



# Developing a social media firestorm scale: from conceptualization to AI-assisted validation

Kalle Nuortimo<sup>1,2,3</sup> · Janne Harkonen<sup>2,4</sup> · Kristijan Breznik<sup>2,4,5</sup> · Rajeeka Hannes<sup>3</sup>

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## Abstract

A social media firestorm (SMF) refers to a sudden surge of negative reactions, criticism, or controversy on social media platforms, typically triggered by a specific event, statement, or action. Such firestorms can affect individuals, organizations, or brands, with potential reputational and financial consequences if not addressed appropriately. This paper elaborates on an SMF scale inspired by the Saffir-Simpson hurricane scale, adopting a structured approach to SMF measurement and management. The scale defines three measurable dimensions: width (reach or scope), height (intensity of negative sentiment), and duration of peak activity (the shark-fin shape). To provide preliminary validation, an artificial intelligence-based approach was applied to selected real-world firestorm cases. The findings suggest that the framework represents a first step toward a fully validated scale, offering an initial basis for assessing the potential impact of SMFs and supporting more structured organizational responses to digital crises.

**Keywords** Social media firestorm · Digital hurricane · Reputational damage · Social media · Media sentiment · Scandal · Predictive tool · AI based scale validation

## Introduction

Social media firestorms (SMFs), sudden surges of negative reactions and controversy on digital platforms, have become a pressing challenge for organizations in the digital era. In recent years, well-known brands have suffered severe

reputational and financial losses within days due to viral firestorms. Although prior studies have explored the detrimental effects of SMFs on brand perception (Hansen et al. 2018; Hauser et al. 2017) and emphasized the importance of crisis communication (Lee & Kim 2020), there is still no structured, scalable framework for detecting, measuring, and managing these crises systematically. This gap limits organizations' ability to anticipate firestorms and respond effectively in real time (Pfeffer et al. 2014; Lappeman et al. 2018).

The lack of standardized measurement frameworks also hinders the development of a comprehensive understanding of how firestorms unfold and how they can be mitigated. While some studies propose crisis management strategies, they often fail to integrate them into unified models for assessing SMF severity and predicting outcomes (Delgado-Ballester et al. 2021). Moreover, the roles of market intelligence and reputation management in addressing SMFs remain insufficiently explored (Nuortimo et al. 2020; Salo 2022). In addition, existing methods are largely descriptive and lack the rigor associated with the development and validation of measurement tools, while practical cross-industry instruments for early detection and benchmarking remain underdeveloped. Challenges in global data analytics, such

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✉ Kalle Nuortimo  
kalle.p.nuortimo@utu.fi

Janne Harkonen  
Janne.harkonen@oulu.fi

Kristijan Breznik  
kristijan.breznik@mfdps.si

Rajeeka Hannes  
rajeeka.hannes@oamk.fi

<sup>1</sup> Department of Marketing, Turku School of Economics, University of Turku, Turku, Finland

<sup>2</sup> International School for Social and Business Studies, Celje, Slovenia

<sup>3</sup> Oulu University of Applied Sciences, Oulu, Finland

<sup>4</sup> Industrial Engineering and Management, University of Oulu, Oulu, Finland

<sup>5</sup> Faculty of Environmental Protection, Velenje, Slovenia



as scalable, real-time crisis monitoring across multiple platforms and regions, further highlight the need for robust solutions.

Figure 1 illustrates this research gap by conceptualizing the SMF phenomenon across multiple dimensions. On the left, the firestorm is depicted through its measurable dynamics, width (reach of mentions), height (intensity of negative sentiment), and overall emotional tone (sentiment). On the right, the figure highlights the broader impact of SMFs across different levels of the business environment: the corporation, its employees, its products, and the wider market context. This dual perspective demonstrates why a standardized scale is necessary, not only to quantify firestorms consistently but also to link their measurable dynamics with practical outcomes in reputation, communication, and crisis management.

Accordingly, this study responds to three specific gaps: (1) a lack of theoretical integration in defining SMF severity; (2) a lack of methodological rigor in developing and validating measurement tools; and (3) a lack of practical instruments that organizations can apply across industries to manage crises consistently.

This study aims to address these gaps by applying the Social Media Firestorm (SMF) scale (Nuortimo et al. 2020), a novel tool for assessing firestorm severity using the dimensions of engagement volume, sentiment, and reach. Although Nuortimo et al. (2020) introduced the SMF scale conceptually, their work did not extend to its systematic development or empirical validation. Advancing this contribution, the present study develops, tests, and validates the SMF scale through a constructive research approach that combines theoretical frameworks, empirical case analysis, and AI-assisted validation, thereby moving beyond prior conceptual

frameworks to deliver a structured, theory-informed, and empirically validated tool for assessing firestorm severity that strengthens both methodological rigor and practical applicability.

## The concept of social media firestorms

Social media firestorms (SMF) are characterized by the rapid, large-scale diffusion of negative electronic word-of-mouth (eVOM) targeting specific entities (Khalid et al. 2020). They have become a prevalent phenomenon in the digital age, posing challenges for organizations across industries (Pfeffer et al. 2014). Despite the availability of technological tools, systematic approaches for measuring and managing SMFs remain underutilized (Koch et al. 2021).

SMFs can arise in diverse forms, brand crises, product controversies, corporate scandals, or personal scandals (Kapoor & Bannerjee, 2021), and often result in significant reputational consequences (Hauser et al. 2017; Lappeman et al. 2018). They directly influence public relations and reputation management (Hovener 2015) and highlight the importance of proactive strategies to prevent or mitigate reputation loss (Lee 2020). Key characteristics such as speed, scale, and intensity (Pantano 2021; Hansen et al. 2018) highlight the need for structured measurement, as reputational impacts are shaped by both the volume (width) and severity (height) of negative sentiment, as well as the persistence of activity (duration).

Cultural context also influences firestorm dynamics: while in the U.S. online firestorms often center on political and social activism, in China they are more concentrated in

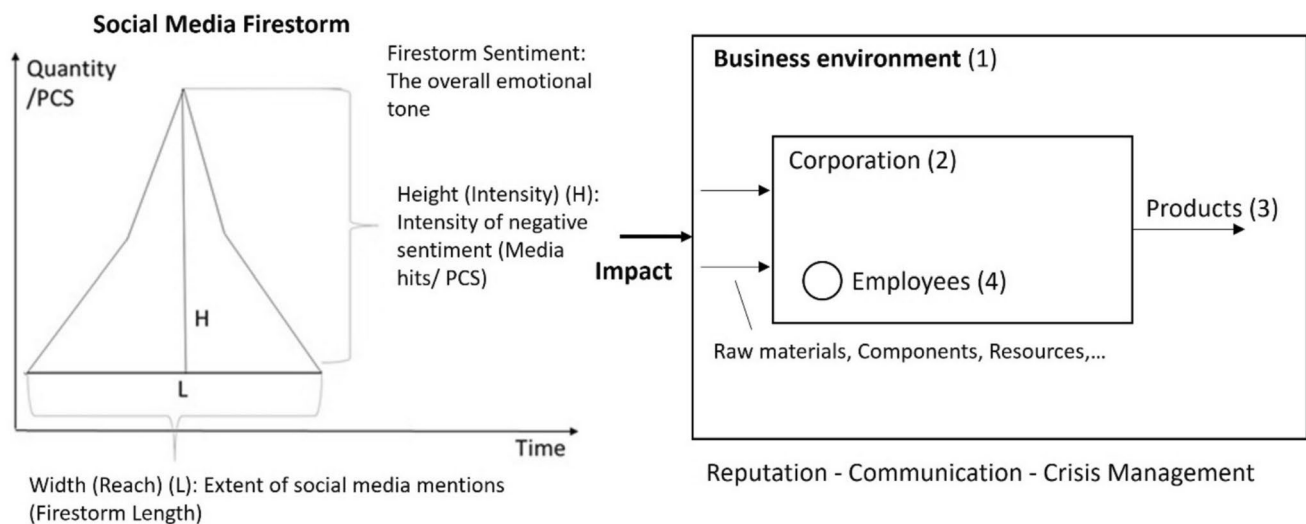


Fig. 1 Social media firestorm and its impact



entertainment and media (Kim et al. 2021). These differences highlight the necessity of a scale that can account for both global and local dynamics of width and intensity.

