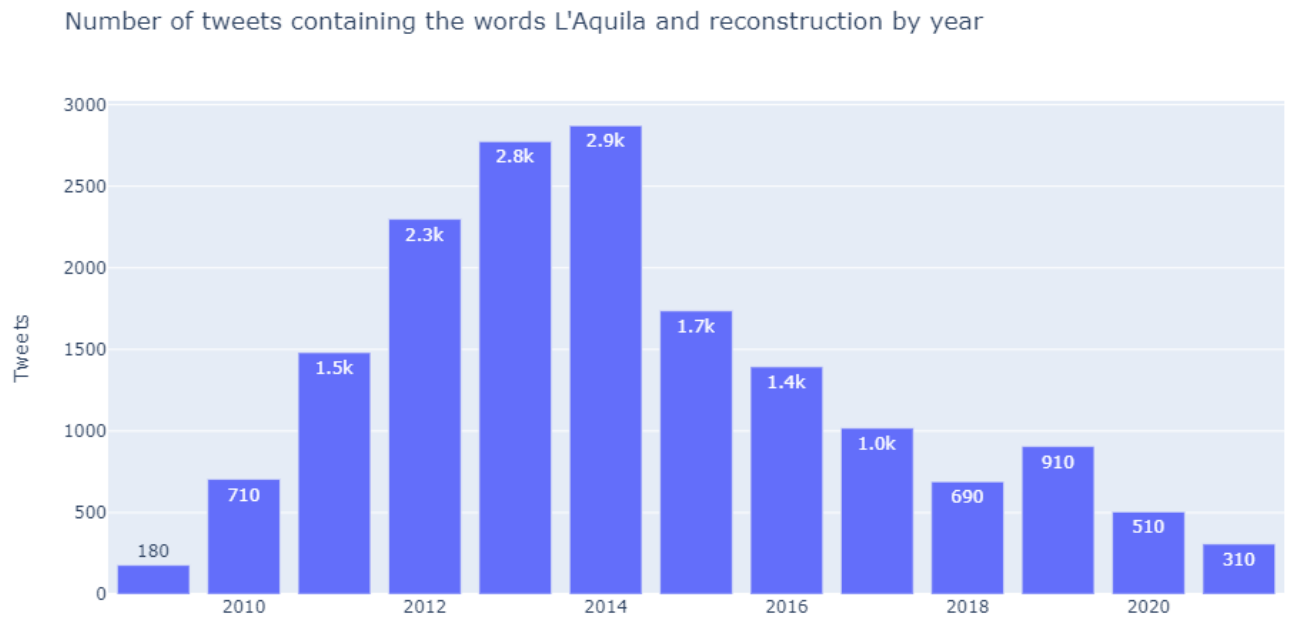

Figure 6. Total tweets containing the words L'Aquila, earthquake (or its synonyms) and the word reconstruction. Own elaboration on Twitter data

