An empirical investigation of electronic word-of-mouth: product recall and crisis response strategy in social media

Abstract

Product recall crises are usually accompanied by damaged reputation, further financial losses of related companies and negative word-of-mouth from customers. This is important to understand the perception of customers toward the product recall crisis when it outbreaks. Most importantly, appropriate response strategies on social media platforms can help companies minimise the losses caused by recalls and save the company's electronic word-of-mouth (eWOM). This study used social media data (i) to explore the customer perceptions and (ii) examine the performance effect of the company's social media response strategy in the context of product recall crisis. We collected 32,697 customer comments from Facebook and conducted two studies to answer the above questions: In study 1, the topic dynamics and customers' general sentiment polarity were analysed by topic modelling and sentiment analysis. The legitimacy and public relation actions of the company are highly discussed in two extreme groups. In study 2, hypotheses were tested by using OLS regression. The results indicated that the accommodative response strategy positively improves overall eWOM compared with the indifferent response strategy. This study provided a comprehensive understanding of the impact of social media crisis response strategy on eWOM and derived evidential managerial insights for better customer perceptions.

Keywords: Product recall, Social media, Electronic word-of-mouth, Response strategy, Topic modelling

Introduction

Individuals and companies have begun to use social media, which has become an effective channel for companies to disclose information (Roshan, Warren, and Carr 2016) and create good relationships with customers (Ibrahim and Wang 2019). Social media also provides a platform for customers to communicate directly with companies and receive timely feedback (Roshan, Warren, and Carr 2016; Jansen 2019). Customers express their thoughts, beliefs, and experiences by writing posts or comments and create electronic word-of-mouth (eWOM) (Kim and Choi 2019). EWOM is formed and influenced by customers' experience related to the product or the brand. This kind of customer-generated content (Hennig-Thurau et al. 2004) contains valuable information for companies to learn about customer perception of the brand and future purchasing behaviour (Yadav and Rahman 2017). In addition, a considerable amount of literature has been published on stakeholders' eWOM communication and management to understand customer perception and reactions to crises (S. Park and H.Park 2020). Therefore, understanding and improving eWOM plays a vital role in building good relationships with customers (Ibrahim and Wang 2019).

In January 2021, the Customer Product Safety Commission (CPSC) in the U.S. updated the 'Social Media Guide for Firms'. It announced that companies in a product recall must respond to customers by publishing relevant information on their social media platforms (CPSC 2021). Despite CPSC's focus on companies' use of social media when responding to customers, academia is also of great interest. Most research on crisis response strategies on social media and their effectiveness has been carried out through case study and experimental study. Whilst some research has been carried out on the role of social media when a product recall arises (Hsu and Lawrence 2016; Tse et al. 2018; Ma et al. 2021), few empirical investigations have been undertaken from the lens of electronic word-of-mouth (eWOM). The lack of research on the characteristics of eWOM behaviours (S. Park and H.Park 2020) makes it difficult for managers to understand the incentives of customers who made negative eWOM regarding the recall crisis. In order to provide comprehensive insights of eWOM characters and dynamics in the context of social media, we developed two interrelated studies: Study 1 targeted to identified the characteristics of eWOM toward the brand when a recall outbreaks by exploring the topics that customers discussed. An accurate analysis of customers' messages and opinions is necessary. Nevertheless, the huge amount of unstructured social media data and insufficient analytical tools make it difficult for companies to understand customers' concerns (Ibrahim and Wang 2019). This dilemma motivates our first research question:

RQ1: How do customers perceive a recall crisis, and what topics will customers concern in different levels of eWOM?