The consequences of SMFs extend beyond reputational loss to sales and stock performance (Delgado-Ballester et al., 2018), with negative information generally having greater impact than positive (Tirunillai & Tellis 2012). The spread of misinformation further amplifies trust erosion (Friggeri et al. 2014). Reputation loss, with long-term implications for stakeholder trust (Kaul et al. 2015) and the need for repair strategies (Wekwerth 2019), further strengthens the case for a standardized tool that captures sentiment polarity as a distinct measurement dimension.

In addition to the overall size of the firestorm, the topic and content also significantly influence corporate actions. To illustrate this diversity and to underline the need for a standardized measurement tool, Table 1 summarizes key firestorm types discussed in the literature, their typical influence, and sentiment orientation. This categorization demonstrates the variety of contexts in which firestorms occur, reinforcing the necessity of a scale that can consistently capture severity across cases.

Scholars have emphasized the centrality of crisis communication and stakeholder engagement in managing SMFs (Su et al. 2019; Lee & Kim 2020; Abdullah & Ahmad 2021). Proactive planning, including predefined crisis protocols (Gruber et al., 2015) and predictive analytics (Cwiak 2014), can help organizations anticipate risks. Apology strategies (Langaro et al. 2024; Woods 2022; Schweitzer et al. 2015), proactive transparency (Björnsson 2023), and compensation (Kuipers & Schönheit, 2022) have been shown to influence recovery trajectories. However, the effectiveness of these strategies depends on the severity level of the firestorm (Herhausen et al. 2019; Widdershoven et al. 2024).

Taken together, the literature demonstrates that while SMFs are widely studied, prior research has been largely descriptive, lacking validated tools to classify severity. By

consolidating insights from different firestorm types, this study addresses that gap by operationalizing SMF intensity through a scale inspired by the Saffir-Simpson hurricane model (Saffir & Simpson 1974; Taylor et al. 2010), and measuring crises via width, height, and sentiment (Nuortimo et al. 2020).

## Applicable theories

Social media firestorms are inherently multidisciplinary, connecting international business, marketing, and crisis management theories. Their management requires integrating insights from market orientation, reputation management, stakeholder theory, digital marketing, and social influence processes, all of which inform the construction of the SMF scale.

Market orientation and intelligence serve as a foundation for corporate monitoring. Early work (Narver & Slater 1990; Kohli & Jaworski 1990) emphasized the generation, dissemination, and organizational responsiveness to market intelligence. These principles remain highly relevant as firms increasingly rely on big data and AI-based tools for monitoring public sentiment. The SMF scale builds on this tradition by translating market intelligence into measurable severity dimensions (width, height, sentiment) that can be tracked systematically. While marketing research has often focused on the cultural characteristics of market-oriented organizations (Gebhardt et al., 2006), the SMF scale operationalizes market intelligence for crisis detection and early warning. Recent work also supports this direction: for example, Bielecka et al. (2025) shows how trigger conditions and early detection shape crisis outcomes via sentiment and reach. Similarly, Nuortimo et al. (2024) demonstrates that in real crises, speed, stakeholder perception, and communication strategies mediate the relationship between negative social media activity and reputational damage.

**Table 1** Types of Firestorms in the Literature

Firestorm Category	Example(s)	Influence	General sentiment	References
Brand Crisis	Starbucks tax crisis; McDonalds, Air Europa, Ballantine's, Qantas, H&M, United Airlines, Pepsi; Goodyear boycott	Loss of reputation	Negative	Sisson & Bowen 2017 Delgado-Ballester et al. 2021 Brooks et al., 2024
Personal scandals	Public figures facing reputation damage or controversy	Loss of reputation	Negative	Nuortimo et al. 2020
Product-related controversies	Negative sentiments surrounding products or services	Loss of reputation	Negative	Chung et al. 2019
Corporate scandals	Volkswagen emissions scandal	Loss of reputation	Negative	Jung and Sharon 2019
Global events	COVID-19 pandemic	Long-term organisational impacts	Mixed	Nuortimo & Harkonen 2021



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Reputation management and stakeholder theory (Weiss et al. 1999; Kaul et al. 2015) highlight how crises can damage relationships with customers, employees, investors, and the public. The SMF scale's three-level structure aligns with these theories by offering a stakeholder-centric tool: minor firestorms (Level 1) may only require targeted communication, while more severe cases (Levels 2–3) demand broader engagement and repair strategies. This framing clarifies how the scale links perceived severity to concrete stakeholder management actions.

Social influence theory (Friedkin, 1998) explains how individuals' emotions and reactions are shaped by collective behavior online. This provides theoretical support for the "height" dimension of the scale, as sentiment intensity captures how strongly negative emotions spread in networks. Similarly, cases of personal scandals illustrate how the visibility of individual brands interacts with social influence to escalate firestorms.

Digital marketing frameworks (Salo 2022) highlight the centrality of online platforms in shaping brand perception. Integrating the SMF scale into this framework connects crisis severity with the dynamics of social media engagement, enabling organizations to manage reputational risks in real time.

Finally, advanced media monitoring systems (Stavrakantonakis et al. 2012) provide the technological basis for applying the SMF scale in practice. These tools enable real-time detection of width (reach), height (intensity), and sentiment polarity, thus operationalizing the theoretical foundations into actionable crisis metrics. Together, these theories provide the conceptual foundation for the SMF scale and justify its validation through both case-based and AI-assisted approaches.

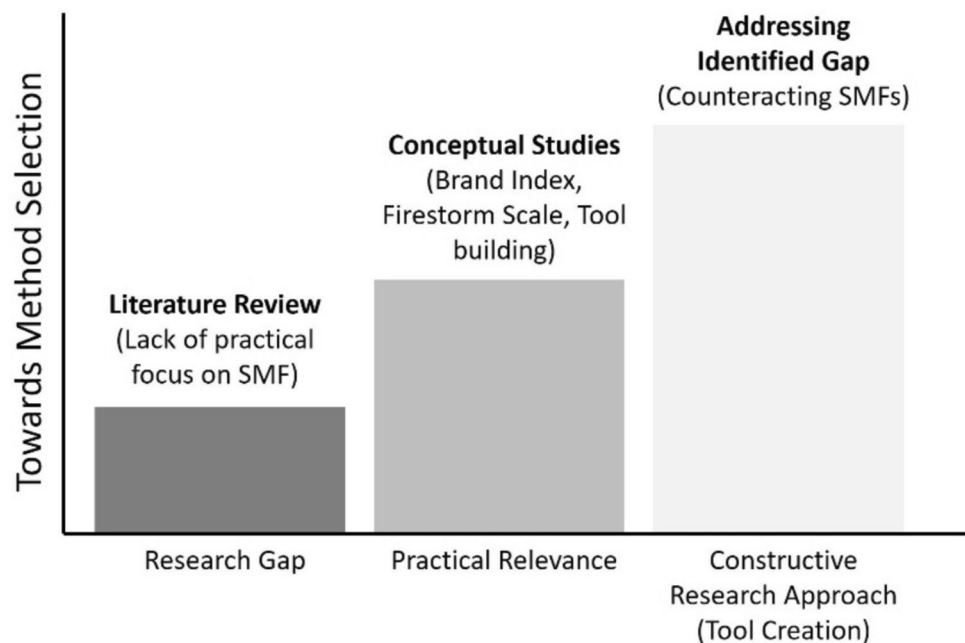
## Research approach and methods

This chapter outlines the constructive research approach applied in this study, detailing its principles, the scale construction process, and the research methods used. Given the complexity of social media firestorms (SMFs), a structured methodology is essential for developing a robust and theoretically grounded measurement scale.