5. Results

The results highlight the link between public sentiment and the development of the reconstruction process. As expected, speaking of sentiments, people express a generalised negative sentiment when referring to the earthquake. The bad feelings toward the quake are expressed almost every year by more than 80% of the population (Figure 7). The most remarkable difference can be noticed in 2019, the year of the 10th anniversary, in which a positive sentiment has been expressed almost by 30% of the population. This can be explained by the positive, although sad, memories expressed for commemorating the tragedy and victims. Regarding emotions (Figure 8), the year of the earthquake is characterised mainly by fear and sadness. In the first year, the latter two did not leave much space for anger. Anger started increasing in the following years, reaching its maximum in 2014. One of every two tweets five years after the earthquake expressed anger. The word analysis (Tables 1 and 2 in the appendix) explains the causes behind these sentiments. The first reason is related to the politics in the post-earthquake. Many of the tweets expressing anger refer to Berlusconi (Prime Minister in that period), Verdini, the national coordinator of Berlusconi's party, Cialente, the mayor of L'Aquila at the time of the earthquake, and Renzi, Prime Minister in 2015, the year in which users expressed maximum level of anger for the still stagnant reconstruction of the city. Anger has also been expressed from 2011 to 2015 for the trial against the National Major Risks Commission, which concluded recognising the scientists as innocents in the controversial "L'Aquila Seven" trial. In the text analysis, the word "*case*" (houses in Italian) stands out throughout the entire post-earthquake. The word "*case*" can refer to its original meaning of houses but also to the CASE plan, the new towns created after the quake. In 2009 this word was accompanied both by anger and joy. The fact that in the year of the earthquake, anger is accompanied not only by the word "*case*" but also by the word student suggests that this emotion was expressed towards the collapse of the "*Casa dello Studente*", the student residence destroyed during the quake and in which eight students lost their lives. The joy may derive instead from the CASE project, sponsored through the so-called miracle narrative in the initial part of the reconstruction. However, anger towards the CASE project stands out throughout the rest of the reconstruction. As reflected by the text analysis, this is mainly due to corruption, poor planning, and the long series of issues that emerged over time. Focusing more specifically on the reconstruction (Figure 10), anger appears even more predominant, exceeding 40% of the tweets from 2011 to 2018 and above half from 2013 to 2016. Although referring to the reconstruction fear is a marginal feeling that never exceeds 6%, the content analysis of the tweets offers some interesting insights. In general, fear concerns the difficulties in the management of funds and the progress of the reconstruction. In the early stages of the post-disaster, this sentiment was expressed mainly towards the possible difficulties in managing public funds. In 2020, this sentiment emerged related to the possibility of stops in the reconstruction deriving from the Covid-19 pandemic and the spending capacity of the PNRR (National Recovery and Resilience Plan). Broadening the analysis to the whole dataset concerning L'Aquila and the earthquake, fear is mainly expressed in the year of the earthquake. Over the years, this sentiment decreased, but it reappeared in correlation with the earthquake swarms in 2016 and 2017 in Central Italy. This sentiment is often accompanied by words such as magnitude or seismic, and in 2016-2017 by the words Rieti, Perugia, Ascoli, Teramo, and Amatrice, which refer to the seismic swarm that struck L'Aquila's neighbouring villages. The feeling of sadness is, as expected, together with anger, the most frequent in the tweets since the earthquake. It is generally linked to the memory of the victims and the tragedy, especially with the word April, which corresponds with the various anniversaries.