In addition, customers often refer to eWOM given by previous customers to judge the quality of a product and decide a purchase behaviour. However, the user-centred nature of social media poses unique challenges to a company's eWOM management. Customer-generated content is not always favourable for companies. Some of them may dilute or even distort a company's eWOM, leading to rumours, speculation, and other irreversible damage (Lee, Hutton, and Shu 2015). In order to eliminate the potential negative influence of customer-generated content, companies must understand how to maintain their positive eWOM with appropriate response strategies during a recall crisis. With interest in exploring the effects of different response strategies announced by companies, we collected 32,697 comments from Facebook during product recall crises. Thus, the second research question for this study is:

RQ2: What crisis response strategy works best for companies in consideration of maintaining their eWOM on social media platforms?

To answer the first research question, we adopted a topic modelling method to decode the topic dynamics of customers. We analysed the themes by revealing the underlying customers' concerns in different eWOM groups. To answer the second research question, regression analysis and sentiment analysis are adopted. Firstly, we divided the companies' responses into three types: accommodative strategy, defensive strategy, and indifferent strategy. Next, sentiment analysis helps to find the underlying attitude of customers related to each strategy. According to the results, we developed our hypotheses and examined them by regression analysis.

The next section provides a literature review on eWOM, crisis management and recent development using social media and techniques in social media research. Section 3 introduces study 1 which focused on customer concerns. Section 4 presents study 2 and develops the hypotheses. Section 5 provides regression analysis and results. The last section presents conclusions and discussions.

Literature review

Electronic word-of-mouth

Word-of-mouth refers to any positive or negative informal communication among potential, actual, or former customers about products, services, or companies (Liu 2006). Further, Hennig-Thurau et al. (2004) and Chu and Kim (2011) defined electronic word-of-mouth by emphasising the role of the Internet and social media when customers make statements online. Though the eWOM's definition came from WOM, there are differences between the two concepts. EWOM is generally in a lexical format and is anonymous while WOM is commonly from relational sources and in a verbal format (Park and Lee 2009). Customers' online comments are a typical type of eWOM.

Different from advertising in traditional marketer-driven communication, eWOM is an effective way of non-market-driven communication (Verma and Yadav 2021). Currently, in the time of Web 2.0 era, customers do well in sharing and finding information about a product on social media platforms (Weisfeld-Spolter, Sussan, and Gould 2014). EWOM generated on blogs, review websites, emails, and other social media platforms (e.g., Facebook and Twitter) plays a significant role in providing credible and trustworthy information for customers considering purchasing a product or service from the company (Liu 2006). Therefore, improving eWOM is conducive for companies to persuade customers' purchase. With an increasing interest in eWOM, researchers have adopted text analysis, sentiment analysis, semantic analysis, and other methods to evaluate the eWOM construct in empirical research (Verma and Yadav 2021). By representing positive, negative, or neutral sentiment polarity of customers' statements online, sentiment analysis appears to be an effective tool to help researchers interpret the valence of eWOM. The usage of sentiment analysis to mine eWOM information is very common in eWOM literature (e.g., Kim and Choi 2019; Liu 2006; Tang et al. 2016).

The effects of eWOM on product sales, purchase decisions, and application downloads have been well recognised in WOM literature (Themba and Mulala 2013; Kim and Choi 2019). However, there is relatively little research on the influence of the company's behaviour on their eWOM. To fill this research gap, this study uses social media data sets involving eWOM information to demonstrate how response strategies affect eWOM during a recall crisis.

Crisis management and recent develop in social media

The definition and conceptualisation of crisis began with the study of Hermann (1963), who enunciated organisational crisis as an unexpected event that happened in a limited amount of time and brought hazard to the organisational values. He also highlighted the short decision time for the organisation's response as an important aspect of this concept. Later on, Seeger, Sellnow and Ulmer (1998) and Tang (2008) put forward three critical elements of crisis management, namely stakeholder communication, responsiveness, and damage repair. For a considerable amount of time, researchers have shown a keen interest in crises and crisis management at the organisational level. Studies have been undertaken to investigate a range of topics, including crisis communication strategies (Coombs 2015), customer relationship management (Li et al. 2019), post crisis image repair (Ma et al. 2019) and crisis informatics (Reuter, Hughes and Kaufhold 2018). Product recall is a typical example of an organisational crisis. A recall crisis involves repairing, refunding, or removing a hazardous product from the market (Zhang, Hu, and Zhao 2020). The recall will expose the involved company to severe damage, such as loss of reputation, revenues, legal liability, and the strength of a brand (Lee, Hutton, and Shu 2015). Except for supply chain quality management (Zhang, Hu, and Zhao 2020), crisis communication management is another responsive