Figure 2 illustrates the rationale for selecting the constructive research approach (CRA). The literature review identified a clear research gap, as prior studies lacked practical focus on SMFs. Conceptual studies such as the Brand Index and the initial SMF scale highlighted the practical relevance of the phenomenon but remained descriptive. The CRA was therefore selected to provide a systematic methodology for constructing and validating a measurement tool.

Among interventionist research methods, CRA has been successfully applied in fields such as management accounting (Rautiainen et al. 2017) and information systems design (Crnkovic 2010), where practical solutions must

**Fig. 2** Selection of the constructive research approach for scale development



be both theoretically justified and empirically validated. In this study, CRA was selected because of its focus on systematically constructing and testing artifacts, in this case a measurement scale for assessing SMFs. Following the stages described by Lukka (2003) and Crnkovic (2010), the research process advanced through six steps: (1) problem identification, where the lack of a standardized measurement tool for SMFs was recognized; (2) theoretical grounding, drawing on crisis communication, reputation management, and sentiment analysis to conceptualize scale dimensions; (3) construction, in which the SMF scale was designed by operationalising width, height, and sentiment as measurable indicators; (4) practical validation, carried out through expert input, empirical case studies, and AI-assisted simulations; (5) reflection, in which the outcomes were compared with theoretical expectations and prior research; and (6) generalization, where the potential cross-industry applicability of the scale was outlined. This systematic progression, combined with multiple validation strategies, ensured that the scale was grounded in both theory and practice, while also leaving room for iterative refinement and innovation (McGregor 2018; Jones et al. 2023). These steps are further operationalized in the development process shown in Fig. 3, which illustrates how theory, construction, and validation were integrated.

Figure 3 visualizes how these CRA steps were applied in the development of the Social Media Firestorm (SMF) scale. Instead of restating the six steps, the figure highlights their concrete application: the integration of multiple theory bases, the construction of measurable indicators (width, height, sentiment), and the validation cycle through expert input, case studies, and AI-assisted simulations.

The development of the SMF scale also followed established guidelines in scale construction (Churchill 1979; Hinkin 1995; DeVellis & Thorpe 2022). The process began with conceptualisation, drawing on patterns of scandals reported in the literature and aligning them with crisis management theory. Item generation was inspired by the Saffir–Simpson hurricane scale (Saffir & Simpson 1974), which provided a template for structuring levels of intensity. Refinement was supported by expert feedback and pilot testing to ensure clarity, relevance, and content validity. The resulting dimensions of the SMF scale included the volume of engagement (width), sentiment intensity (height), and duration of influence (length), which together captured the severity and dynamics of social media firestorms. The iterative nature of the process allowed items to be revised to ensure that they accurately represented the underlying constructs.

Validation of the scale was carried out through three complementary approaches that provided triangulation. First, expert review was used to refine construct definitions and scale items. Second, case-based testing was conducted through the analysis of six real-world SMFs from Finland. Although geographically limited, these cases represented diverse industries and contexts, which strengthened internal validity. Third, AI-assisted validation was performed through simulations, which enabled systematic comparison of scale performance across different scenarios. While these simulations simplified reality by not including organizational responses, they nonetheless provided an independent and replicable means of testing the severity dimensions. Ensuring validity and reliability is a core principle of CRA; while full psychometric testing such as exploratory and confirmatory factor analysis, discriminant validity tests,

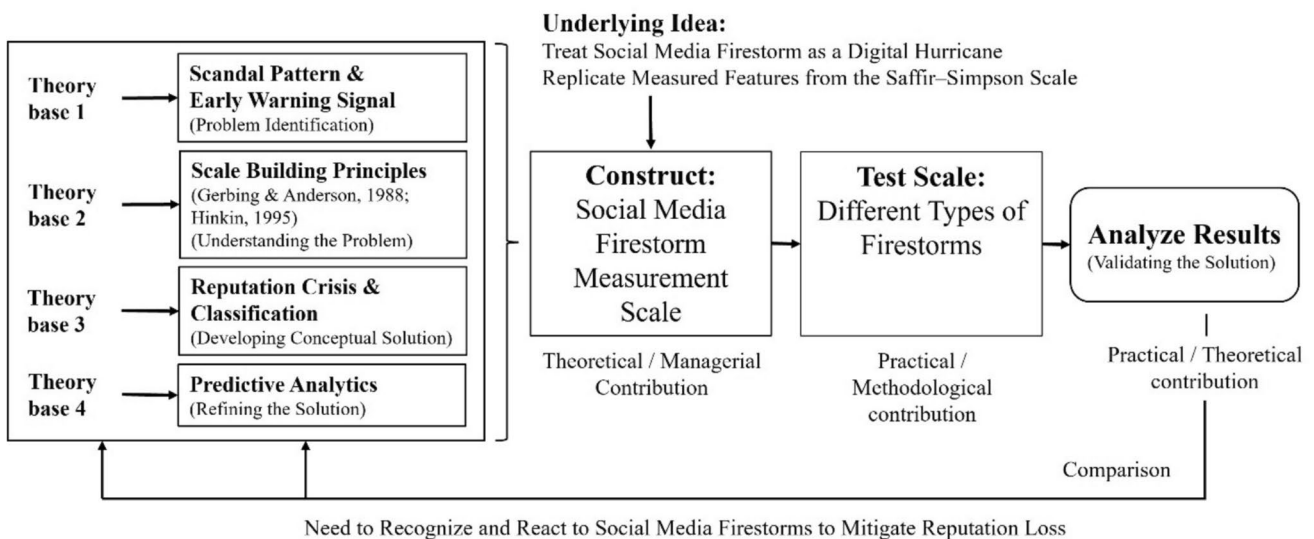


Fig. 3 Constructive research approach for SMF scale development



and reliability analysis with Cronbach's alpha are identified as essential next steps, the triangulated validation strategies used here provide initial robustness. This triangulated design strengthens credibility, as combining qualitative expert insights, empirical cases, and computational simulations reduces the risk of method-specific bias and increases confidence in the robustness of the scale (Jick 1979).

Finally, the constructive research approach ensures that the SMF scale contributes not only as a measurement tool but also as a theoretical advancement. By operationalising severity in a structured framework, the scale enables future hypothesis testing, comparative case analysis, and integration into crisis communication and reputation management models. Rather than viewing scope limitations, such as reliance on Finnish case data and the absence of large-scale statistical testing, as weaknesses, these are identified as opportunities for future research. Extending validation across different cultural contexts and applying full psychometric testing will be essential next steps to strengthen generalizability and reliability. This study therefore represents a critical first step in systematic SMF measurement. It delivers a structured, validated scale, demonstrates its managerial utility across industries, and establishes a foundation for future cross-cultural and psychometric validation.

## Scale building and use

The scale-building process draws an analogy from the Saffir-Simpson Hurricane Scale, which categorises hurricanes based on their intensity, ranging from Category 1 to Category 5 (Saffir & Simpson 1974; Taylor et al. 2010). In this study, the scale is adapted to three levels (1–3), as lower-level firestorms (Level 1) are subtle, hard to detect, and challenging to measure using standard social media monitoring (SMM) tools.

To create a modified scale for assessing social media firestorms (SMFs), several key measurement dimensions are included:

- *Volume of Social Media Engagement (width)* captures the overall level of engagement triggered by the firestorm, such as the number of mentions, shares, comments, and total reach of the content. It reflects the magnitude of the firestorm's impact and its potential to escalate. On the scale, this is visualised as the spike's width.
- *Sentiment Intensity (height)*: the prevailing sentiment of the firestorm, whether negative, positive, or mixed. A higher negativity score indicates a more severe and potentially damaging firestorm.
- *Duration of Influence (length)*: measures how long the firestorm remains active and influential in public dis-

course. This dimension ensures that short-lived spikes are distinguished from sustained crises.