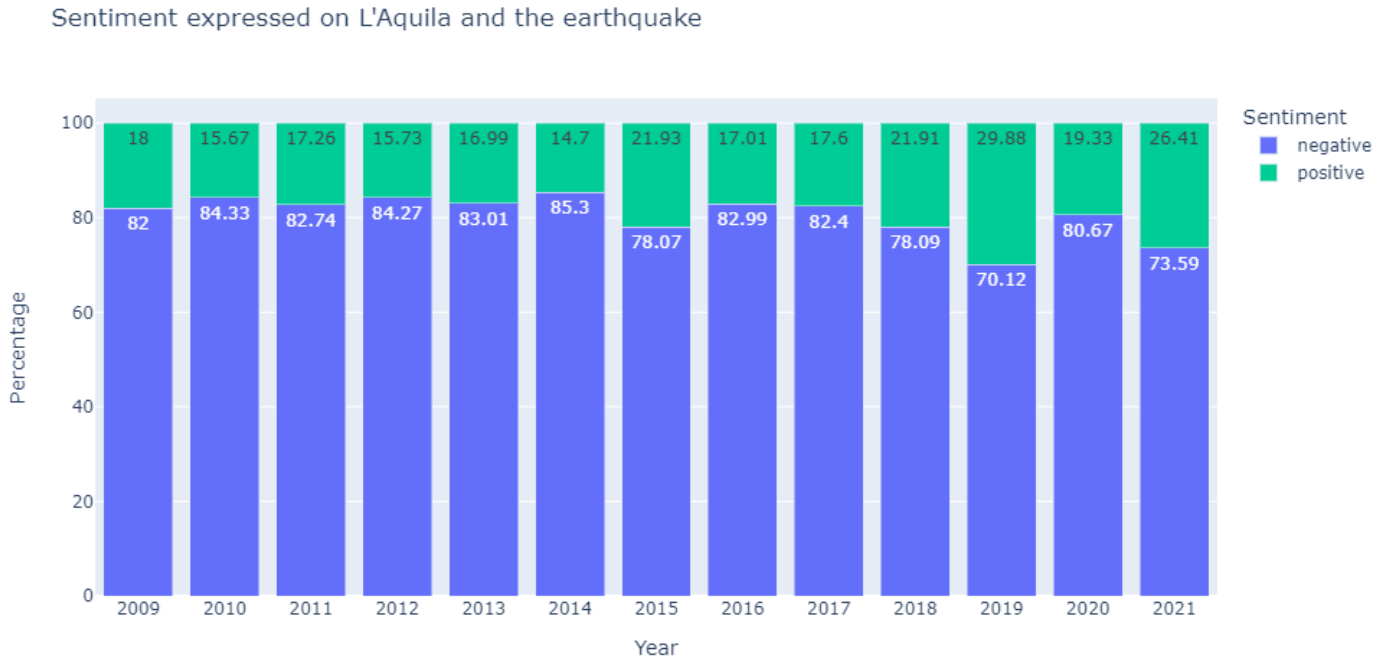

Figure 7. Results of the sentiment analysis on tweets containing the words L'Aquila and earthquake (or its synonyms). Own calculation on Twitter data

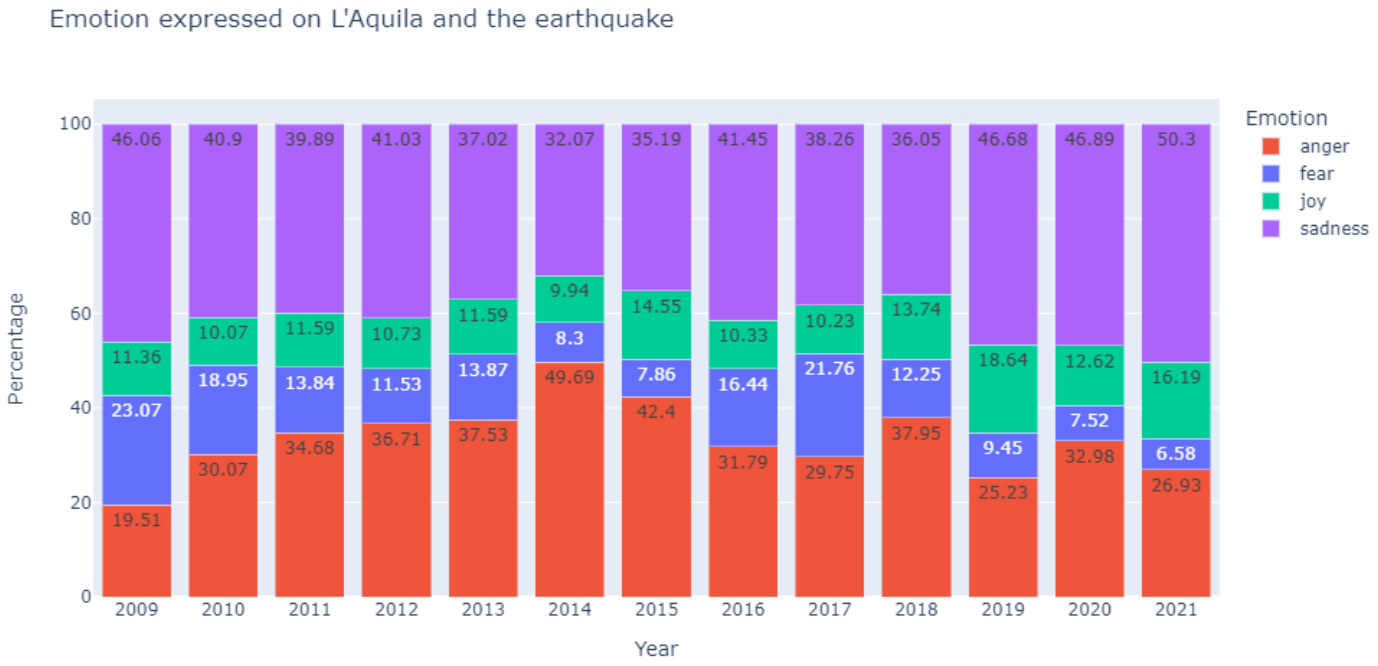

Figure 8. Results of the emotion analysis on tweets containing the words L'Aquila and earthquake (or its synonyms). Own calculation on Twitter data

