Online Firestorms in Twitter

Exploring Risks to Large Infrastructure Projects from Digital Communities

Williams, Nigel; Ninan, Johan; Kwak, Young Hoon

DOI
10.1109/TEM.2024.3432712

Publication date
2024

Document Version
Final published version

Published in
IEEE Transactions on Engineering Management

Online Firestorms in Twitter: Exploring Risks to Large Infrastructure Projects From Digital Communities

Nigel Williams, Johan Ninan, and Young Hoon Kwak

***Abstract*—Large infrastructure projects can often cause disruptions with those outside the immediate project area experiencing negative effects. Twitter (now X) and its ensuing online firestorms are ways these project community make themselves heard and influence the project and its societal outcome. Using the case study of the High Speed Two large infrastructure project in the U.K., this article retrieves over 950 000 tweets regarding the project from 2013 to 2019, and using dynamic topic modeling classifies 10 instances of online firestorms over this period covering environmental impacts, legislative dynamics, budget of the project, performance of the project, etc. We then theorize how online firestorms are practiced in large infrastructure projects, discussing the different topics considered in them, their sociomateriality, their difficulty in sustaining, how they can be recreated with similar new issues, how it is used as a persuasive tool, how they can change the project, and how they can be used for risk management. The findings help project managers by enabling them to understand social risks in projects and take proactive steps in addressing them.**

***Index Terms*—External stakeholder management, large infrastructure projects, latent Dirichlet allocation (LDA), online firestorms, social media, Twitter.**

I. Introduction

EXTERNAL stakeholders are defined by Mitchell et al. [1] as those stakeholders who are not directly involved in the economic transactions of a firm. Since large infrastructure projects cause disturbances in the local environment, society, and politics, the project community among the external stakeholders often shoulder the majority of the negative consequences stemming from the project [2]. They voice their worries regarding the mandatory acquisition of homes and parks, the upheaval during the project's construction phase, as well as its continuous effects on their way of life, health, and overall well-being, and oppose the completion of construction activities [3]. This resistance can take the form of protests and, at times, politically driven public actions [4] which can ultimately lead to the cancellation of the projects, raising it as an important risk in large infrastructure projects.

Effectively managing these project community concerns becomes paramount because the success of a project hinges on how the affected communities perceive its outcomes and impact [5]. Traditionally, there has been less exploration into broader indicators of project success, such as customer satisfaction and loyalty, with more focus on specific efficiency metrics like time, cost, and quality [6]. The project community take on the role of organizational legitimacy evaluators making judgments on whether a given project organization has the right to perform project activities and use resources in their proximity [7]. Researchers have called for projects to extend project design and other consultations beyond the politically active to community members as the intensity of public voices against major infrastructure projects is increasing and explore how these project community make themselves heard and influence the project and its societal outcome [8], [9].

Project management literature discusses different avenues through which project community interact with large infrastructure projects, such as in community engagement, workshopping, training sessions, physical demonstrations, social media, and other digital avenues [10], [11]. Particularly, social media plays a pivotal role by uniting, empowering, and mobilizing stakeholders to form a cohesive collective identity either in support of or against the project [12], such as through online firestorms. Basak et al. [13] defines an online firestorm as the "sudden discharge of large quantities of messages containing negative word-of-mouth (WOM) and complaint behavior." At the same time, online firestorms in Twitter (now X) presents a new risk assessment and management approach that enables capturing the complex and dynamic interactions between projects and people in its surroundings [14]. However, there is a gap in literature on the different types of online firestorms in large infrastructure projects and their characteristics regarding intensity, duration, or tactics used. This article contributes to understanding the interaction between the project community and projects by examining the implications of online firestorms on a project. Specifically, 1) what are the different online firestorms prevalent in a large infrastructure project? and 2) what are the characteristics of online firestorms in them? Thus, this article argues that while

Manuscript received 6 January 2024; revised 24 May 2024 and 12 July 2024; accepted 16 July 2024. Date of publication 23 July 2024; date of current version 8 August 2024. Review of this article was arranged by Department Editor I. Dikmen. *(Corresponding author: Young Hoon Kwak.)*

Nigel Williams is with the Faculty of Business and Law, University of Portsmouth, PO1 2UP Portsmouth, U.K. (e-mail: nigel.williams@port.ac.uk).

Johan Ninan is with the Faculty of Civil Engineering and Geosciences, TU Delft, 2628 Delft, The Netherlands (e-mail: j.ninan@tudelft.nl).

Young Hoon Kwak is with the Department of Decision Sciences, The George Washington University School of Business, Washington, DC 20052 USA (e-mail: kwak@gwu.edu).

Digital Object Identifier 10.1109/TEM.2024.3432712

the project's decision-makers may not hear a single social media post or Tweet, an online firestorm is a way for communities to make their voices heard when large infrastructure projects become transgressive for local laws, implement mandatory land acquisitions, or disrupt communities.

II. Literature Review

A. Project Community in Large Infrastructure Projects

Individuals or groups close to projects in terms of physical distance, and not party to the project contract, can be defined as project community [2]. Some large infrastructure projects are perceived as tone-deaf to local demands, ignoring the disruption that can affect communities [4]. As a result, they have often faced opposition from community groups, which is increasingly being redefined from simply geography to incorporate externally identifiable groups with shared interests and conditions, including geographical, interest, and virtual [15]. Community-derived identity can positively reinforce trust and loyalty to the group [16]. Community members may therefore adopt symbols, behaviors, and practices consistent with these external representations of identity [17]. Community identities may also be interconnected with other roles and shift over the project's development, resulting in unpredictable outcomes [18]. This may increase the complexity faced by project organizations as it increases the number of stakeholders along with the diversity of possible demands on the project.

Further, community members recruited via media may exhibit extreme versions of community identity [19]. Rove [20] noted that these members may not have moderating relationships as in the case of physical outreach and may seek to demonstrate loyalty via conflict. Recruitment via media can use negative emotional appeals, such as fear and loss, enabling the development of groups whose purpose could be disruption rather than opposition or resolution of public issues. Therefore, members of these groups may be vociferous in their opposition to projects as they have little exposure to differing opinions from trusted sources that may moderate their stance [8].

In addition, modern communication networks play an active role in project protests where narratives and counternarratives are crafted, deployed, and evaluated in near real-time with automated tools [21]. These environments enable automated identification of potential respondents, rapid experimentation, and evaluation of differing approaches [22]. Digital communication facilitates the increased use of microtargeting to motivate existing community members to perform additional actions, such as letter-writing campaigns or recruit others to oppose projects [23].

Project community in megaprojects, to provide visibility for content or opinions, can organize in central or decentralized information environments. In centralized information environments, information is provided through a formal process of sourcing, reviewing, and distributing content to an audience of specific customers [24]. These sources can include traditional media, industry associations, and governments. In decentralized systems, such as social media, formal methods do not exist, and activity such as retweeting and sharing is required to ensure that content is visible.

B. Social Media Use by Community

Social media has revolutionized information dissemination and consumption, as it offers several advantages over traditional media, including multiple-way, real-time communication, reduced coordination costs, and nonhierarchical interaction [25]. The ubiquity of mobile social media platforms has empowered individuals to actively participate in public discourse, enabling individuals to connect and engage with larger communities than ever before [26].

The emotional echochamber effect of social media further amplifies the reach of messages, as emotions can be amplified through interactions [27], encouraging participation in collective actions, such as physical protests, sustaining conflict with well-resourced organizations [28]. Communities can now link their professional, personal, and geographic identities to virtual platforms [29], leading to hybrid activism strategies combining online and offline actions sequentially, leveraging public attention generated online to embed change offline [30].

Social media's disruptive potential is evident in its ability to trigger crises, destabilize existing arrangements, and challenge the legitimacy of organizations and institutions [31]. Social media played a pivotal role in the Arab Spring as noted by Comunello and Anzera [32], destabilizing existing institutional arrangements and fueling protests and activism by empowering individuals to challenge influential organizations and institutions. While social media, such as Twitter, has become an indispensable tool for organizations and communities, its potential for disruption and conflict underscores the need for projects to manage their online presence and engage with communities constructively. By understanding the dynamics of Twitter and its impact on organization–community interactions, organizations can effectively navigate this complex landscape and foster positive relationships with the communities they serve.