- *Media Attention*: considered as a contextual amplifier rather than a core dimension, traditional and online media coverage can act as an amplifying factor, reinforcing the breadth of exposure.

By combining these factors, the scale enables the classification and comparison of firestorms based on their intensity, sentiment, and reach, providing organisations with a practical tool for monitoring and responding to online crises.

To ensure methodological rigour, the development of the Social Media Firestorm (SMF) scale followed established protocols for scale construction (Churchill 1979; Gerbing and Anderson 1988; Hinkin 1995; DeVellis & Thorpe 2022), which provided a structured framework for item generation, refinement, and validation.

The scale building-process has now advanced to the testing and validation phase, although further validation is still required to confirm its reliability and applicability across contexts (Fig. 4). The initial conceptualisation and foundation of the scale are summarised in Table 2.

The analogies from the Saffir-Simpson (S–S) scale are presented in Table 3. Initially, items were replicated, the scale was constructed, and preliminary testing was concluded in Nuortimo et al. 2020. Further testing took place in case of COVID-19 pandemic (Nuortimo & Harkonen 2021). In this paper, an additional content analysis case was included with classification, along with several others evaluated using the scale. The final stage of this study focuses on enhancing the scale's validity through further testing. Table 3 illustrates how items were replicated and adapted from the Saffir-Simpson scale to the SMF scale.

After progressing to the Item Testing phase, multiple cases were added to the dataset to support validation. At this stage, the tested cases are exclusively from Finland, which limits generalizability. As noted in the Methods, this limitation will be addressed through future cross-cultural validation and full psychometric testing, ensuring broader reliability of the SMF scale.

This staged process ensures that the SMF scale is theoretically grounded, progressively validated, and ready for future replication across cultural contexts and industries.

## Case comparison from different aspects of measurement (item testing)

To validate the scale structure, six cross-case comparisons from different types of firestorms were made to estimate their impact, as presented in Table 4. These cases represented a range of firestorm categories, each with unique characteristics and implications.



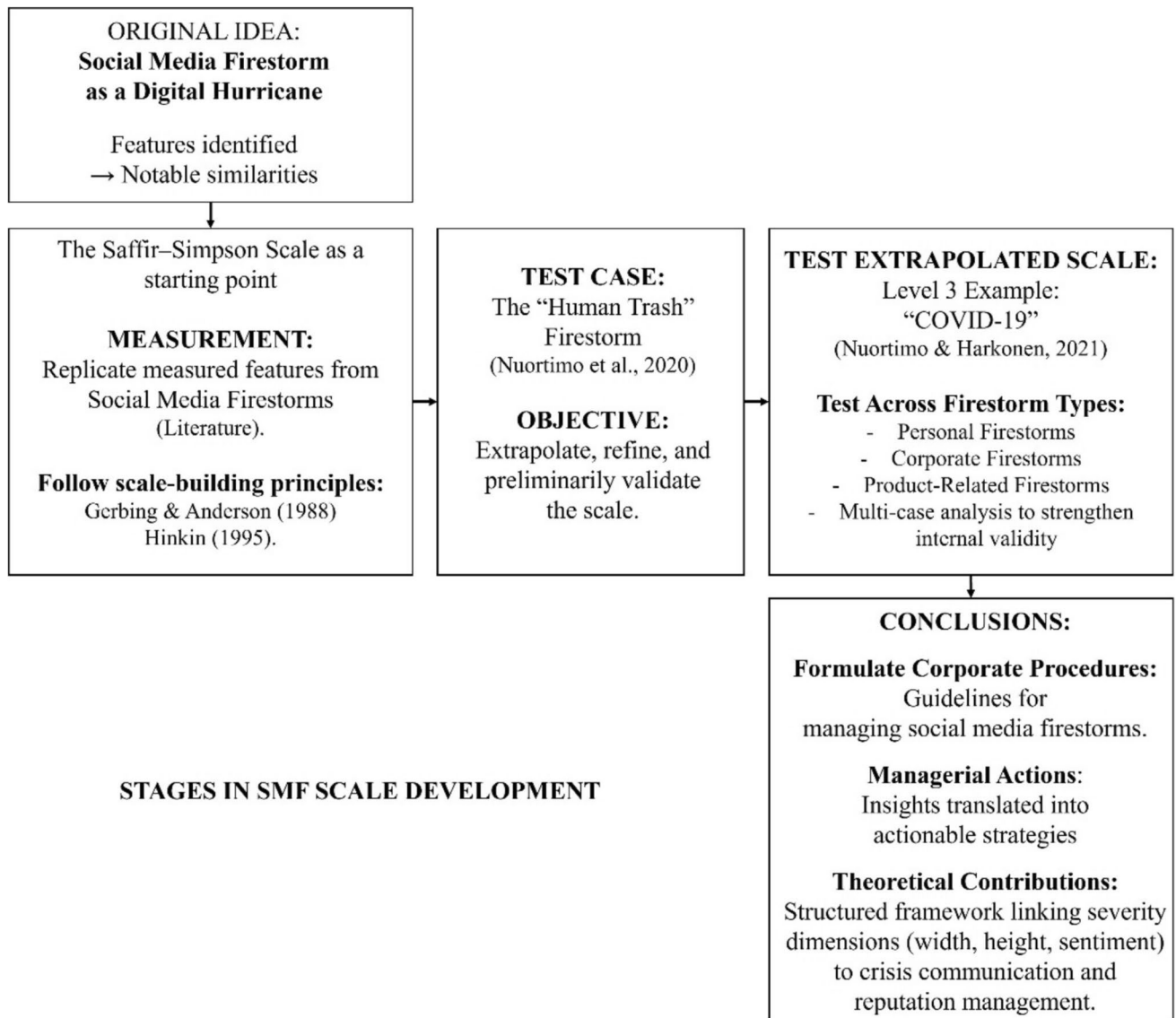


Fig. 4 Social media firestorm scale building

Table 2 Saffir-Simpson Scale with Potential Damage (Adapted from Lester, 1995)

Category	Pressure (hPa)	Wind speed (kt)	Storm surge (ft)	Potential damage
1	> 980	64–82	4–5	Damage mainly to trees, shrubbery, and unanchored mobile homes
2	965–979	83–95	6–8	Trees blown down; exposed mobile homes damaged; moderate roof damage possible
3	945–964	96–113	9–12	Large trees blown down; mobile homes destroyed; significant damage to small buildings
4	920–944	114–135	13–18	All signs blown down; extensive damage to roofs, windows, and doors; complete destruction of mobile homes; flooding inland up to 10 km; major damage to lower floors near the shore
5	< 920	> 135	> 18	Severe damage to windows and doors; extensive damage to homes and industrial buildings; major destruction of lower floors less than 4.5 m above sea level within 500 m of the shore



**Table 3** Analogies derived from scale building principles

Scale building principles: Item Replication from Saffir-Simpson (S–S) to SMF		
Stage/Step	Item replication	Measurement/Testing notes
Stage 1: Developing the measures		
Step 1: Item generation	S–S: Pressure → SMF: Negative Sentiment	Reduced from 5 levels (S–S) to 3 levels (SMF), based on literature
Step 2: Item wording	S–S: Wind → SMF: Duration (Length)	Reflects the temporal dynamics of firestorms
Step 3: Number of items	S–S: Storm Surge → SMF: Spike Height	Captures intensity and visibility of online escalation
Step 4: Item scaling	Adapted to 3-point ordinal scale	Consistent with firestorm intensity levels
Step 5: Content validity assessment	Expert review and pilot testing	Ensures conceptual clarity and practical relevance
Stage 2. Testing the new measures		
Step 1: Selecting a sample	First Case: “Human Trash” Firestorm	Initial application in real-world setting
Step 2: Preliminary factor analysis	Scale extrapolation:	Used to identify latent dimensions
Step 3: Confirmatory factor analysis	Scale 1 (derived from literature) showed no significant influence; items were refined based on empirical fit	Refined items based on empirical fit
Step 4: Internal consistency assessment	COVID-19 firestorm (Nuortimo & Harkonen 2021)	Example of reliability testing
Step 5: Convergent and discriminant validity	Across multiple firestorm cases	Tested construct distinctiveness (Type + Influence + Actions)
Step 6: Criterion-related validity	Alignment with corporate response strategies	Tested the predictive utility of the scale
Step 7: Replication	Across new datasets and cases	Future validation for generalizability