action for managers when facing a recall crisis (Coombs 2004). Utilising social media as a crisis communication platform is a viable approach (Reuter, Hughes and Kaufhold 2018), especially in product recall scenarios, wherein companies are obliged to alert customers regarding possible risks related to their products (Ledford and Anderson 2013). Timely disclosure of product recall information is an essential and effective way to reduce the damage to the company (Lee, Hutton, and Shu 2015). Besides, many studies highlight the importance of appropriate crisis response and the relevant consequences (Raithel and Hock 2021; Johnen and Schnittka 2019). Specifically, Raithel and Hock (2021) found that companies that use an overconforming strategy will have an unexpected negative effect on stock return and organisational reputation compared with a conforming strategy. Johnen and Schnittka (2019) noted that a defensive response strategy is superior to other response strategies in hedonic contexts. This research classified a company's response into accommodative, defensive, and indifferent strategies (Lee and Song 2010; Lee and Cranage 2014). Accommodative strategy refers to a responsible response, acknowledging, accepting, and apologising for the recall crisis (Weitzl and Hutzinger 2017). In contrast, a defensive response strategy denies the company's responsibility (Weitzl and Hutzinger 2017). An indifferent response strategy was identified as a 'no action' strategy if the company offers no substantive comment or takes no overt action (Lee and Song 2010; Lee and Cranage 2014).

To reduce the potential harm to customers from defective products, as well as save the company's reputation and stock performance, the provision of recall information and timely response on a company's social media accounts is crucial. In today's era of Web 2.0, social media has become a vital tool for businesses to engage with their customers effectively (Li et al. 2019). Social media refers to several Internet-based applications built upon the ideological and technological foundations of Web 2.0 (Kaplan and Haenlein 2010). Social media platforms such as Facebook, Twitter, LinkedIn, and YouTube make it easy for customers to share ideas or express their views through user-generated content (Bello-Orgaz, Jung, and Camacho 2016; Al-Tit, Omri, and Hadj 2020; Cho and Chan 2019). Similarly, concerning the penetration of social media into society, companies that have social media accounts also use social media platforms as an essential part of their advertising, marketing, and brand-building activities (Seo and Park 2018; He, Rui, and Whinston 2018). On the one hand, social media provides companies with an opportunity for in-depth communication (Jansen 2019; Roshan, Warren, and Carr 2016) and helps develop meaningful relationships with customers (Lipsman et al. 2012). On the other hand, compared with traditional media, social media has the characteristics of quick and direct broadcasting (Lee, Hutton, and Shu 2015). The emergence of social media has created fertile ground for corporate crises (Vignal and Barki 2018). Therefore, a company's post-crisis communication through social media can substantially influence the outcomes of an incident. Alexander (2014) stated that social media is favourable in extending crisis response and management. Recent

research explored how a crisis can be fueled by social media (Gruber et al. 2015), how an organisation establish reassurance via social media (Rao et al. 2020), and how the public consumes crisis information on social media platforms (Jin, Liu and Austin 2014). In addition, social media is recognised to have an impact on stock prices regarding negative information to investors (Jong, Elfayoumy, and Schnusenberg 2017). There is no doubt that 'the role of social media is massive and direct' (Helsloot and Groenendaal 2013, 178).