C. Online Firestorms

An online firestorm according to Pfeffer et al. [33] refers to the abrupt surge of numerous messages filled with negative WOM and complaints targeting a person, company, or group across social media networks. Electronic negative WOM stems from incidents, such as service failures, product recalls, issues with e-commerce site usability, product shortages, controversial brand campaigns, and unsatisfactory customer service interactions [34]. Effective management of these eWOMs can reduce the damage to the brand, organization, and top management reputation [35].

Pfeffer et al. [33] highlighted several characteristics of online firestorms that distinguish them from other WOMs, such as rumors, including their rapid and extensive communication, binary choices, clustering within networks, unrestricted flow of information, lack of diversity, cross-media dynamics, and network-driven decision processes. Moreover, individuals can contribute to an online firestorm not just by posting messages but also by engaging with its content through actions like liking or

sharing, thereby amplifying its virality. An online firestorm can be triggered by various factors, including controversial news, public figures' actions or statements, viral content, or social movements by project community.

Online firestorms can represent the darker side of social media as it has the potential to significantly negatively impact brands [36]; however, they can be an effective way for communities to draw attention to project issues that might be overlooked. While social media gives voice to the underrepresented stakeholders, the viral nature of online firestorms ensures that the voices are heard. The collective aspect of crowd-based outrage can be considered a core element of online firestorms, as the community can establish a collective identity and a shared sense of efficacy in raising awareness, organizing, and advocating for desired social changes [37]. Additionally, Jackson and Foucault Welles [38] note online firestorms facilitate the democratization of the public sphere through the collective hijacking and subsequent virality of hashtags. However, the mere presence of a firestorm does not ensure sustained or substantive engagement from the state, mainstream institutions, or even the majority of the public themselves [39]. For handling firestorms, Hauser et al. [40] advocate resolving the conflict effectively through a combination of cooperation with credible aggressors and assertiveness with less credible actors. Thus, along with the issues that raise firestorms in large infrastructure projects, their characteristics specific to these projects have to be studied for a new risk assessment and management approach that enables capturing the complex and dynamic interactions between projects and people in its surroundings.

III. Methodology

Case studies offer rich insights for constructing theories, in this article for conceptualizing how online firestorms exist in the context of project practice. Single case studies aim to deeply explore phenomena within a specific context, preserving the holistic and significant features of real-life events [41]. These are well-suited for initial investigations, such as ours, where the focus is on developing understanding and exploring the scope for future article. Despite focusing on a sole case, Ragin and Becker [42] note that such studies encompass multiple instances within it, supplying ample data for theorization serving as collections of mini-cases. Recognizing the challenge of generalizing from a single case study, our aim is to propose a robust theoretical framework which enables the interpretation of single case studies to draw potential connections to broader contexts. In this article, the chosen single case is the U.K.'s High Speed Two (HS2) rail large infrastructure project.

The HS2 project unfolds across multiple phases, aiming to link London, Birmingham, Manchester, and Leeds through a 345-mile high-speed railway network. This ambitious endeavor seeks to significantly reduce travel time between these U.K. cities, effectively bringing them closer together. The initial phase focuses on establishing a 140-mile high-speed line connecting London and Birmingham, slashing travel time between these cities to just 45 min at a cost of £30 billion. Proposed in 2009, the project is slated for operational readiness by 2026. It is the successor of the 108-km long High Speed 1 Channel Tunnel Rail link between London and the Channel Tunnel and is a solely public undertaking. The project involved acquiring private properties for the high-speed track, environmental damage to protected areas, and also came at a huge cost to the exchequer, all of which resulted in the negative reaction from the public. We chose the HS2 megaproject in the U.K. based on a multifaceted approach by considering the disruptive impact, active stakeholders, critical case nature, and data availability. First, as a large infrastructure project, HS2 inherently triggers environmental, social, and political disruptions within its local surroundings. Second, it faces robust opposition from various protester groups, indicating strong project community involvement. Third, HS2 was considered as a critical case because of the changes in project due to community movements. Finally, extensive discussions about the project abound on Twitter, making it a valuable case study for examining online firestorms due to the wealth of available data. Hence, the HS2 project stands as a critical case due to its disruptive impact, active project community, and the abundance of Twitter data facilitating the study of online firestorms.

Twitter and similar social media platforms can be used to study discourses over the project lifecycle, as Zhou et al. [43], who used a public opinion analysis of the Hong Kong–Zhuhai–Macao Bridge in China. While researchers have used computational analysis of media text to examine stakeholder positions [44], Twitter (now X) is a real-time medium that requires an analytical approach that explicitly incorporates activities over time. We used dynamic topic modeling for analyzing data from the HS2 project because it offers several advantages. It allows for extracting meaningful topics from large text corpora and provides insights into how they evolve. This capability is particularly useful when analyzing data from social media platforms like Twitter (now X), where public sentiment and discussion topics can shift rapidly in response to current events [45]. Twitter users can be younger, have a higher level of formal educational attainment, and can be higher income than others in a given region [46]. Since Twitter data are observational, it is not possible to control the demographics of respondents, which suggests that attempts at causal claims by researchers can be limited [47]. For academic research seeking to examine high volume discussions (for example, the Olympics or large-scale crises), data collection may be incomplete, limiting the representativeness of the research [48].

The research methodology involved six steps, as detailed in Table I.

A. Data Collection and Preprocessing

The data were collected using Communalyic (https://communalytic.org/), which provided access to the Twitter Academic API (https://developer.twitter.com/en/use-cases/do-research/academic-research). This approach has previously been used by Alperstein [49] for understanding online social movements. The hashtag #HS2 and the search terms "High Speed 2" and "HS2" were used to identify tweets. Microsoft Excel was used to remove duplicate tweets, which resulted in

TABLE I
OVERVIEW OF THE SIX STAGES IN OUR RESEARCH METHODOLOGY

Stage	Tools	Output
Tweet collection and preprocessing	Communalyic excel	950 000 tweets from 2013 to 2019
Topic identification	Python (Gensim package)	Document-topic distribution
Topic over time	Python (Seaborn Library)	Plot of topics over time
Identify firestorms from tweeting rates	Excel (threshold of 10 000 per day)	Number and time of firestorm
Keyword analysis of firestorm data	Python	Terms discussed in firestorm
Inductive classification of firestorms	Manual qualitative analysis	Context, practice, and effects of online firestorms

over 950 000 tweets regarding the project from 2013 to 2019. As recommended by Kaminsky [50], these years can be representative of the discourses throughout the project because we have no reason to believe that they are unusual or does not adequately represent Twitter exchanges. Preprocessing included cleaning the text data by removing URLs, mentions, and images using the re (regular expression) library. The text was then tokenized into individual words. Commonly used words, such as "the," "is," "and," etc., were removed using the Natural Language Toolkit (NLTK) library's list of English stop words. Words of length less than three letters were also removed along with nonword terms, such as emoji [51]. After stop word removal, remaining words were then converted to their base form using NLTK's WordNetLemmatizer. To support the later topic over time analysis, the date column in the Twitter data was transformed into a standard format.