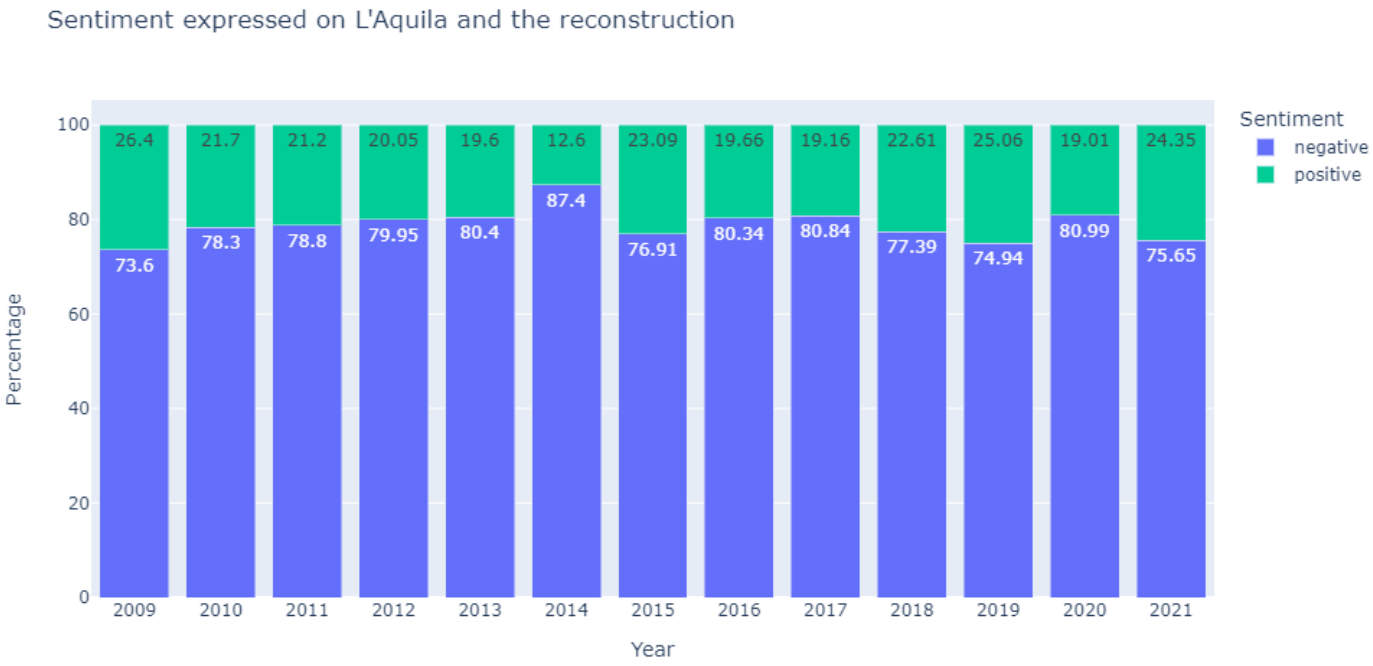

Figure 9. Results of the sentiment analysis on tweets containing the words L'Aquila, earthquake (or its synonyms) and reconstruction. Own calculation on Twitter data