Topic modelling and sentiment analysis

Scholars deliberated on various methodologies that have been reported to "effectively and efficiently extract, summarise and/or visualise" social media data (Saroj and Pal 2020, 17). Among these methodologies, topic modelling and sentiment analysis stand out as the most employed techniques. Topic modelling is a statistical model that clusters the latent semantic structure of the corpus and uses the 'bag-of-words' assumption to infer hidden topics from documents (Hong and Davison 2010). In the process of natural language understanding, the meaning is extracted through a series of levels, which are words, sentences, paragraphs, and then documents. And the most effective ways to understand a text is to analyse its topic at the document level. Each document can be regarded as the probability distribution over some topics, and each topic is the probability distribution over many words (Hong and Davison 2010). Thus, the process of learning, identifying, and extracting topics in a document is topic modelling. This unsupervised machine learning technique is widely used in the operations management field to extract insights and theorise research construct from unstructured text data (Bansal, Gualandris, and Kim 2020; Chun, Leem, and Suh 2021). In this research, we adopted Latent Dirichlet Allocation (LDA), a generative probabilistic model (Blei, Ng, and Jordan 2003) with the highest performance among different topic modelling algorithms (Chiru, Rebedea, and Ciotec 2014). LDA is a typical bag-of-words model which considers a document to be a collection of a group of words where each word in the document is generated from one of the topics. Compared with the classical clustering model with two levels, the LDA model involves three levels so the documents will be related to several topics (Blei, Ng, and Jordan 2003).

The method of LDA-based topic modelling has been viewed as a standard tool. It has been widely applied to research in social networks and social media (Hong and Davison 2010), such as microblog topic detection in the community (Huang et al. 2012), topic-related article recommendation (Wang and Blei, 2011), automatic crime prediction (Wang, Gerber, and Brown 2012), and group spamming detection in product review data (Wang, Gu, and Xu 2018). Bansal, Gualandris, and Kim (2020) argued that the use of topic modelling in the supply chain domain offers new potential for

researchers. Social scientists also use topic modelling as a perfect tool to deal with the growing textual data nowadays (Ramage et al. 2009).

Another commonly used tool in social media-related research is sentiment analysis. Sentiment analysis is used to identify and extract sentiment information from text, adopting natural language processing (NLP), machine learning, text-mining, and other methods (Xu et al. 2019). Sentiment analysis is very helpful when mining the emotional tendency of text, such as comments on news, products, films, and social media (Xu et al. 2019; Krishnamoorthy 2018). The purpose of sentiment analysis is to examine the bipolar attitude of text towards certain topics. Adapting sentiment analysis on social media data has become a hot topic in a wide range of operational management domains. For example, Liu et al. (2021) examined the impact of opportunistic behaviour in supply chain finance on companies' financial performance and constructed variables of relevance to sentiment analysis using Sina Weibo data. Tse et al. (2018) used sentiment analysis to examine Facebook users' understanding of attitudes, opinions, and emotions during a product recall scandal. Xu et al. (2019) argue that Facebook comments transmit customers' perspectives about topical events or products. The purpose of this study is to explore the effectiveness of various response strategies from the eWOM perspective, it is essential to dig into the meaning behind social media data, including sentiment and themes in the comments. Sentiment analysis and LDA-based topic modelling can be helpful and productive when extracting customers' concerns from a large amount of social media data. Therefore, we adopted sentiment analysis and topic modelling as the major techniques in this study.

Despite the increasing need to explore eWOM and crisis management, few studies have investigated the effects of crisis response strategies through the lens of eWOM as organisations struggle to understand how to survive in the social media ecosystem (Gruber et al. 2015). Research to date has not yet considered the actions of involved firms to have a direct impact on customers' sentiment and revealed customers' concerns about product recall from undetected social media data. The literature review presents this research gap. Therefore, this study attempts to fill the gap by uncovering the power of eWOM and its implication for crisis management.

Methodology

Overall Research Design

This study contains two interrelated studies and an additional test. Study 1 intends to extensively understand eWOM characters by exploring hot topics in the comments. On the basis of study 1, study 2 was designed to examine the effects of three different crisis response strategies considering eWOM and firms' financial performance as outcomes

that might be affected. Figure 1 shows the overview of the research methodology in Study 1 and 2. Following that, the additional study takes a further look at the relationship between crisis response strategy and the magnitude of customers' sentiment to provide a supplement for study 2.