### Firestorm categories and analysis

1. Level 1 Firestorms: These firestorms were harder to detect and, as a result, required more thorough scanning and classification. They were typically characterized by smaller but still impactful incidents.
2. COVID-19 Impact: The coronavirus pandemic’s impact on corporations was considered within the Finnish context only. The global implications of COVID-19 were linked to market orientation and market intelligence (Narver and Slater 1990). Although an early warning signal existed (Nuortimo & Harkonen 2021), the impact on company reputations was minimal (Nuortimo et al. 2024), indicating that such global events generally affected market orientation (Narver & Slater 1990) and strategic adaptation rather than direct reputational loss. This highlighted how the SMF scale differentiated between crises that reshape market intelligence and those that directly damage corporate reputation.
3. Social Media Firestorms: These were diverse cases selected from various contexts, including market environments, products, company brands, and personal brands. Each case was linked to different theoretical fields based on the nature of the topic at hand.

### Case descriptions and insights

The analyzed cases presented in Table 4 can be briefly explained as follows.

*Significant global event* (Covid-19 Pandemic): was extensively covered in the media over a prolonged period, with wide-ranging economic, social, and political impacts globally reported. This case demonstrated how global events can reshape market intelligence without necessarily producing direct reputational loss, highlighting the SMF scale’s ability to differentiate between market-level and reputational crises.

*Personal Scandal* (Human Trash, Nuortimo et al., (2020)): Oulu city councilor Riikka Moilanen, also CEO of a healthcare company, referred to marginalized individuals as “human trash” during a council meeting. The statement triggered widespread outrage and ultimately forced her dismissal, illustrating how public opinion storms can cause severe personal and organizational reputational damage. This case demonstrates the SMF scale’s ability to capture personal-level reputational crises amplified by social media sentiment.

*Personal Scandal* (National Audit Office—Yli-Viikari): Auditor General Tytti Yli-Viikari was dismissed after revelations of inappropriate spending practices and misuse of benefits, which severely undermined the credibility of the National Audit Office. The scandal followed a two-peak



**Table 4** Firestorm Intensity in the SMF Scale

Firestorm	Category	Duration (length, days)	Sentiment Intensity (height)	Sentiment	Engagement Volume (width)	Type	Early Warning	Damage
Covid pandemic (A significant global event)	3	90	4000	20% negative	72,000	Global influencing event	Yes	Global, no reputation loss
Human trash (A politician called the disadvantaged human trash)	2	30	420	42% negative	5292	Local personal scandal	No	Personal reputation loss, individual fired
National Audit Office Yli-Viikari (Breach of official duties laid down in the Act on Parliamentary Public Servants)	2	90	230	29% negative	6003	Local personal scandal	No	Personal/ Corporate reputation loss, individual fired
Sanna Marin's phone (Prime minister did not have government phone on her during a day off)	2	8	2500	32% negative	6400	Global personal scandal	No	Media damage, no job loss
Vastaamo (Finnish Private Psychotherapy service)	2	25	1500	31% negative	11,625	Local large company scandal	No	Reputation loss, customer data breach
Oura (Company providing Smart rings)	2	15	120	8% negative	144	Local small product scandal	No	Product delivery issues

pattern of public outrage, first after her denial of wrongdoing and Parliament's condemnation, and later during her parliamentary hearing and dismissal. This dynamic illustrates how the SMF scale captures multi-wave crises through its height and length dimensions, strengthening understanding of temporal variation in firestorms.

*Political Scandal (Sanna Marin's Phone Incident):* The incident where Finland's Prime Minister, Sanna Marin, went to a bar without her official phone, created a media frenzy. The Marin case demonstrated how a firestorm scored high on width (engagement volume) and media attention while remaining relatively short in duration (length), demonstrating the utility of the SMF scale in distinguishing between transient and sustained crises. This case, while generating significant media coverage, did not have early warning signals and had minimal long-term impact on reputation. This case demonstrated the SMF scale's ability to distinguish between transient and sustained crises, despite minimal long-term reputational damage.

*Corporate Scandal (Vastaamo):* The cybersecurity breach that led to the bankruptcy of Vastaamo, a Finnish Private Psychotherapy service, exemplified a large corporate scandal with widespread consequences, including reputation loss and financial damage due to a customer data breach. This case validated the severity dimension (height) of the SMF scale, showing how reputational damage escalated when combined with sensitive data breaches, thereby confirming the scale's ability to capture high-impact organizational crises.

*Product Scandal (Oura):* The delivery challenges during key product launches associated with the Oura product, smart rings, represented a small-scale product firestorm. This case fell under the category of a product-related scandal, where the damage to reputation was significant at the time but limited in scope. This case validated the width (volume) and length (duration) dimensions on a smaller scale, showing that the SMF scale can consistently capture even limited product-related firestorms and confirming its applicability across different scales of crises.



*Social Media Impact:* Several of these cases were linked to social media firestorms, highlighting the increasing role of platforms in shaping public opinion and reputation, further underlining the value of the SMF scale in detecting and classifying such events. The presence or absence of early warning signals and the intensity of public sentiment played critical roles in determining the extent of damage.

These cases collectively validated the SMF scale's applicability across personal, political, corporate, and product crises, demonstrating its robustness as a cross-contextual framework.

### Scale validation via AI

A test by AI simulation was conducted to validate the Social Media Firestorm (SMF) scale using real-world data. The purpose of the simulation was to evaluate the predictive validity of the SMF scale. GPT-4o-mini was utilized to simulate analysis and validate the scale in five firestorm scenarios, each representing different crisis types: two personal scandals, one product failure, one corporate scandal, and one global crisis. The cases were deliberately selected to represent diverse crisis types (political, product-related, corporate, and global) and industries (government, healthcare, technology, and pandemic response). While this selection ensured conceptual variety, all cases were drawn from the Finnish context, reflecting its cultural and demographic environment. This enhances internal consistency but constrains cross-cultural representativeness, which is acknowledged in "Limitation" section.

The engagement and sentiment datasets were sourced from a commercial M-Brain monitoring platform, which applies proprietary machine-learning sentiment analytics. These structured metrics (reach, sentiment distribution, engagement counts) served as the inputs for the AI-assisted validation. GPT-4o-mini was applied off-the-shelf, without fine-tuning, as a general-purpose NLP tool to cross-check scale predictions.

For each scenario, the SMF scale's three core dimensions were applied:

- (1) *Width (Reach):* Number of mentions across social media platforms;
- (2) *Height (Intensity):* Level of negative sentiment, rated on a scale from 1 to 5;
- (3) *Sentiment:* Overall tone of the firestorm (negative, neutral, or mixed).

**Note:** Length (Duration) was excluded due to dataset limitations, which should be considered when interpreting the results.

Height (Intensity) was operationalized by mapping sentiment proportions onto a 1–5 scale (e.g., < 20% = 1,

40–59% = 3, ≥ 80% = 5). Width (Reach) was derived from total mention counts. These were then benchmarked against the SMF scale's three-level classification (weak, moderate, strong).

The SMF scale was operationalized with three severity levels, reflecting weak, moderate, and strong effects. This choice balances conceptual clarity and managerial usability, as highlighted in recent crisis measurement research (Herhausen et al. 2019; Pfeffer et al., 2014). Furthermore, the AI validation results showed that cases clustered naturally into these three levels, confirming that this structure captures observable variation without unnecessary complexity.