B. Topic Identification

Latent Dirichlet allocation (LDA) model training through the Gensim package in Python was used for the preprocessed data. LDA was applied in this article due to its ability to discover underlying themes, flexibility, and interpretability which enabled sensemaking from the dataset. It uses a probabilistic approach where documents are modeled as mixtures of topics and each topic is characterized by a distribution over words enabling the identification of underlying themes in large collections of text that may not be visible from analysis of keyword frequency. In a comparison study on unstructured text document classification by Mohammed and Al-augby [52], LDA outperformed latent semantic analysis in terms of coherence value, demonstrating better results when clustering words into topics. So in this article, we choose LDA as it can enable a comprehensive understanding of the themes present in data, track changes in topics over time, and identify relationships between different pieces of text [53]. LDA functions as a text analysis approach to interpret sets of observations by attributing them to underlying, unobserved groups or topics. In LDA, each document (in this case, tweet) is represented as a mixture of word groupings or clusters known as topics. Each topic in an LDA model is a collection of words with a probability of occurrence. The LDA model is trained using Gensim's LdaModel class [54], which is used to calculate coherence values for different numbers of topics. Coherence measures the relative similarity of words within a topic, and a higher coherence score indicates that the topics are more interpretable and distinct. During the training process, the LDA model iteratively assigns each word in each document to a topic (randomly at first), then updates the topic assignments based on how often each word appears and how often each topic is used in each document. This process is repeated until the topic assignments stabilize. The result is a set of topics where each topic is a collection of words, and each document is a collection of topics. After the model is trained, the document-topic distribution for each document is extracted. The topic distribution is a probability distribution over the set of topics according to Curiskis et al. [55] and, if a document has a high likelihood for a topic that contains words like "parliament," "vote," "bill," etc., it is probable that the document is referring to politics.

C. Topic Over Time

After document-topic distributions were finalized, the seaborn library was used to plot each topic's share over time. The data are grouped by date, and for each date, the share of each topic in the documents of that date is plotted. This step is crucial for understanding trends, patterns, and shifts in the dataset's overall discourse.

D. Rate of Tweeting of Firestorms

To identify firestorms from tweeting rates, researchers have not agreed on a universally accepted threshold for the number of tweets per hour that defines an online firestorm. In previous article, however, statistical analysis has been applied to identify peaks in activity that are significantly higher than the baseline number of tweets, retweets, and mentions within a short timeframe [56]. For this article, the threshold was set as the average number of tweets per day. When that threshold was exceeded for a sustained period of time, the incident was classified as a firestorm, following the recommendations of Koch et al. [57]. We defined a firestorm as a significantly higher-than-average number of tweets, i.e., above 10 000 per week in the case of the HS2 project, as shown in Fig. 1. In our dataset, mean (average) is 3974.19 tweets, median is 3478.00, one standard deviation around the mean ranges from 1500.33 to 6448.04, and two standard deviations around the mean ranges from −973.53 to 8921.90. Therefore, our choice of 10 000 tweets is based on it being more than two standard deviations above the average tweets per week.

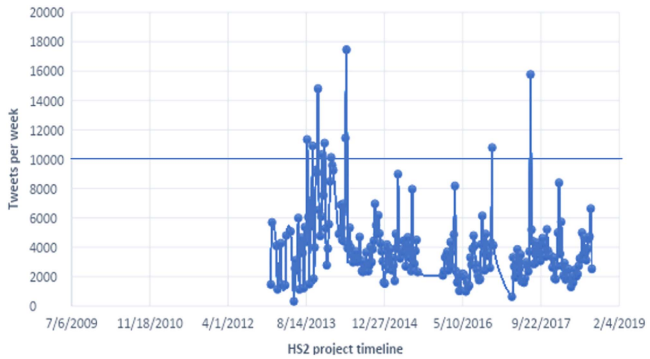

Fig. 1. Tweets per week in the HS2 project.

E. Keyword Analysis of Firestorm Data

The keyword analysis of the online firestorm data involved a quantitative keyword analysis of the text of single words and bigrams using python.

F. Inductive Classification

For qualitative inductive classification, data regarding the firestorms were systematically analyzed to identify patterns that emerge from them. The approach is beneficial for exploring rich data in detail and context, understanding complex phenomena, and building theory [58]. Initially, the data are carefully read to assign initial codes to critical concepts. These codes are then organized around common more significant categories. The data analysis process from initial codes to the final category is iterative, meaning revisiting the data multiple times as new insights emerge is often necessary. Thus, the categories were refined iteratively as insights emerged from the data, a process often described as the data "talking back" [59]. These categories were then organized into a tabular format and cross-referenced with existing literature to ensure their validity and alignment [60].

IV. Findings

The LDA analysis identified five topics which were individually dominant (the focus of most discussions) in the Twitter posts about HS2 at differing temporal periods. The first topic was focused on discussions about the Hybrid Bill which was debated in parliament at the time and was dominant from 2013-01 to 2014-03. The second topic was focused on the proposed costs of the project and was dominant between 2014-04 and 2014-09. The third topic was focused on criticisms of the business case and rationale for HS2 based on the publication of a critical report and was dominant during 2014-06 and 2014-07 and 2014-11 to 2016-01. The fourth topic was focused on the environmental damage caused by HS2 to ancient woodland along with the view that the project was a waste of money (vanity project) and was prominent from 2016-02 to 2016-09, the month of 2017-02, 2018-04 to 2018-09. Finally, the fifth topic sought to motivate political opposition in order to scrap the project and was prominent from 2016-10 to 2017-12 and 2018-02 to 2018-04.

TABLE II
Topics From LDA and Details of Firestorms Considered in This Article

Start date	LDA topic	Tweets/ week	Topic covered
19/08/ 2013	1	11339	Class war—legislative dynamics
23/09/ 2013	1	10909	Wasting our money on your dream—missing business case
28/10/ 2013	1	14802	Wildlife sites affected—environmental concerns
25/11/ 2013	1	10329	Stop wasteful vanity project—issues with new routes
09/12/ 2013	1	11097	The project will walk on water—acknowledging protests
20/01/ 2014	1	10119	Court backs protesters—386-weekend closures in project
21/04/ 2014	2	11444	Opposition within the ruling party counted as a victory
28/04 /2014	2	17458	Most MPs vote for the project—The opposition is minority
14/11/ 2016	5	10784	Project construction behind cost and schedule—fails economic logic
17/07/ 2017	5	15769	Most costly railway ever

Only few of the topics from LDA resulted in an online firestorm as shown in Table II.

There were 10 instances of online firestorms which are detailed as follows.

A. Class War—Legislative Dynamics

On week 19/08/2013, 6254 unique tweets were identified in this firestorm when the legislative dynamics were prominent with the project undergoing legislative review and political discussions. This aligned with the overall topic 1 about the reading of the bill. MPs from the ruling signaled that they would revolt against the bill as a way of protesting, as they stated. *#HS2 legislation will not have my vote, Tory MP Michael Fabricant to Grayling.* Activists also used several attacks to delegitimatize the project by saying that it was a form of class warfare and wealth transfer from poor residents to affluent business people. These attacks also incorporated financial and other economic arguments. For example, the government was portrayed as bankrupt and unable to afford this investment. Further, activists indicated that there was child poverty and hunger, and the money spent on high-speed rail could be used on social welfare, *Children go hungry in the U.K., yet billions can be spent on #HS2 Trident*

Big Business, Banks, Tax Dodgers, Bonuses, shame and *David Cameron is using class war to get his #HS2 plans through.*

B. Wasting Our Money on Your Dream—Missing Business Case

From the week of 23/09/2013 to 30/09/2013, there were 7850 unique tweets. While political themes were observed throughout which align with Topic 1, this specific theme was more pronounced in later 2013 and 2014, indicating political decisions, shifts, or significant political commentary regarding the HS2 project. The opposition party labor said they will oppose the bill due to the leadership's inability to provide a robust business case, *#HS2 an all fur coat no knickers project. Finally, Labour wising up to the fact.* The theme of politicians vs. the people and the potential rebellion by conservative politicians was also highlighted. *We're all in this together, George (Osborne), but while we're all against #HS2, you're ignoring us and wasting our money on your dream.* In this Twitter storm, there were also advocates for HS2 who indicated that the mobs were attempting to smear a politician based on his support for the project, *The anti #HS2 mobs desperate attempts to smear Sir David Higgins show both their dishonesty & desperation.* The online firestorm focused on wasting money and it echoed similar sentiments during the time, such as the House of Commons voting against U.K. military involvement in Syria.