Social media data collected from Facebook were used to examine the proposed hypotheses, as social media platforms can provide a large amount of data and enable timely feedback in response to active commenting by customers (Feldman 2013). The social media comments data were conducted using sentiment analysis powered by Google Natural Language API and LDA-based topic modelling. The Google Natural Language API lets users extract information from unstructured text based on thousands of pre-trained classifications without extra training or validation (White and Rege 2020). Google API is trained in a supervised manner with a large training set. Thanks to its unprecedented model power, Google Natural Language API provides us with high-fidelity sentiment analysis. Some related studies have relied on Google's Natural Language API when extracting sentiment from news data or Facebook comments (e.g., Garvey and Maskal 2020; Jalbani et al. 2018). While LDA-based topic modelling is an efficient tool to identify co-occuring words and descriptive information in huge volumes of data (Bansal, Gualandris, and Kim 2020).
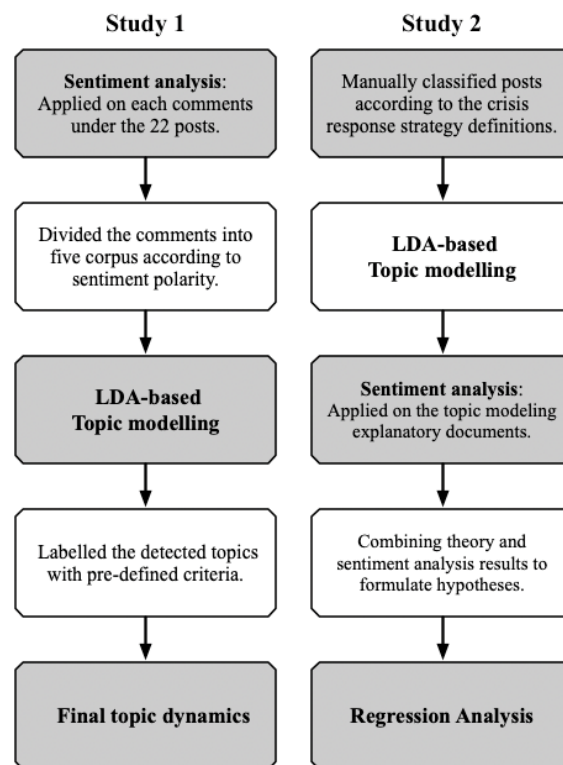

Figure 1. Overview of research methodology.