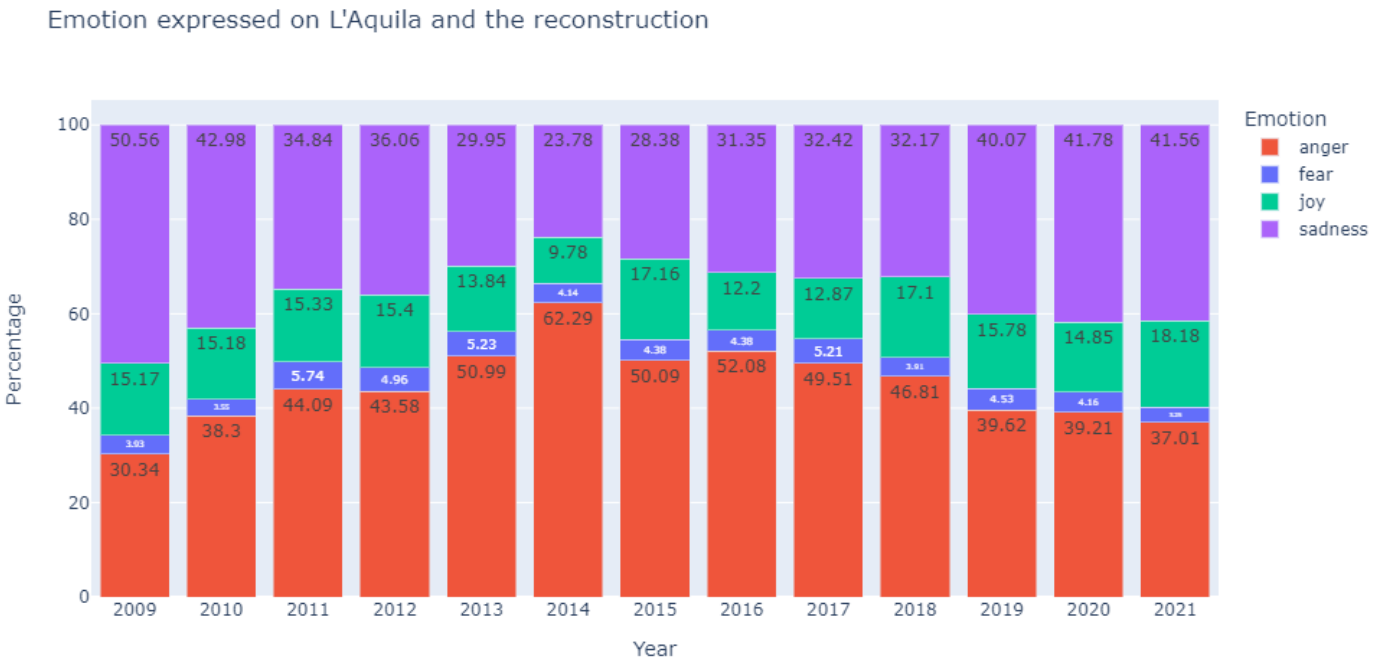

Figure 10. Results of the emotion analysis on tweets containing the words L'Aquila, earthquake (or its synonyms) and reconstruction. Own calculation on Twitter data

Joy is the most controversial emotion to analyse in relation to this tragedy. It is, as expected, the least frequent in the tweets that refer to the earthquake. In general, approximately one tweet in ten expresses joy if no specific reference is made to the reconstruction. There was a slightly higher presence of this sentiment in 2015 (14.55%), 2019 (18.64%) and 2021 (16.19%). In 2015 there was a return to the city of some events, such as the Jazz Festival, which, as demonstrated by the text analysis, certainly played a role in expressing this sentiment. The contribution to the positive tweets derived in 2019 from the celebrations for the tenth anniversary and in 2021 from the inauguration of the new park dedicated to the memory of the victims in the presence of Prime Minister Mario Draghi. Concerning the reconstruction, joy is more common than in the whole dataset. Joyful tweets about the reconstruction are on average around 15%. Compared to the first phase, positive tweets experienced a decline in 2013 and 2014, the years in which anger dominated the public debate. Since 2015, the feeling of joy in the reconstruction context has often been accompanied by cultural events and a vision of the future. Among the most frequent words, there are jazz, events, exhibitions, and photographs, and in 2020 the positive debate focuses on words such as model and marvellous city.