C. Wildlife Sites Affected—Environmental Concerns

In the week starting 28/10/2013, there were 8844 unique tweets where the legitimacy of HS2 was again attacked but from a new angle where the need for local ecological problems was highlighted, *160 wildlife sites are affected by phase 1 alone. Stop the madness #stopHS2.* The suggestion was that more effort was needed to reach local councils, as seen in the Tweet, *Local councils need to be more involved in the #HS2 discussions.* There was also a report from the Institute of Economic Affairs, which did not support the business case for high-speed rail two, where the cost was seen as far higher than the proposed benefits:

> *Excellent #IEA report debunks notion white elephant #HS2 will transform the North. Gross misallocation of resources.*

There was also a call for anti-high-speed real activists to focus their efforts on political organizing so that political parties would listen to them or risk losing votes, *Time for a wider #stopHS2 campaign to finally get serious about organizing politically to inflict real electoral pain on pro-HS2 parties.* In response, opposition politicians began to present critiques of the projects. There was also a second reading of the high-speed rail two bill, and the Labour Party indicated that the environmental impact was not adequately accounted for, as, *Labour's Joan Walley, chair of the environmental audit committee, says the environmental impact of #HS2 has not been properly assessed.*

D. Stop Wasteful Vanity Project—Issues With New Routes

Week starting 25/11/2013 6395 unique tweets. Concerns were expressed about the change in route because there was a variation from the planned round to the final proposed high-speed design, *which bright spark came up with the new route around Measham last Nov, only for it to reveback to the original today? #hs2 #cockup.* New polls were issued that show that public sentiment was against the project, as a tweet highlighted, *A tiny 3% of voters believe #HS2 will be built on time and budget – ICM Poll.* There was also a new angle of opposition to the project in the form of suggesting that the project was obsolete. New digital technologies, such as video conferencing, will encourage potential commuters to work via these platforms rather than travel from one place to the other.

The theme looks at HS2 as a vanity project or a white elephant whose cost was too high for the supposed benefits. The theme talks about issues of cost as well as potential design flaws. There were discussions about the localization theme of production, where British manufacturing firms should be allowed to provide services, the cost of high-speed rail, and the fact that the estimated cost was increasing. Posts also discussed redundancy payouts for staff members, which were somehow unauthorized.

E. Project Will Walk on Water—Acknowledging Protests

There were 6880 unique tweets in the week starting 09/12/2013. Opposition was expressed by a well-respected politician, Michael Heseltine, who was giving his evaluation of the project, viewing it as an act of faith, *Heseltine proposes to abandon #HS2 rails and declares 'it will walk on water' Now hear de word of de Lord!* The Twitter storm also indicated that the public opposed the project, and they starkly contrasted with the representatives who were proponents of the project, *The #HS2 project is losing public support, a new poll suggests"* and *"Opposition to #HS2 reaches an all-time high.* These points align with the overall discussion topic 1.

F. Court Backs Protesters—386-Weekend Closures in the Project

There were 5403 unique tweets in the week starting 20/01/2014, where the environmental impact of the project was brought to the fore, and there was successful legal action against the project in a judgment handed down by the Supreme Court, *Another delay as now both Commons and Lords judge #HS2 failed the public on the environmental statement.* The potential harm to Heritage sites and disruption was much higher than planned in the project. In addition to the disruption of the environment, the disruption to communities, social life, and working patterns was also emphasized by protesters. They indicated the number of closures via the weekends to make these projects feasible and the number of disruptions and difficulties in journeys that people living in these eras would have to experience for a prolonged period before the project is finalized, *386-weekend closures to be suffered by those who will get no benefit from #HS2. And pros said we were scaremongering!*

G. Opposition Within the Ruling Party Counted as a Victory

The week starting 21/04/2014, there were 8117 unique tweets because the ruling party faced further opposition from their MPs regarding the project, *Fresh questions over #HS2 benefits*

as faces rebellion. The rebellion was also seen in the form of government ministers who, for whatever reason, chose to miss key commons votes on the high-speed project, which indicated to some online viewers that they did not support the project, *#HS2: at least three Tory ministers to miss key Commons vote.*

The project also tilted the election prospects as information was put forward as a potential way of changing or swinging the vote against the ruling party since they supported the project and the public did not, *MPs from all parties express concerns about #HS2.*

H. Most MPs Vote for the Project—Opposition is Minority

There were 7692 unique tweets in the week starting 28/04/2014. HS2 voted through parliament despite the earlier Rebellion, and most ruling party and opposition MPs voted for the project, *#HS2 bill been voted thru 451 against 50. Good to hear the minister of transport suggest more talk of protection.* The call was then made to get on with the project and to stop the campaigning and fighting. there was a related point where the online audience was seen as alarmists and not necessarily representative of the population, *Today's woeful muster - proves what some of us have tweeted for ages Opposition to #HS2 = minority of noisy alarmists.* This online firestorm involved most MPs voting for the project and in this period there was growing anti-EU sentiments surging local U.K. support for many initiatives which finally lead to Brexit.

I. Project Construction Behind Cost and Schedule—Fails Economic Logic

From the week of 14/11/2016 to 21/11/2016, there were 5013 unique tweets. The project management office was called into question because the project was behind cost and schedule. The project's cost was estimated to increase again, and there were discussions on how the rail would destroy heritage along the route aligning with Topic 5. There was also an opposing view where commentators said that the anti-project people would merely be wingers and that this project needed to go ahead, *Alarming that it was blamed on poor government project management. Doesn't bode well for #HS2 cost and schedule!* Notes were made on the increase in cost and the high consultancy fee spent on the project, all requiring a spending review because of the potential increased cost. The political aspect came back here with local taxes, accounts of taxes, and overseas age budget being put in part.

J. Most Costly Railway Ever

There were 6062 unique tweets in from the week of 17/07/2017 with accusations of mismanagement, where unapproved payments would be made, new houses would be demolished, and the project was estimated to cost 400 million pounds per mile, making it the most expensive project ever. A new project segment was also approved, confirmed to be from Manchester to Leeds, *#HS2 what a farce, new houses to be demolished, Â£400m a mile most costly railway ever, politicos folly.*

V. Discussion

A. Topics Discussed in Online Firestorms

Multiple topics were discussed by the community in the online firestorms of the HS2 project. An emergent theme was freezes and job cuts in the public sector, with the implicit suggestion that the money could have been spent better elsewhere on issues, such as potholes and other local matters. There was a theme related to the select committee that the project would have been debated in front of, along with the characteristics of that committee and its influence on the infrastructure project. Another theme was the project's features, with some basic information about the project and its benefits and costs. A big theme was the potential environmental damage that could occur from HS2 and that the project should be opposed on sustainability grounds. Specifically, there was a legal challenge to high-speed rail, and there was a petition that campaigners were encouraging members of the public to get involved in to remove the threat of HS2 and that there was an ancient woodland that would have been affected by high-speed rail. The other debate was linked to the proposed route and that families would have been displaced due to the new project. There were discussions on HS2 as legalized corruption where taxpayers' money would be wasted, and residents' views would be overlooked. Some themes were linked to the rear encouragement, how they were fit or not fit, and that liberties would be removed. Another theme of the project is wasteful spending, with the high-speed rail two being a white elephant and that the money could have been spent elsewhere. These themes are similar to topics discussed on social media in other projects in the literature, such as sustainability, embracing local, increased cost, etc. [5].

B. Sociomateriality of Online Firestorms

Online firestorms can have diverse interactions between people and technology. Traditionally, Twitter and other social media platforms were used for sharing information and traits of this can be seen with updates on the progress of projects, such as when MPs from all parties expressed concerns about the project or when HS2 announced construction contracts. However, firestorms are also highly emotional, with tweets that called for stopping the madness, voting against political parties supporting the project, etc. Engaging in these online firestorms is a means for people to express their anger, protest against issues, and confront the problem at hand [33]. The highly emotional nature of these online firestorms, particularly negative emotions, is noted in the study by Delgado-Ballester et al. [61]. Firestorms can also be based on exaggerated information, such as in the tweet regarding children going hungry because of spending on HS2. Rost and Stahel [62] highlight firestorms spread regardless of whether the information spread is accurate, false, or exaggerated in retrospect. The higher the use of emotional and triggering words a tweet contains, the more potential it has to go viral and become an online firestorm [63]. Firestorms are often negative because negative news spreads like wildfire. In addition, an individual can be interested in sharing particular information in their social ties without the intention to create a

firestorm [64]. Stakeholders also make known their approval and psychologically identify with the project on Twitter engaging in emotionally charged interactions while disseminating their opinions on the project. In addition, the firestorms are amplified because of social media platforms, such as Twitter, contributing to the scale of online interactions and, thereby, the rapid spread of emotions around the project.