Data collection and sample

A primary intention of our study is to provide a universal solution for firms' crisis management practice, so we reduced potential partiality by not selecting certain recall events particularly. Instead, we designed a selection criterion using Factiva Database, a business news service provider with access to many newspapers, magazines and other information channels worldwide. The sample selection process first focused on product recall news in the database. To build the sample, 'recall' was chosen as the keyword for searching, and the search was restricted to news published in the last five years in Europe or North America. In order to match the recall crisis to companies' responses on Facebook, the language of news was restricted to English. This criterion resulted in a list of 100 companies that appear the most often in product recall business news. Given the study's focus on affected stock performance, we restricted the selection of firms to those listed companies. In addition, product recalls are frequently observed in the manufacturing industry compared to non-manufacturing industries, as manufacturing companies typically produce tangible goods that can be defective or contaminated and pose a risk to consumers' safety. Therefore, we excluded 39 non-manufacturing companies from the sample. After that, the authors manually looked through the official Facebook page of each company and identified whether they had made any responses to any of their recalls. If so, the company, the recall incident and related social media data will be included into our final sample. An external website was used to download all social media data from Facebook. Lastly, our final sample consisted of 22 response posts from five companies, with 32,679 comments from social media (see Table XX in the Appendix). The data needed to measure financial performance were obtained from the Orbis Global database. Figure 2 summarises the data selection procedures and criterion.
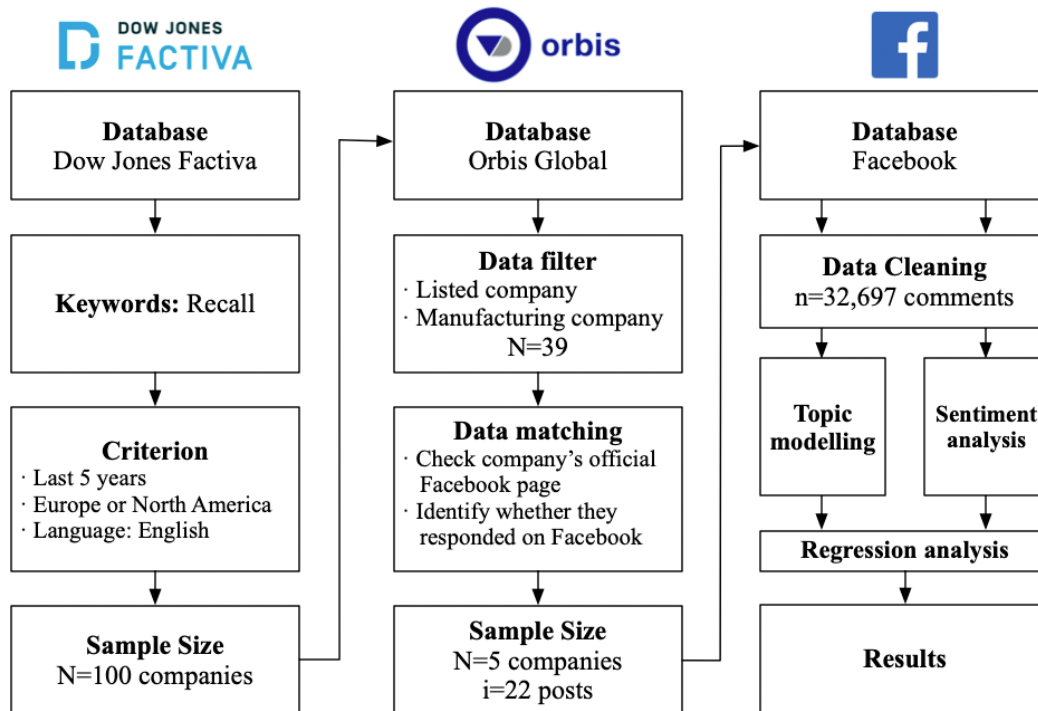
Figure 2. Data selection procedures and criterion.

Study 1 EWOM themes in product recall crisis

Detecting public perceptions behind eWOM helps companies facing reputation damage to understand the effects of crisis response strategy (Liu, Austin, and Jin 2011). By appraising the existing eWOM on social media, companies can better intervene in customers' eWOM and reduce negative eWOM (Yadav and Rahman 2017). In study 1, we used LDA-based topic modelling to identify themes discussed by customers on Facebook when a company responds to their product recall crisis. Byun, Duhan, and Dass (2020) have divided customers into two categories according to their responses towards product recalls. The first type is called 'leaving', which refers to customers who feel disappointed, betrayed by the product or even the brand. This kind of customer holds a negative attitude toward the brand and will completely reject the product in the future. Instead, another type of customer is called 'staying'. Customers who hold a positive attitude toward the recall and continue to support and repurchase the recalled product are in the range of 'staying'. Following Byun's approach, we measured eWOM by sentiment (Kim and Choi 2019) and considered comments with negative emotions as negative eWOM, and comments with positive emotions as positive eWOM. The neutral attitude describes a middle stance between 'positive' and 'negative' eWOM. In order to accurately understand the customer's attitude to the recall so as to collect more detailed findings, we divided all samples into five groups instead of three groups, using 'neutral' as the midpoint of the scale.