Each scenario was evaluated for its predicted outcome, including reputational damage, escalation, and financial impact. These predictions were based on the assigned values for width, height, and sentiment. The predicted outcomes were compared with reported real-world consequences to assess consistency and predictive accuracy. This procedure ensured that both the predictive logic of the scale and the contextual variation of the cases were tested. The validation test provided insights into the scale's effectiveness and robustness in categorizing firestorms based on their potential consequences.

This approach aligns with recent advances in crisis informatics and AI-driven sentiment analysis. For example, recent reviews such as Wahid et al. (2025) and Cao (2023) demonstrate how modern natural language processing (NLP)/AI models are used reliably for crisis detection, sentiment anomaly detection, and resilience analytics, supporting the methodological credibility of our AI validation design.

However, the test has limitations, including the simplified nature of the simulated scenarios. The representativeness of the cases is also limited, as the dataset reflects Finnish-only cases, which may not capture linguistic, cultural, or industry-specific differences across other countries. The exclusion of organizational crisis management procedures, reliance on Finnish-only datasets, and potential bias in AI-driven sentiment analysis (e.g., sarcasm, cultural nuance, multilingual data) may also affect the validity of the results. These findings should be interpreted cautiously, as the simplified scenarios and exclusion of organisational crisis responses may limit the generalizability of results.

The validation results are presented as shown in Table 5 and Fig. 5.

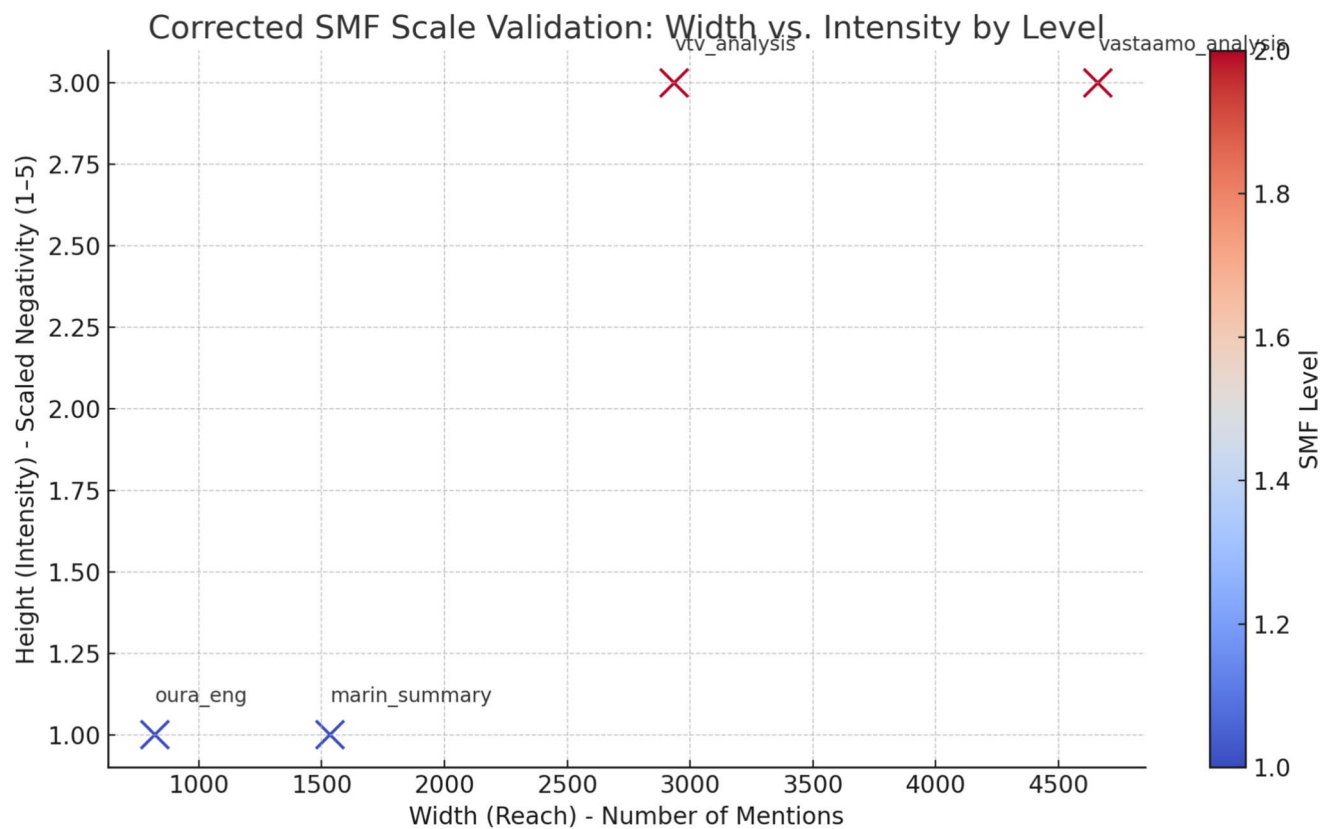
The AI system analyzed key SMF dimensions, Width (Reach), Height (Intensity), and Sentiment, and compared the computed values to the SMF scale's predictive categories. Alignment with expected reputational escalation was assessed to evaluate the scale's predictive robustness.



**Table 5** AI-based scale validation

Case	Width (Reach) (L)	Negative (%)	Height (Intensity) (H)	Senti-ment (Overall)	SMF Level	Description
Marin	1,534	19.3%	1	Neutral	Level 1	Demonstrated a weak effect, hard to detect, minimal action needed
Oura	821	14.4%	1	Neutral	Level 1	Validated as a weak effect, low risk
Vastaamo	4,660	41.2%	3	Mixed	Level 2	Validated as moderate, requires strategic PR and engagement
National Audit Office	2,935	47.3%	3	Mixed	Level 2	Validated as moderate, requires strategic PR and engagement
COVID	12,194	41.9%	3*	Mixed	Level 3	Confirmed as an extremely large effect; high reach and moderate negativity require full crisis readiness

\*The value '3' indicates an extreme case where a scale adjustment was applied to account for global reach effects



**Fig. 5** AI-simulated validation results: width (reach) vs. height (intensity), with SMF levels color-coded

The coding rules (e.g., mappings from sentiment percentages to intensity levels) and validation spreadsheets (applying these rules to each case) were systematically documented to ensure internal consistency. While the proprietary nature of the M-Brain data prevents external sharing, the procedures are described in sufficient detail to support methodological transparency and reproducibility.

**AI Validation results**

AI validation was performed using real case data. An initial AI simulation was conducted without real data to calibrate the model. The AI validation is consistent with manual validation done earlier, main differences including scale classification differences between level 1 and 2 in two cases (Marin and Oura). AI validation confirmed that



the scale performs consistently with expectations across the varied real-world crisis cases. The predictive accuracy and practical applicability of the SMF scale, when applied to structured sentiment and engagement data, even across distinct types of firestorms, is validated. The scale captures the volume and extremity of negativity and is analogous to the "storm surge height" in the Saffir-Simpson hurricane model.

The simulation results to validate the SMF scale are presented in Table 5. The simulation results indicate that the SMF scale is effective in predicting outcomes, with higher width and height leading to more severe reputational damage and escalation in all scenarios.

The simulation was carried out by constructing five firestorm scenarios with varying severities (low, moderate, and high). For each scenario, the SMF scale was applied using the three core dimensions: width, height, and sentiment. The dimensions were assessed as follows:

*Width (Reach)*: The extent of social media mentions and discussions about the firestorm, ranging from low reach (100 mentions) to high reach (20,000 mentions).

*Height (Intensity)*: The intensity of negative sentiment expressed in the firestorm, rated from 1 (low intensity) to 5 (high intensity).

*Sentiment*: The overall emotional tone of the conversation (negative, neutral, or mixed).

For each scenario, the predicted outcome was estimated based on the combination of width, height, and sentiment:

- *Reputational Damage*: The anticipated impact on the brand or individual's reputation.
- *Escalation*: The likelihood of the crisis intensifying based on intensity and sentiment.
- *Financial Impact*: Potential consequences such as loss of sales, stock market decline, or other financial losses.