C. It Is Difficult to Sustain an Online Firestorm

The online firestorms faded after the peak even though they raised critical issues on the project. For example, the firestorm on the economic argument of the project was raised during the legislative review and political discussions of the project. Even though the firestorm included exaggerated information, such as class war, wealth transfer, and children going hungry, the government still went ahead with the project. With no success in the legislative review stage, the online firestorm may have faded away mainly because issues raised as an online firestorm are under constant scrutiny by the community and become difficult to sustain if the problem is not legitimate. Therefore, when new information emerges that challenges the original narrative of the controversy, public interest may wane, and the online firestorm can fade away [65]. This was evident when the firestorm on opposition within the ruling party disappeared when most MPs voted for the project, and the opposition was a minority. Even in cases when the issue raised in the online firestorm does not get the widespread coverage and amplification, it needs to maintain its virality from news organizations or Twitter influencers, the online firestorm will die down [66]. Similarly, Conover et al. [39] record that the mere presence of a firestorm does not ensure sustained or substantive engagement from the mainstream institutions or from the community themselves. Thus, an online firestorm can die quickly as users lose interest, circumstances change, or new information emerges, making it difficult to sustain.

D. Online Firestorms are Recreated With New Similar Issues

Megaprojects impact various stakeholders, and their planning and delivery attract a significant level of public interest and discontent from negatively affected stakeholders. The discussions regarding the project being expensive were raised in different periods. The 2013 Twitter storms in 19/08, 23/09, 28/10, and 25/11 reflect the campaigning before the vote for the hybrid bill. In all these periods, there were concerns about the cost and business case of the project. These negative dynamics may be amplified by the networked nature of social media. In this article, several factors were visible in repeated firestorms. Persistent engagement on the same issue, for example, potential project cost, provided the basis for firestorms to reignite these unresolved discussions within an online community [67]. Further, areas where the focal organization, in this case, HS2, is perceived to be behaving unethically can create higher moral arousal, influencing participation behavior and encouraging users to participate more actively in the discourse [68]. Media coverage can contribute to the recurrence of firestorms, especially if the media continuously spotlights unresolved or ongoing controversial topics, such as the vote in parliament for an "expensive" project, keeping them in public discourse [69]. Thus, even when online firestorms have become frequent [39], no extant research has identified repeated firestorms on the same topic.

E. Online Firestorm as a Persuasive Tool

Online firestorms are used mainly against the project, as out of the ten firestorms analyzed in this article, nine were against the project, and one was for the project. Firestorms were used as a persuasive tool to mobilize action against the project by influencing public perception, promoting agendas, and even damaging the reputation of the large infrastructure project and the government that backs the project. It works by discrediting the project, such as in the instance of opposition within the ruling party regarding the project to exert pressure on the project. Social media is currently called the "most important source" of news [70], and an online firestorm on Twitter can hamper the reputation of the project. They can also be strategically used to mobilize support for social justice causes, such as in the case of the project affecting wildlife sites. The social cause context can amplify the voice of the activists [71] and thereby resistance against the project. Hence, while online firestorms can be harnessed to raise awareness of important issues, mobilize support for social justice, and hold power to account, they can also be weaponized to spread misinformation, manipulate public opinion, and undermine democratic norms [72]. Notably, the role of opposition parties, influencers, and media outlets in using online firestorms as a persuasive tool has to be investigated in future article.

F. Online Firestorm Changes the Project

Most of the ten firestorms discussed were against the project and multiple small wins result in the big win of canceling critical parts of the project. As of October 2023, the high-speed railway line will link London and Birmingham but will no longer continue to Manchester as was initially planned [73]. The firestorms #1, #2, #4, #9, and #10 focused explicitly on the excessive cost of the project, which could have led to the cancellation of part of the project as existing research highlights how online firestorms can bring about significant changes in public policy [71]. Additionally, the online firestorms #3 and #6 discussed above on wildlife sites being affected could have resulted in the project adopting a new design in the Chilterns with a green roof to help blend into the landscape. Project sponsors mindful of how the public perceives the intervention adopt a more inclusive and transparent approach to decision-making focused on stakeholder engagement [74]. While highlighting the influence of online firestorms in prompting changes to the project, we acknowledge that other factors may have also contributed to these changes, such as protests, parliamentary debates, and opposition movements. These can be investigated in future article to understand the role of online firestorms in contributing to these other factors.

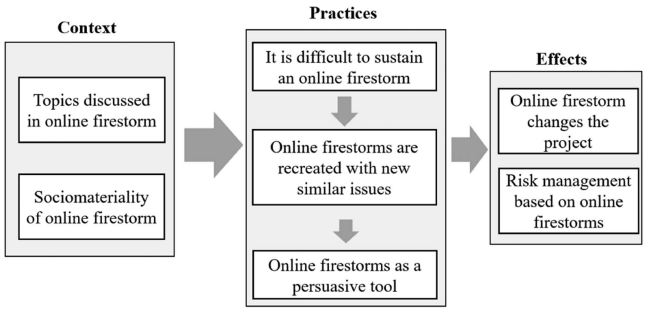

Fig. 2. Theorizing online firestorm in large infrastructure projects.

G. Risk Management Based on Online Firestorm

Online firestorms can erupt seemingly out of nowhere and pose significant risks to large infrastructure projects, such as damaging reputations and derailing progress. Project managers must adopt proactive strategies that address concerns early and respond swiftly and strategically to mitigate potential damage [75]. Early identification of topics of community concern where project managers monitor Twitter channels to detect emerging issues before they escalate into full-blown firestorms can help anticipate potential risks and enable taking preemptive measures to address them based on prevailing sentiments and concerns. These proactive measures enable project managers to identify brewing discontent and take proactive steps to address it before it erupts into an online firestorm. Project managers must have a repertoire of response mechanisms at their disposal to address the concerns of the community. A social media strategy involving marketing and branding of projects throughout the lifecycle in Twitter is important to get into the hearts and minds of the community [76]. Responses follow a fair process approach [77] with persuasion, negotiation, give and take, incentives, flexibility, and concessions to proactively manage the risks. While literature talks about these responses, we extend the existing literature by highlighting the Twitter environment as an avenue for project managers to understand the concerns of the community through a combination of cooperation with credible aggressors and assertiveness with less credible actors [40]. Rather than viewing online firestorms solely as threats, project managers should recognize them as opportunities to generate more value for the project community by strengthening trust and building stronger relationships with the community. It should be treated as an opportunity to make communication clear on important decisions of the project and increase transparency. Thus, online firestorms, if managed effectively, can serve as catalysts for positive change and innovation. Despite the growing prevalence of online firestorms, there remains a dearth of research on their effective management and by systematically analyzing past firestorm incidents and their outcomes, project scholars can refine risk management strategies and enhance preparedness to handle future crises.

Fig. 2 highlights how online firestorms are practiced in large infrastructure projects. The context of an online firestorm can be understood based on the topics discussed and the sociomateriality. As observed from our data, the practices in the case of projects involve the difficulty in sustaining them and how firestorms can be created with similar new issues. These firestorms are also used strategically as a persuasive tool by the protesters of the project to make their voices heard. Using online firestorms in large infrastructure projects results in a change in the project or policy regarding the project. In the case of the HS2 project, the project will no longer continue to Manchester as was initially planned [73]. Thus, these online firestorms can be considered a risk as the project does not have complete control over the narrative and does not fully understand the scope and potential impact of the issue during this time. The way the project is perceived significantly influences its acceptance within the affected communities [78]. While not every negative online post escalates into an online firestorm, being able to detect and respond to these instances is crucial for organizations, especially large infrastructure projects, as they operate under continuous public scrutiny. Managers in these projects should aim to tailor practices in their projects for more success [79].