6. Conclusions

This study provides a medium-long-term framework that reflects the link between the development of the reconstruction works and the sentiment expressed by the population. The analysis of a long period of time permits finding different dynamics that are difficult, if not impossible, to obtain with spot studies. Moreover, this approach could be the basis for more granular analyses of these events. As acknowledged in the literature, this analysis shows some peculiarities of post-disaster management in Italy, against which the population manifested clear feelings during the reconstruction process. A top-down approach, excessive politicisation, and the occurrence of various occasions of corruption, trials and criminal activities are confirmed to be primary causes of public anger. Time is another crucial aspect of post-disaster management. The tension between speed and deliberation has been widely discussed in the literature (R. Olshansky et al., 2006; R. B. Olshansky et al., 2012; Rubin et al., 1985). In the case of L'Aquila, the hope for reconstruction and the social cohesion started decreasing two years after the earthquake. Sadness and fear of the immediate post-disaster are replaced with a constant increase in public anger in the first years of stagnation of the reconstruction process. In fact, anger peaked between 2012 and 2015, when, despite removing the state of emergency, the reconstruction works did not begin, exacerbating the sense of abandonment. The significant allocation of funds in 2011 was not enough to mitigate this resentment. The analysis demonstrated that anger has started decreasing only since the reconstruction works have effectively begun. Anger expressed on social media is also the result of a general controversial communication pre, during and after the earthquake, for example, concerning the judicial consequences that followed the quake. Policy-wise, this study confirms the role of investments in cultural events as a tangible beneficial outcome on the population's sentiment. Coherently with the literature on other cases, such as New Orleans and Kobe (Gotham, 2007; Richards & Palmer, 2010), events such as festivals and exhibitions effectively enhance trust and social cohesion besides producing economic benefits. In general, fear is caused by the concerns associated with the earthquake. This sentiment weakens as time passes, returning when new seismic episodes occur, even in other parts of Italy. Fear is also expressed in terms of a lack of confidence in the management of reconstruction resources. In the early stages, many concerns were expressed towards the expected difficulties in managing public funds. In 2020, the fear rose towards the possibility of stops in the reconstruction deriving from the Covid-19 pandemic and, in 2021, in relation to the spending capacity of the National Recovery and Resilience Plan. This suggests that the effects of mismanagement of a single crisis can have lasting effects due to the perduring distrust in post-shock management. Beyond the specific case, this paper highlights the

suitability of Artificial Intelligence in analysing community sentiment over the long term. Sentiment analysis in times of crisis, in fact, helps to understand and interpret the possible causes of distrust in the socio-economic reconstruction of a community, and it is crucial in providing a set of feelings that can reappear in successive and unrelated crises.

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Appendix

Table 1. Ten most common words (stems) by emotion in the complete dataset.