After assigning values to width, height, and sentiment, the SMF scale's predictive ability was assessed by comparing the expected outcomes with the simulated crisis consequences, helping evaluate the scale's effectiveness in predicting the severity of different firestorm types. The SMF scale was found to be validated as effective in predicting the outcomes based on the simulated data, with higher width and height leading to more severe reputational damage and escalation in all scenarios.

Across all five scenarios, the scale performed effectively in predicting firestorm severity:

- *Personal Scandal (Marin & National Audit Office)*: The scale demonstrated minimal damage in the Marin case

and validated moderate damage in the National Audit Office case. These predictions aligned with expert manual classifications, with a one-level difference observed in the Marin case.

- *Product Crisis (Oura)*: The scale validated its reliability in predicting minor reputational damage, escalation, and financial impact, with one-level difference from manual classification.
- *Corporate Scandal (Vastaamo)*: The scale validated Level 2 reputational and financial damage, aligning with manual classification for this crisis type.
- *Global Crisis (COVID-19)*: The scale confirmed Level 3 damage and noted uncertainty regarding escalation, reflecting the complexity of global events like a pandemic.

These results collectively validated the robustness and predictive value of the SMF scale in assessing diverse firestorm scenarios.

## Limitations

The AI validation of the SMF scale has several limitations. First, it lacks organizational context, as the simulation excludes how organizations actually respond to crises, which may influence real-world outcomes. Second, it risks sentiment classification bias, as sentiment analysis can misinterpret sarcasm, cultural nuances, or multilingual content. Third, it reduces complex crises to simplified variables, capturing them only through numerical dimensions (width, height, and sentiment), which may oversimplify the dynamics of actual firestorms. Fourth, the length (duration) dimension was excluded in this AI validation due to dataset limitations, which constrains the scale's completeness. In addition, while recent studies (e.g., Wahid et al. 2025; Cao 2023) demonstrate the reliability of AI and NLP in crisis detection and sentiment analysis, their application to SMF scale validation is still novel. This limits comparability with prior validation frameworks and highlights the need for further replication and benchmarking across contexts. Fifth, the representativeness of the cases is limited. While the five selected cases span personal, corporate, product-related, and global crises, they are drawn exclusively from the Finnish context. This cultural and geographic concentration limits its broader applicability. Future research should therefore extend validation to cases across different countries, languages, and industries to ensure cross-cultural robustness. Sixth, several standard psychometric validation procedures such as exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and internal reliability assessments (e.g., Cronbach's alpha) were not executed in the current study due to data constraints. Finally, the analogy to the Saffir-Simpson



hurricane scale, while useful as a heuristic starting point, carries inherent risks of oversimplification. Natural disasters and social phenomena differ in complexity and dynamics, and the analogy should be regarded as illustrative rather than definitive. This study moves beyond the metaphor by operationalizing the dimensions (width, height, sentiment) and testing them empirically, yet future research should refine the scale independently of the analogy.

Overall, these factors suggest that the validation results should be seen as indicative but not yet confirmed and should be supplemented by real-world testing to strengthen robustness and applicability. While the triangulated validation design (expert input, case studies, and AI-assisted simulations) provides preliminary rigor, the absence of EFA, CFA, and reliability testing remains a methodological limitation. Likewise, reliance on Finnish-only case data constrains cross-cultural applicability. Future research will need to undertake full psychometric testing (e.g., factor analysis, reliability measures) on larger, multi-contextual datasets to establish generalizability.

## Discussion

This paper examines social media firestorms (SMFs), a rapidly emerging phenomenon in digital crisis management. It provides a theoretical framework for understanding these events, drawing parallels between SMFs and hurricanes, and introduces a preliminary scale for measuring their intensity. Based on the dimensions of width, height, and sentiment, the SMF scale enables organizations to assess firestorm severity and develop more structured, proactive responses. The findings emphasize the importance of timely crisis communication, effective reputation management, and continuous monitoring to mitigate the impact of such crises.

From a broader perspective, the SMF phenomenon reflects the growing influence of digital platforms in shaping public opinion and organizational reputation. The proposed scale offers organizations a practical tool to predict and prepare for potential crises, reinforcing the need for systematic approaches to crisis management in an era of heightened digital scrutiny. As social media increasingly amplifies even minor controversies, the inevitability of SMFs highlights the critical role of advanced tools for detection and mitigation. Furthermore, the study's emphasis on personal branding, as illustrated in several case studies, demonstrates how individual visibility can significantly contribute to the escalation of online controversies.

## Theoretical implications

The development of the Social Media Firestorm (SMF) scale provides significant theoretical contributions to the fields

of crisis management (Gruber et al., 2015), communication (Lee & Kim 2020), and reputation theory (Hauser et al. 2017; Delgado-Ballester et al. 2021; Sisson & Bowen 2017). By offering a structured framework for measuring firestorms based on severity, engagement volume, and sentiment, the scale enhances conceptual clarity and operationalizes key factors influencing crisis outcomes. This structured approach enables comparative analysis across diverse cases, refining existing theories and fostering new insights into the effectiveness of crisis management strategies.

In addition to these theoretical contributions, this study makes a methodological advancement by moving beyond prior conceptual proposals of the SMF scale (e.g., Nuortimo et al. 2020) to its systematic development and empirical validation. The triangulated validation design, combining expert input, case-based testing, and AI-assisted simulations (Jick 1979), addresses methodological gaps by reducing method-specific bias and strengthening robustness. While large-scale psychometric testing (e.g., exploratory factor analysis, confirmatory factor analysis, reliability measures) remains future work, the study clearly identifies this as the next step to confirm generalizability, thereby ensuring methodological transparency. Accordingly, the present study should be seen as a first step in operationalizing and testing the SMF scale rather than a definitive end product.

The SMF scale also brings fresh perspectives to a range of prior works (e.g., Björnsson 2023; Brooks, 2024; Hansen et al. 2018; Herhausen et al. 2019; Kim et al. 2021; Lappe-man et al. 2018; Nuortimo et al. 2020; Pfeffer et al. 2014; Wekwerth 2019; Woods 2022). For example, its application facilitates a more systematic exploration of the relationship between firestorm severity and organizational responses, contributing to the development of predictive and explanatory theories regarding reputational damage (Nuortimo et al. 2020; Hovener 2015). Drawing inspiration from the Saffir-Simpson hurricane scale (Saffir & Simpson 1974; Taylor et al. 2010), the SMF scale's unique contribution lies in measuring firestorm intensity through the dimensions of width, height, and sentiment, thereby aligning with and extending previous research (Nuortimo et al. 2020).

Compared to earlier literature, the SMF scale strengthens crisis management frameworks by introducing a more granular and standardized tool for assessing digital crises (Hauser et al. 2017; Lee & Kim 2020). This approach aligns closely with market orientation theory, which emphasizes the importance of gathering market intelligence to guide organizational responses (Narver & Slater 1990). Applying the SMF scale enables organizations to better allocate resources, tailor communication strategies, and respond effectively to crises of varying severity, a capability that is particularly critical during global challenges such as the recent pandemic (Nuortimo & Harkonen 2021).



Moreover, integrating the SMF scale into reputation management theory supports the development of proactive reputation strategies. It allows organizations to anticipate potential crises and align their actions with stakeholder expectations, thereby mitigating reputational risks and fostering resilience in highly volatile digital environments (Lappeman et al. 2018; Kaul et al. 2015). By addressing theoretical, methodological, and practical gaps, the study demonstrates how the SMF scale advances beyond descriptive crisis studies toward a validated and actionable measurement tool.

Taken together, the study's primary contributions are methodological and practical: developing and preliminarily validating the SMF scale and illustrating its potential utility as a standardized decision-support tool. The secondary contribution is theoretical, as the proposed scale operationalizes firestorm severity dimensions (width, height, sentiment) and links them to crisis communication and reputation management theories. This distinction highlights how the study advances beyond prior conceptual works, ensuring scholarly relevance while delivering tangible managerial value. While current validation is based on Finnish cases and computational simulations, these scope limitations represent opportunities for future research, particularly through cross-cultural validation and full psychometric testing.