VI. Conclusion

The potential of social media, such as Twitter, to disrupt large infrastructure projects underscores the need for project organizations to manage their online presence and engage with communities constructively. Studying the HS2 project in the U.K. as a case study, this article retrieved over 950 000 tweets regarding the project from 2013 to 2019 and classified 10 instances of online firestorms over this period covering environmental impacts, legislative dynamics, budget of the project, performance of the project, etc. By understanding the firestorm dynamic of Twitter and its impact on organization–community interactions, organizations can effectively navigate this complex landscape and foster positive relationships with the communities they serve.

This article has multiple contributions. First, while existing studies in the large infrastructure projects highlight how the community expresses their concern in physical consultation meetings, this article highlights how the community uses online firestorms to make their voice heard. Second, the article highlights the sociomateriality of Twitter, varying its use from sharing information to mobilizing resistance depending on users. Additionally, online firestorms in Twitter present an opportunity for project managers to understand social risks in projects and be proactive in taking steps to address them. Third, the article found how recreating firestorms with similar issues can help rekindle a previous firestorm. Fourth, the article shows how the community can use firestorms as a persuasive tool to change the project, thereby creating more value. However, more research is required to understand the role of interest groups, such as opposition parties, influencers, and media outlets in firestorms. Finally, this article provides a framework through which online firestorms are practiced in projects from the different topics considered in them, its sociomateriality, its difficulty in sustaining, how it can be recreated with similar new issues, how it is used as a persuasive tool, and ultimately how it changes the project. Additionally, online firestorms could be used as a tool for external knowledge search to support earlier identification of emerging negative dynamics [80] as part of risk management.

We also note managerial contributions, such as engaging with the project community in the online environment to gain insights into prevailing sentiments and concerns, a social media strategy involving marketing and branding of projects throughout the lifecycle in social media to get into the hearts and minds of the community, and treating firestorms as an opportunity to make communication clear on important decisions of the project and change project to create more value for society.

The article has some limitations and presents scope for further article. While not discounting the impact of online firestorms in potentially changing the project, we acknowledge that other reasons could have also caused these changes, such as protests, parliamentary debates, and opposition movements. However, the role of online firestorms in these other reasons also needs to be investigated in future article. The topics in online firestorms raise awareness and public discourse which could have shaped political and community discourses. Additionally, the article is focused on a single in-depth case study of the HS2 project in the U.K. and future articles can study the phenomenon in multiple projects worldwide as online firestorms can have different characteristics depending on the project type and host country. The role of other external stakeholders, such as opposition parties, influencers, and media outlets, in using online firestorms as a persuasive tool has to be investigated in future article. The article is exploratory and built exclusively from Twitter posts. Future article can combine Twitter posts with other social media posts, news articles, parliamentary reports, and interviews to understand the practice of online firestorms and their impact on the project. Additionally, Twitter is plagued with issues, such as selection bias, where certain groups may be more active on Twitter in contrast to other social media platforms, along with misinformation, fake news, privacy concerns, bots, and echo chamber effects, requiring more research on the potential of online firestorms in social media as a new risk assessment and management approach in projects. In this article, the focus was no on the microdynamics of online firestorms, such as how they are created, how they are sustained, how they fade away, and the role of resistance in these. Future articles can also explore the practice through a triangulated, mixed-methods approach that may help identify additional findings. With this exploratory research, we call for more research on understanding how project managers can leverage social media analysis to predict potential firestorms and develop targeted strategies to mitigate them.

REFERENCES

[1] R. K. Mitchell, B. R. Agle, and D. J. Wood, "Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts," *Acad. Manage. Rev.*, vol. 22, no. 4, pp. 853–886, 1997.

[2] J. Ninan, A. Mahalingam, and S. Clegg, "Power and strategies in the external stakeholder management of megaprojects: A circuitry framework," *Eng. Project Org. J.*, vol. 9, no. 1, pp. 1–20, 2020.

[3] Y. H. Kwak and J. Lee, "Toward sustainable smart city: Lessons from 20 years of Korean programs," *IEEE Trans. Eng. Manage.*, vol. 70, no. 2, pp. 740–754, Feb. 2023, doi: 10.1109/TEM.2021.3060956.

[4] C. Suresh and M. Floris, "Investigating perspective taking when infrastructure megaproject teams engage local communities: Navigating tensions and balancing perspectives," *Int. J. Project Manage.*, vol. 38, no. 3, pp. 153–164, 2020.

[5] J. Ninan and R. Yadav, "Megaproject and the city: Theorizing social media discourses across the lifecycle of an infrastructure project," *City Environ. Interact.*, vol. 20, 2023, Art. no. 100123.

[6] N. Ashill, P. Williams, M. S. Khan, and E. Naumann, "Dynamic and ordinary capabilities: A project management perspective," *IEEE Trans. Eng. Manage.*, vol. 69, no. 5, pp. 2173–2186, Oct. 2022.

[7] Y. Fu and N. Gil, "Financial buffers in megaprojects: A contingent model of joint value production and policy implications," *IEEE Trans. Eng. Manage.*, doi: 10.1109/TEM.2023.3308163.

[8] J. H. Min, W. Jang, S. H. Han, D. Kim, and Y. H. Kwak, "How conflict occurs and what causes conflict: Conflict analysis framework for public infrastructure projects," *J. Manage. Eng.*, vol. 34, no. 4, 2018, Art. no. 04018019.

[9] F. Di Maddaloni and R. Derakhshan, "Stakeholders' perception of organization: An attribution and fairness perspective," *Int. J. Manag. Projects Bus.*, vol. 17, no. 1, pp. 27–49, 2024.

[10] S. Mathur, J. Ninan, L. Vuorinen, Y. Ke, and S. Sankaran, "An exploratory study of the use of social media to assess benefits realization in transport infrastructure projects," *Project Leadership Soc.*, vol. 2, pp. 1–10, 2021.

[11] J. Lehtinen and K. Aaltonen, "Community stakeholders' online engagement in infrastructure projects: A theory-testing single-case study," *Construction Manage. Econ.*, vol. 42, pp. 758–786, 2024.

[12] N. L. Williams, N. Ferdinand, and B. Pasian, "Online stakeholder interactions in the early stage of a megaproject," *Project Manage. J.*, vol. 46, no. 6, pp. 92–110, 2015.

[13] R. Basak, S. Sural, and S. K. Ghosh, "Progress tracking and responding to online public shaming events on Twitter," *IEEE Trans. Comput. Social Syst.*, vol. 11, no. 2, pp. 2091–2104, Apr. 2023.

[14] T. Aven, "Risk assessment and risk management: Review of recent advances on their foundation," *Eur. J. Oper. Res.*, vol. 253, no. 1, pp. 1–13, 2016.

[15] L. Dunham, R. E. Freeman, and J. Liedtka, "Enhancing stakeholder practice: A particularized exploration of community," *Bus. Ethics Quart.*, vol. 16, no. 1, pp. 23–42, 2006.

[16] J. E. Stets and P. J. Burke, "Identity theory and social identity theory," *Social Psychol. Quart.*, vol. 63, pp. 224–237, 2000.

[17] M. A. Hogg and D. J. Terry, "The dynamic, diverse, and variable faces of organizational identity," *Acad. Manage. Rev.*, vol. 25, no. 1, pp. 150–152, 2000.

[18] R. J. Yang and G. Q. Shen, "Framework for stakeholder management in construction projects," *J. Manage. Eng.*, vol. 31, no. 4, 2015, Art. no. 04014064.

[19] Y. Wang, Y. H. Kwak, and Q. Cui, "The power(lessness) of flexibility in public–private partnership: Two capital projects from the national capital region," *Project Manage. J.*, 2024, doi: 10.1177/87569728241241301.

[20] D. Rowe, "Assessing the sociology of sport: On media and power," *Int. Rev. Sociol. Sport*, vol. 50, no. 4–5, pp. 575–579, 2015.

[21] J. Ninan and N. Sergeeva, "Battle of narratives: Interaction between narratives and counter-narratives in megaprojects," *Project Leadership Soc.*, vol. 3, 2022, Art. no. 100069.