year	Emotion	Most 10 common words
2009	anger	font, cas, berluscon, indag, protest, croll, procur, rom, apr, student
	fear	magnitud, nuov, sismic, font, paur, provinc, due, news, nott, stat
	joy	prim, font, cas, news, giorn, nuov, citt, dop, agenz, vis
	sadness	font, news, nuov, dop, ancor, prim, mes, vis, magnitud, rom
2010	anger	indag, rom, dop, protest, govern, berluscon, fus, verdin, procur, chiod
	fear	sismic, riet, stat, magnitud, magnitudin, provinc, sciam, local, ore, registr
	joy	dop, vide, ital, prim, anno, firm, ricord, oggi, comun, citt
	sadness	dop, anno, citt, ricord, nuov, mes, prim, ancor, cas, stat
2011	anger	indag, dop, grand, fond, arrest, giudiz, truff, risc, comun, chiod
	fear	sismic, magnitud, risc, paur, nuov, stat, grand, commission, process, due
	joy	anni, dop, progett, googl, salon, oggi, citt, nuov, vide, prim
	sadness	anni, dop, due, ricord, vittim, cas, citt, stat, cronac, ancor
2012	anger	anni, risc, grand, condann, cas, arrest, commission, dop, stat, sentenz
	fear	sismic, risc, magnitud, paur, grand, stat, commission, provinc, anni, torn
	joy	anni, tre, dop, citt, nuov, prim, grand, oggi, present, cialent
	sadness	anni, dop, tre, ancor, citt, ricord, vittim, stat, ora, new
2013	anger	cas, condann, anni, sold, govern, dop, berluscon, consult, stat, sentenz
	fear	sismic, magnitud, paur, teram, nott, risc, cas, impreved, dop, torn
	joy	anni, dop, citt, oggi, fiaccol, salon, quattr, ricord, april, vide
	sadness	anni, dop, quattr, ancor, citt, cas, ricord, vittim, stat, april
2014	anger	arrest, tangent, grand, risc, cas, post, cialent, sindac, assolt, commission
	fear	sismic, risc, magnitud, grand, cas, assolt, paur, via, anni, commission
	joy	anni, dop, citt, april, buon, prim, cinqu, ricord, fiaccol, salon
	sadness	anni, dop, ricord, vittim, cas, cinqu, ancor, citt, fiaccol, balcon
2015	anger	arrest, imprenditor, sold, dop, post, renz, grand, anni, cas, commission
	fear	sismic, provinc, risc, temp, real, nuov, magnitud, grand, oggi, cassazion
	joy	anni, dop, ricord, salon, fiaccol, citt, jazz, memor, buon, vittim
	sadness	dop, anni, fiaccol, vittim, ricord, ancor, citt, april, stat, prim
2016	anger	cas, dop, arrest, sold, ancor, ital, anni, amatric, stat, sol
	fear	sismic, provinc, riet, perug, ascol, teram, magnitud, paur, amatric, ital
	joy	anni, dop, citt, ricord, sett, fiaccol, prim, amatric, centr, vittim
	sadness	anni, dop, cas, ital, amatric, ancor, ricord, croll, citt, vittim
2017	anger	appalt, dop, arrest, cas, post, rid, anni, amatric, govern, imprenditor
	fear	magnitud, sismic, provinc, riet, epicentr, ital, paur, scuol, centr, nott
	joy	anni, citt, ital, fiaccol, dop, nuov, amatric, raccont, centr, giorn
	sadness	anni, dop, scuol, ital, ancor, amatric, magnitud, stat, vittim, cas
2018	anger	tass, dop, govern, stat, anni, fatt, restitu, ancor, cos, amatric
	fear	magnitud, paur, nott, sismic, ital, provinc, ingv, km, risc, teram
	joy	dop, anni, ital, jazz, lavor, raccont, citt, ricord, donn, giorn
	sadness	anni, dop, ricord, vittim, april, ancor, citt, centr, ital, cas
2019	anger	anni, govern, dop, stat, ancor, fatt, cos, sol, cas, amatric
	fear	magnitud, paur, provinc, sent, sismic, anni, dann, stat, epicentr, rom
	joy	anni, dop, citt, diec, april, ricord, decennal, raccont, stat, grand
	sadness	anni, dop, april, citt, ricord, diec, stat, ancor, vittim, colp
2020	anger	dop, fatt, stat, ancor, anni, govern, cas, sol, rid, cos
	fear	magnitud, paur, provinc, ricord, april, cas, stat, mes, cos, ital
	joy	ricord, anni, dop, citt, luc, sempr, qui, april, abbracc, collemagg
	sadness	anni, ricord, dop, stat, april, vittim, ancor, centr, cas, cos
2021	anger	dop, anni, stat, ricord, cas, sold, rid, ancor, vittim, fatt
	fear	dop, cas, ital, sub, sismic, paur, magnitud, risc, legg, effett
	joy	dop, vittim, parc, memor, inaugur, april, anni, luc, ricord, drag
	sadness	ricord, anni, vittim, dop, april, citt, stat, ancor, dimentic, cas

Table 2. Ten most common words (stems) by emotion in the subsample of the dataset referred to the reconstruction.