At the same time, the study contributes to ongoing methodological debates by situating AI-based validation within the broader field of crisis informatics. Recent advances in crisis informatics and AI-based sentiment analysis confirm the reliability of such methods for crisis detection and monitoring (Wahid et al. 2025; Cao 2023). These studies support the credibility of using AI as part of the SMF scale validation. The decision to adopt three SMF severity levels is grounded in both conceptual and empirical reasoning: prior research emphasizes the value of simple, managerially usable classification tools (Herhausen et al. 2019; Pfeffer et al. 2014), and our validation results showed that the diverse cases clustered naturally into weak, moderate, and strong effects, indicating that three levels capture observable variation without unnecessary complexity. Thus, while this study cannot yet claim full statistical validation, its triangulated design provides a more rigorous foundation than descriptive case illustrations alone.

## Managerial implications

The Social Media Firestorm (SMF) scale offers valuable managerial insights for organizations seeking to mitigate the impact of digital crises and safeguard their reputation in volatile online environments. Integrating the SMF scale into crisis management strategies enables businesses to detect, assess, and respond to social media firestorms proactively, thereby minimizing reputational damage and protecting

brand equity. However, its use at this stage should be seen as exploratory, illustrating how the scale could guide practice, rather than as a finalized or universally validated tool.

From a methodological perspective, the preliminarily validated SMF scale ensures that managerial recommendations are not only conceptually grounded but also empirically tested. This increases confidence in its use as a decision-support tool across industries, enabling organizations to calibrate responses proportionally to crisis severity.

Early detection is a critical advantage. By leveraging social media monitoring tools to track mentions, sentiment, and emerging firestorms, companies can intervene rapidly to prevent escalation. This proactive approach highlights the importance of comprehensive crisis response plans that include predefined roles, responsibilities, messaging templates, and escalation protocols calibrated to the severity levels identified by the SMF scale.

For example, a consumer products company facing delivery delays could apply the SMF scale to classify the incident as a Level 1 firestorm (low width and height). This would justify a proportionate response such as targeted customer updates rather than a costly full-scale PR campaign, thereby conserving resources while maintaining trust. Conversely, a service provider experiencing a data breach might be classified as a Level 2 firestorm, triggering escalation protocols including regulatory notification, stakeholder briefings, and enhanced monitoring. At the personal level, a public figure facing a local scandal might also be classified as Level 1 or 2, guiding whether discreet clarification or a formal public statement is required. At the corporate level, a large-scale breach of trust (e.g., mismanagement or fraud) could reach Level 3, necessitating comprehensive crisis communication, executive accountability, and long-term reputation repair initiatives. In this way, managers can use the SMF scale to calibrate responses and guide action across personal, product, corporate, and global crises.

Transparent and empathetic communication during a firestorm is essential. Organizations must maintain consistent messaging and engage stakeholders, including customers, employees, and partners, by addressing their concerns and demonstrating accountability. Training spokespersons in crisis communication ensures the delivery of timely and effective messages across all channels. Furthermore, collaboration with industry experts, regulatory bodies, and third-party organizations can enhance credibility and support effective crisis resolution.

Post-crisis, the SMF scale serves as a valuable tool for evaluating response effectiveness and refining future crisis management protocols. Cultivating a culture of learning and adaptation strengthens organizational resilience. In addition, proactively engaging in positive brand communication and community-building reinforces corporate reputation and reduces vulnerability to future crises.



## Conclusions

This study contributes to addressing the challenge of managing social media firestorms (SMFs) by proposing a structured framework for organizations to assess and respond to digital crises. The SMF scale, inspired by the Saffir-Simpson hurricane scale, is based on three key dimensions: width, height, and sentiment. Unlike prior conceptual proposals, this study advances the discussion of the SMF scale through its systematic development and preliminary validation, using triangulated methods (expert input, case studies, and AI-assisted simulations). This suggests that the scale can serve as a tool to monitor and evaluate potential firestorms, supporting more proactive crisis management. By combining theory and empirical analysis, the study offers initial insights into SMF dynamics and provides a structured basis for further empirical testing, while highlighting the importance of early detection, transparent communication, and stakeholder engagement.

The study addresses three gaps: a theoretical gap (lack of integrated definition of SMF severity), a methodological gap (absence of validated measurement tools in prior work), and a practical gap (need for cross-industry instruments for early detection and benchmarking). Its primary contributions are methodological and practical, through the development and preliminary validation of the SMF scale and illustrating its potential managerial utility. The secondary contribution is theoretical, as the scale operationalizes severity dimensions and links them with crisis communication and reputation management theories. At the same time, the study acknowledges that full psychometric validation (EFA, CFA, internal reliability testing) remains future work to ensure cross-cultural applicability and generalizability. In doing so, it lays a foundation for addressing these gaps and for strengthening both scholarly relevance and managerial utility.

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**Data availability** The data underlying this study were obtained from M-Brain under a commercial license and cannot be publicly shared. Aggregated results and methodological documentation are available within the article.

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**Dr. dr. Kalle Nuortimo** is an accomplished scientist, educator, and industry leader focused on addressing global technical, economic, and societal challenges through innovation and data-driven solutions. As an RDI Manager at Oulu University of Applied Sciences, he steers pioneering energy related projects, including geothermal energy, energy storage, autonomous vehicles and data analysis. This role showcases his deep expertise in managing and executing projects geared toward technological transitions. Over 22 years of experience in industry is combined with dual doctorates in Industrial Engineering & Management and Science Communication, also Docentship at the University of Oulu and an Assistant Professorship at ISSBS, Slovenia. These academic positions underscore his commitment to merging research, education, and industrial innovation. In 2024, he was awarded an Assistant Professorship at ISSBS and became a member of the Slovenian Science Academy (Aris), reflecting his growing international influence.

**Dr Janne Harkonen** is a senior research fellow and Adjunct Professor at the University of Oulu in Finland, and Associate Professor at International School for Social and Business Studies (ISSBS), Slovenia. He received his Bachelor's degree (1st Class Honours) in Engineering Business Management from University of Greenwich in the UK and both his M.Sc. in Process Engineering and Dr (Tech) in Industrial Engineering and Management, from the University of Oulu, Finland. He has also studied in the University of North Carolina at Wilmington, USA. He has experience working in the IT and environmental technology industries. His primary research interests involve product

management, service management, product portfolio management, productization, and product data management. The secondary interest includes Big data, Opinion mining, Sentiment analysis, Product acceptance, Technology acceptance, and Market intelligence. Dr Harkonen has authored and co-authored over a hundred journal articles, and several other publications.

**Dr Kristijan Breznik** is a Dean, Professor of Mathematics and an Associate Professor of Research Methodology at International School for Social and Business Studies (ISSBS), Celje, Slovenia. He obtained his Bachelor's degree in Mathematics from the University of Maribor, followed by a master's degree in Mathematics and a PhD in Statistics from the University of Ljubljana. He is course coordinator at all three academic levels. His research focuses on (social) network analysis, structural modeling, data analysis, and visualization. He actively collaborates with several international institutions and has led or participated in over ten research projects. Dr Breznik has authored or co-authored of more than thirty original scientific articles in indexed journals (WoS and/or Scopus). Additionally, he serves on the editorial boards of several indexed scientific journals.

**Rajeeka Hannes** is an experienced researcher at the Oulu University of Applied Sciences, Finland. She holds a Bachelor of Science in Computer Science and a Master's degree in Software Engineering, both from the University of Oulu. Her expertise spans drones, data analytics, artificial intelligence, interdisciplinary research, and the metaverse. Her research interests include neuroscience, medical technology, drones, data analytics, and interdisciplinary research, with an emphasis on exploring how advanced technologies shape business, healthcare, and digital ecosystems. She has published in peer-reviewed journals and supports the academic community as a reviewer and collaborator.