[22] S. C. Woolley and P. N. Howard, "Political communication, computational propaganda, and autonomous agents: Introduction," *Int. J. Commun.*, vol. 10, pp. 4882–4890, 2016.

[23] B. I. Newman, *The Marketing Revolution in Politics: What Recent US Presidential Campaigns can Teach Us About Effective Marketing*. Toronto, ON, Canada: Univ. Toronto Press, 2016.

[24] R. Wallace, "Contextualizing the crisis: The framing of Syrian refugees in Canadian print media," *Can. J. Political Sci./Revue canadienne de Sci. politique*, vol. 51, no. 2, pp. 207–231, 2018.

[25] D. M. Boyd and N. B. Ellison, "Social network sites: Definition, history, and scholarship," *IEEE Eng. Manage. Rev.*, vol. 38, no. 3, pp. 16–31, Jul.–Sep. 2010.

[26] R. I. Dunbar, "Do online social media cut through the constraints that limit the size of offline social networks?," *Roy. Soc. Open Sci.*, vol. 3, no. 1, 2016, Art. no. 150292.

[27] M. Toubiana and C. Zietsma, "The message is on the wall? Emotions, social media and the dynamics of institutional complexity," *Acad. Manage. J.*, vol. 60, no. 3, pp. 922–953, 2017.

[28] K. N. Hampton, "New communication technologies and the future of community," in *Digital Media: Transformations in Human Communication*, P. Messaris and L. Humphreys, Eds., 2017, doi: 10.3726/978-1-4331-3955-0.

[29] S. L. Thorne, S. Sauro, and B. Smith, "Technologies, identities, and expressive activity," *Annu. Rev. Appl. Linguistics*, vol. 35, pp. 215–233, 2015.

[30] M. H. McDonnell, "Radical repertoires: The incidence and impact of corporate-sponsored social activism," *Org. Sci.*, vol. 27, no. 1, pp. 53–71, 2016.
[31] M. Barros, "Tools of legitimacy: The case of the petrobras corporate blog," *Org. Stud.*, vol. 35, no. 8, pp. 1211–1230, 2014.
[32] F. Comunello and G. Anzera, "Will the revolution be tweeted? A conceptual framework for understanding social media and the Arab Spring," *Islam Christian Muslim Relations*, vol. 23, no. 4, pp. 453–470, 2012.
[33] J. Pfeffer, T. Zorbach, and K. M. Carley, "Understanding online firestorms: Negative word-of-mouth dynamics in social media networks," *J. Marketing Commun.*, vol. 20, no. 1–2, pp. 117–128, 2014.
[34] N. Donthu, S. Kumar, N. Pandey, N. Pandey, and A. Mishra, "Mapping the electronic word-of-mouth (eWOM) research: A systematic review and bibliometric analysis," *J. Bus. Res.*, vol. 135, pp. 758–773, 2021.
[35] M. Johnen and O. Schnittka, "When pushing back is good: The effectiveness of brand responses to social media complaints," *J. Acad. Marketing Sci.*, vol. 47, pp. 858–878, 2019.
[36] S. Hudson, L. Huang, M. S. Roth, and T. J. Madden, "The influence of social media interactions on consumer–brand relationships: A three country-study of brand perceptions and marketing behaviors," *Int. J. Res. Marketing*, vol. 33, no. 1, pp. 27–41, 2016.
[37] J. A. Obar, P. Zube, and C. Lampe, "Advocacy 2.0: An analysis of how advocacy groups in the United States perceive and use social media as tools for facilitating civic engagement and collective action," *J. Inf. Policy*, vol. 2, pp. 1–25, 2012.
[38] S. J. Jackson and B. Foucault Welles, "Hijacking# myNYPD: Social media dissent and networked counterpublics," *J. Commun.*, vol. 65, no. 6, pp. 932–952, 2015.
[39] M. D. Conover, E. Ferrara, F. Menczer, and A. Flammini, "The digital evolution of occupy wall street," *PLoS One*, vol. 8, no. 5, 2013, Art. no. e64679.
[40] F. Hauser, J. Hautz, K. Hutter, and J. Füller, "Firestorms: Modeling conflict diffusion and management strategies in online communities," *J. Strategic Inf. Syst.*, vol. 26, no. 4, pp. 285–321, 2017.
[41] R. Yin, *Case Study Research: Design and Methods*. New York, NY, USA: Sage, 2015.
[42] C. C. Ragin and H. S. Becker, "What is a case?," in *Exploring the Foundations of Social Inquiry*. New York, NY, USA: Cambridge Univ. Press, 1992.
[43] Z. Zhou, X. Zhou, and L. Qian, "Online public opinion analysis on infrastructure megaprojects: Toward an analytical framework," *J. Manage. Eng.*, vol. 37, no. 1, 2021, Art. no. 04020105.
[44] Z. Hu, H. Ma, J. Xiong, P. Gao, and P. K. P. Divakaran, "Convergence or divergence: A computational text analysis of stakeholder concerns on manufacturing upgrading in China," *IEEE Trans. Eng. Manage.*, vol. 71, pp. 1285–1295, 2024, doi: 10.1109/TEM.2022.3159344.
[45] K. C. Roy, M. A. Ahmed, S. Hasan, and A. M. Sadri, "Dynamics of crisis communications in social media: Spatio-temporal and text-based comparative analyses of twitter data from Hurricanes Irma and Michael," in *Proc. Int. Conf. Inf. Syst. Crisis Response Manage.*, 2020, pp. 812–824.
[46] G. Blank, "The digital divide among Twitter users and its implications for social research," *Social Sci. Comput. Rev.*, vol. 35, pp. 679–697, 2017.
[47] A. Tear and H. Southall, "Social media data," in *Data in Society*. Bristol, U.K.: Policy Press, 2019, pp. 47–60.
[48] J. Yu and J. Muñoz-Justicia, "Free and low-cost Twitter research software tools for social science," *Social Sci. Comput. Rev.*, vol. 40, pp. 124–149, 2020.
[49] N. Alperstein, "Greenwashing as grassroots or no roots social movement: A multi-platform approach to social media monitoring of hashtag activism," *J. Social Media Soc.*, vol. 11, no. 2, pp. 4–28, 2022.
[50] J. Kaminsky, "Who are we talking to? Situating construction engineering and management knowledge," *J. Construction Eng. Manage.*, vol. 147, no. 2, 2021, Art. no. 06020003.
[51] S. Symeonidis, D. Effrosynidis, and A. Arampatzis, "A comparative evaluation of pre-processing techniques and their interactions for Twitter sentiment analysis," *Expert Syst. Appl.*, vol. 110, pp. 298–310, 2018.
[52] S. H. Mohammed and S. Al-augby, "LSA & LDA topic modeling classification: Comparison study on e-books," *Indonesian J. Elect. Eng. Comput. Sci.*, vol. 19, no. 1, pp. 353–362, 2020.
[53] T. Williams and J. Betak, "A comparison of LSA and LDA for the analysis of railroad accident text," *J. Ubiquitous Syst. Pervasive Netw.*, vol. 11, no. 1, pp. 11–15, 2019.
[54] B. V. Barde and A. M. Bainwad, "An overview of topic modeling methods and tools," in *Proc. 2017 Int. Conf. Intell. Comput. Control Syst.*, Jun. 2017, pp. 745–750.
[55] S. A. Curiskis, B. Drake, T. R. Osborn, and P. J. Kennedy, "An evaluation of document clustering and topic modelling in two online social networks: Twitter and Reddit," *Inf. Process. Manage.*, vol. 57, no. 2, 2020, Art. no. 102034.
[56] B. J. Drasch, J. Huber, S. Panz, and F. Probst, "Detecting online firestorms in social Media," in *Proc. Int. Conf. Inf. Syst.*, 2015. [Online]. Available: https://aisel.aisnet.org/icis2015/proceedings/ISdesign/10
[57] K. Koch, A. Dippel, and M. Schumann, "Does my social media burn?—Identify features for the early detection of company-related online firestorms on Twitter," *Online Social Netw. Media*, vol. 25, 2021, Art. no. 100151.
[58] A. Erfani, Q. Cui, G. Baecher, and Y. H. Kwak, "Data-driven approach to risk identification for major transportation projects: A common risk breakdown structure," *IEEE Trans. Eng. Manage.*, vol. 71, pp. 6830–6841, 2024, doi: 10.1109/TEM.2023.3279237.
[59] B. Flyvbjerg, "Five misunderstandings about case-study research," *Qualitative Inquiry*, vol. 12, no. 2, pp. 219–245, 2006.
[60] K. M. Eisenhardt, "Building theories from case study research," *Acad. Manage. Rev.*, vol. 14, no. 4, pp. 532–550, 1989.
[61] E. Delgado-Ballester, I. López-López, and A. Bernal-Palazón, "Why do people initiate an online firestorm? The role of sadness, anger, and dislike," *Int. J. Electron. Commerce*, vol. 25, no. 3, pp. 313–337, 2021.
[62] K. Rost and L. Stahel, "Hostile-emotional excess of zeal in public social media: A case study of an online firestorm against an organization," *Rationality Soc.*, vol. 34, no. 4, pp. 469–500, 2022.
[63] D. Herhausen, S. Ludwig, D. Grewal, J. Wulf, and M. Schoegel, "Detecting, preventing, and mitigating online firestorms in brand communities," *J. Marketing*, vol. 83, pp. 1–21, 2019.
[64] X. Lin, S. Sarker, and M. Featherman, "Users' psychological perceptions of information sharing in the context of social media: A comprehensive model," *Int. J. Electron. Commerce*, vol. 23, no. 4, pp. 453–491, 2019.
[65] C. Wardle and H. Derakhshan, *Information Disorder: Toward an Interdisciplinary Framework for Research and Policymaking*. Strasbourg, France: Council of Europe, 2017.
[66] S. Y. Lee, "Stealing thunder as a crisis communication strategy in the digital age," *Bus. Horiz.*, vol. 63, no. 6, pp. 801–810, 2020.
[67] T. Hancock, M. Breazeale, F. Adams, and H. Hardman, "Fueling and cooling firestorms: How online community members enable and disable online negative e-WOM," *J. Product Brand Manage.*, vol. 32, pp. 286–304, 2023.
[68] M. Johnen, M. Jungblut, and M. Ziegele, "The digital outcry: What incites participation behavior in an online firestorm?," *New Media Soc.*, vol. 20, no. 9, pp. 3140–3160, 2018.
[69] S. Einwiller, B. Viererbl, and S. Himmelreich, "Journalists' coverage of online firestorms in German-language news media," *Journalism Pract.*, vol. 11, pp. 1178–1197, 2017.
[70] H. Allcott and M. Gentzkow, "Social media and fake news in the 2016 election," *J. Econ. Perspectives*, vol. 31, no. 2, pp. 211–236, 2017.
[71] Z. Tufekci, *Twitter and Tear Gas: The Power and Fragility of Networked Protest*. New Haven, CN, USA: Yale Univ. Press, 2017.
[72] A. M. Kaplan and M. Haenlein, "Users of the world, unite! the challenges and opportunities of social media," *Bus. Horiz.*, vol. 53, no. 1, pp. 59–68, 2010.
[73] M. Landler and S. Castle, "Rishi Sunak cancels a rail project to build an image," New York, NY, USA Times, 2023. [Online]. Available: https://www.nytimes.com/2023/10/04/world/Europe/rishi-sunak-high-speed-rail-project.html
[74] W. T. Coombs, *Ongoing Crisis Communication: Planning, Managing, and Responding*, 3rd ed. Thousand Oaks, CA, USA: Sage, 2014.
[75] J. Ninan, S. Clegg, S. Burdon, and J. Clay, "Overt obstacles and covert causes: An exploratory study of poor performance in megaprojects," *Project Leadership Soc.*, vol. 2, 2021, Art. no. 100011.
[76] W. J. Henisz, "The dynamic capability of corporate diplomacy," *Glob. Strategy J.*, vol. 6, no. 3, pp. 183–196, 2016.
[77] W. C. Kim and R. Mauborgne, "Fair process: Managing in the knowledge economy," *Harvard Bus. Rev.*, vol. 81, no. 1, pp. 127–136, 2003.
[78] J. Guevara, M. J. Garvin, and N. Ghaffarzadegan, "The forest and the trees: A systems map of governance interdependencies in the shaping phase of road public–private partnerships," *J. Manage. Eng.*, vol. 36, no. 1, 2020, Art. no. 04019031.
[79] O. Bentahar and L. A. Ika, "Matching the project manager's roles to project types: Evidence from large dam projects in Africa," *IEEE Trans. Eng. Manage.*, vol. 67, no. 3, pp. 830–845, Aug. 2020.
[80] C. Laurell and C. Sandström, "Social media analytics as an enabler for external search and open foresight—The case of Tesla's autopilot and regulatory scrutiny of autonomous driving," *IEEE Trans. Eng. Manage.*, vol. 69, no. 2, pp. 564–571, Apr. 2022.