year	Emotion	Most 10 common words
2009	anger	infiltr, cas, può, font, edif, dop, ital, ricover, mafios,maron, vigil
	fear	oggi, consigl, ministr, miliard,prossim, miliard,grass, divent, far, west, font, apr
	joy	mod, canades, obam, event, music, danz, cas, news, premier, rinasc
	sadness	temp, prim, post, font, lospedal, dop, uil, asca, verr, dev
2010	anger	commissar, cialent, dimett, vic, indag, chiod, ital, rom, sold, fatt
	fear	lavor, problem, macer, va, affront, minister, europe, scadenz, commissar, chiod
	joy	ital, firm, comun, chiam, vide, sindac, condivision, dop, propost, legg
	sadness	commissar, nuov, dop, protezion, cas, chiod, civil, progett, centr, deleg
2011	anger	indag, questur, stamp, sold, chiod, agenz, arrest, cialent, fatt, fin
	fear	doman, indag, legg, progett, nuov, consigl, risc, novembr, ndranghet, popol
	joy	salon, googl, progett, citt, firm, nuov, senz, sed, stat, prim
	sadness	anni, dop, due, citt, centr, commissar, chiod, pian, cas, stat
2012	anger	arrest, new, town, imprenditor, dop, sold, stat, barc, anni, centr
	fear	barc, band, post, comun, concors, doman, pubblic, decret, lavor, cantier
	joy	salon, cialent, citt, pian, present, chiod, progett, anni, oggi, barc
	sadness	dop, anni, new, ora, town, napolit, citt, pian, tre, barc
2013	anger	govern, consult, sold, berluscon, miliard, tav, fond, anni, serv, cialent
	fear	impres, govern, risc, miliard, allarm, via, centr, fond, present, milion
	joy	salon, terz, progett, citt, convegn, oggi, impegn, giorn, pian, grand
	sadness	anni, dop, ancor, citt, quattr, centr, grass, question, serv, miliard
2014	anger	arrest, tangent, post, indag, cas, perquisizion, casales, sold, cinqu, sindac
	fear	arrest, govern, risc, pezzopan, cantier, casales, sett, bufer, via, legg
	joy	salon, cas, nuov, citt, buon, april, dop, event, punt, ben
	sadness	cas, anni, dop, ancor, milion, preg, stat, francesc, balcon, citt
2015	anger	arrest, imprenditor, ex, impegn, sfrutt, manodoper, lavor, sold, tangent, indag
	fear	risc, ancor, lavor, sed, convegn, immobil, nuov, renz, oggi, inps
	joy	salon, jazz, torn, immobil, cas, present, ital, maraton, citt, fot
	sadness	anni, dop, ancor, paol, stat, jazz, centr, miliard, molt, spend
2016	anger	arrest, sold, ancor, sequestr, sett, cas, eur, anni, lavor, sol
	fear	met, commission, cantier, amatric, lavor, fond, inchiest, comm, pubblic, elenc
	joy	event, citt, cant, lavor, mostr, apre, fotograf, officin, giorn, torn
	sadness	ancor, anni, dop, scuol, stat, progett, citt, cas, milion, lavor
2017	anger	appalt, arrest, anni, post, dop, scuol, pubblic, imprenditor, mil, ancor
	fear	ombre, scuol, post, camp, risc, nuov, monitor, ancor, decis, pd
	joy	citt, futur, parl, giorn, dop, anni, gran, progett, nuov, paol
	sadness	anni, dop, scuol, luc, stat, ancor, ombre, pubblic, lavor, oggi
2018	anger	anni, stat, govern, dop, lavor, ancor, amatric, fatt, scuol, cas
	fear	sicurezz, convegn, milion, prevenzion, giorn, elezion, polit, pubblic, risc, ediliz
	joy	lavor, citt, dop, raccont, anni, donn, convegn, incontr, tour, parl
	sadness	anni, dop, ancor, stat, centr, lavor, citt, scuol, esim, pubblic
2019	anger	anni, stat, dop, govern, ancor, cos, sol, berluscon, fatt, cas
	fear	caserm, sicurezz, pratic, convegn, zon, vvf, comun, marz, cantier, ance
	joy	stat, citt, sfid, anni, dop, grand, nuov, italian, prim, graz
	sadness	anni, dop, ancor, stat, citt, scuol, diec, centr, lavor, cas
2020	anger	anni, ancor, dop, govern, sol, stat, priorit, fatt, sold, amatric
	fear	prim, cantier, stop, coronavirus, scuol, ance, progett, lesion, asl, infrastruttur
	joy	rest, priorit, impegn, ben, crat, grand, sempr, modell, meravigl, citt
	sadness	anni, dop, ancor, rest, stat, mattarell, centr, priorit, april, impegn
2021	anger	polit, anni, lavor, stat, miliard, acceler, ancor, sold, pens, amatric
	fear	protocoll, legal, garant, sicurezz, acceler, miliard, ansa, pnrr,drag, crateresism, milion
	joy	memor, parc, inaugur, drag, nuov, acceler, dop, cultur, oggi, insiem
	sadness	ancor, anni, dop, stat, citt, acceler, ricord, vittim, post, oggi