Nigel Williams received the B.Sc. degree in mechanical engineering and the M.Sc. degree in marketing from the University of the West Indies, Kingston, Jamaica, and the Ph.D. degree in engineering from the University of Cambridge, Cambridge, U.K., in 1996, 2004, and 2010, respectively.

He is currently a Professor in Responsible Project and Systems Management and is the Associate Dean for Research and Innovation with the Faculty of Business and Law at University of Porsmouth. Before joining academia, he worked for 15 years as a Manager and a Business Consultant for enterprises in the Caribbean Region. Since joining academia, he has linked education, research, and professional practice. More recently, he has worked to develop the area of Responsible Project Management. His research interests include examining the evolution of organizational and interorganizational capabilities in a variety of contexts, including projects and networks.

Dr. Williams is also a board member of the Project Management Institute U.K. Chapter (2023–2025) responsible for Research and Academic outreach.

Johan Ninan received the B.Tech. degree from Mahatma Gandhi University, Kerala, India, in 2009, the M.Tech. degree from Indian Institute of Technology Delhi, in 2011, and the Ph.D. degree jointly from the University of Technology Sydney and Indian Institute of Technology Madras, in 2019. He is currently an Assistant Professor with the Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands. Previously, he was a Postdoctoral Fellow with the University College London, London, U.K. His research interests include transdisciplinary design of infrastructure projects with a key emphasis on engaging stakeholders from diverse disciplinary backgrounds to achieve societal impact. His research interests also include stakeholder engagement, collaboration, innovation, resilience, safety, information and communication technology, and project organizing. He particularly emphasizes the significance of social media in infrastructure projects and utilizes online naturalistic data from an organizational power theoretical perspective.

Dr. Ninan is a Guest Editor of the *Project Management Journal* and Project Leadership and Society and is part of the international editorial board of *International Journal of Project Management*. He is the recipient of the PMI Young Researcher Award, the IPMA Global Research Award, the IPMA Global Young Researcher Award, and the APM Paper of the Year Award.

Young Hoon Kwak received the B.S. and M.S. degrees from Yonsei University, Seoul, Korea, in 1991 and 1992, respectively, and Ph.D. degree from the University of California at Berkeley. He is currently a Faculty Member with the Department of Decision Sciences and serves as a Director of the International Center for Project Management Excellence, The George Washington University School of Business, Washington, DC, USA. He also holds a Visiting Professor position with the Department of Business Informatics and Operations Management, Ghent University, Ghent, Belgium. He has consulted and lectured worldwide for governmental organizations and private companies and has numerous publications in top journals in the field. His research interests include project and program management, project delivery and project control, engineering and technology management, and management of complex megaprojects.

Dr. Kwak is the Editor-in-Chief of the *Journal of Management in Engineering*, the specialty editor for the Case Studies section of the *Journal of Construction Engineering and Management*, and the Department Editor for the Project Management of IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT. He is the recipient of the 2023 International Project Management Association's Global Research Award, 2021 Richard. R. Torrens Award by American Society of Civil Engineers, and 2016 Outstanding Leadership Award from Korean American Construction, Engineering, and Project Management Association as a founding president. Please visit his google scholar for a complete list of publications.