Using topic modelling and building a topic dynamic over sentiment polarity, we explore the specific theme customers are discussing when they have positive (or negative) eWOM in a recall and provide insights for public relations managers. Specifically, we adopted sentiment analysis-based topic modelling and used a five-stage process. Firstly, we adopted Google Natural Language API (Garvey and Maskal 2020) to calculate the sentiment score of each comment. We downloaded and converted Facebook comment data into a CSV file. Each Facebook post corresponds to a CSV document. Next, we parse the comment data by using Google API. Comments not written in English or with meaningless URLs and characters were removed. Then, we utilise the API to inspect given text and output sentiment values. Google Natural Language API has a large training data set and thus can provide quick and accurate inspections of a given text. The reliability of the results is robustly validated and Google Natural Language API has been widely adopted in comparable research (Garvey and Maskal 2020). The sentiment values range from -1 to 1, where 1 represents highly optimistic emotion, -1 represents extremely negative emotion and 0 stands for neutral. The parameters of our sample data vary from -0.9 to 0.9. Take the sentence "This is why I love Samsung. They care of their customers and their safety" as an example. We access the API interface and the API will read the text. Then, the API parses the sentence and presents the value 0.89 to the user. A document with a positive value indicates an optimistic attitude; on the contrary, a negative value indicates a negative emotion towards the comment. Therefore, this sentence shows the customer's positive attitude in the case of Samsung's recall incident.

Considering that the number of topics must be sufficient to conceptualise the constructs and be accurately related to research (Bansal, Gualandris, and Kim 2020), we set the number of topics to be five in each corpus. The topic modelling process yielded 25 themes from the five corpora (see Figure 3). Bansal et al. suggested that researchers need to carefully discriminate the content obtained from topic modelling 'by returning to theory and the actual phenomena' (2020, 15). Therefore, three researchers were asked to independently label the topics following the pre-set criteria and then validated each topic by discussion. Finally, after discussion, the final themes were determined and the topic dynamics are shown in Figure 3.

Table 1 Data distribution in each group

	Sentiment score	sample size
Group 1	-0.9≤sentiment score<-0.54	n=6614
Group 2	-0.54≤sentiment score<-0.18	n=8859
Group 3	-0.18≤sentiment score<0.18	n=8431

Group 4	0.18≤sentiment score<0.54	n=5746
Group 5	0.54≤sentiment score≤0.9	n=3047

Results of study 1

General description

As shown in the figure, the themes are divided into five groups. The groups at the left with the colour red are negative eWOM. The emotional attitude gradually becomes positive as moving to the right side, and the groups at the right with green colour are positive eWOM. The group in the middle with the colour yellow stands for neutral attitude. The depth of shade of the themes is determined by the degree of importance. Each group fielded five themes with the highest weighted theme appearing on the top.

In group 1, the higher weighted themes are 'Break laws', 'Quality issues', and 'Fraud', which indicates that in this group companies are considered to be illegal and fraudulent. Customers also believed that the recall crisis may be related to a deficiency of quality monitoring. In group 2, the high-ranking themes are 'Gloss over the mistake', 'Worst customer service' and 'Profits over lives'. These themes apparently show that customers are not satisfied with the involved company when the recall happened. In group 3, 'Mention the competitive products' appeared to be the most concerning theme. In this group, people hold a neutral attitude toward the recall and they compare the recalled product with their competitors. The higher weighted themes in Group 4, including 'No need to apologise', 'Support the company', and 'Forgive the company'. Customers in this group have developed a supportive attitude towards the company that has experienced the recall crisis. Lastly, in the group with the most positive attitude, customers are talking about the involved company's 'Public relation actions' and they 'Show confidence in the brand', or even exhibited 'Loyalty' to the brand. We have noticed that some themes appeared frequently over the sentiment dynamics. Therefore, we connected the same themes together with lines. In the next session, we will explain the themes with the highest weights in each group for the reason that they represent the most concerned issues of customers.
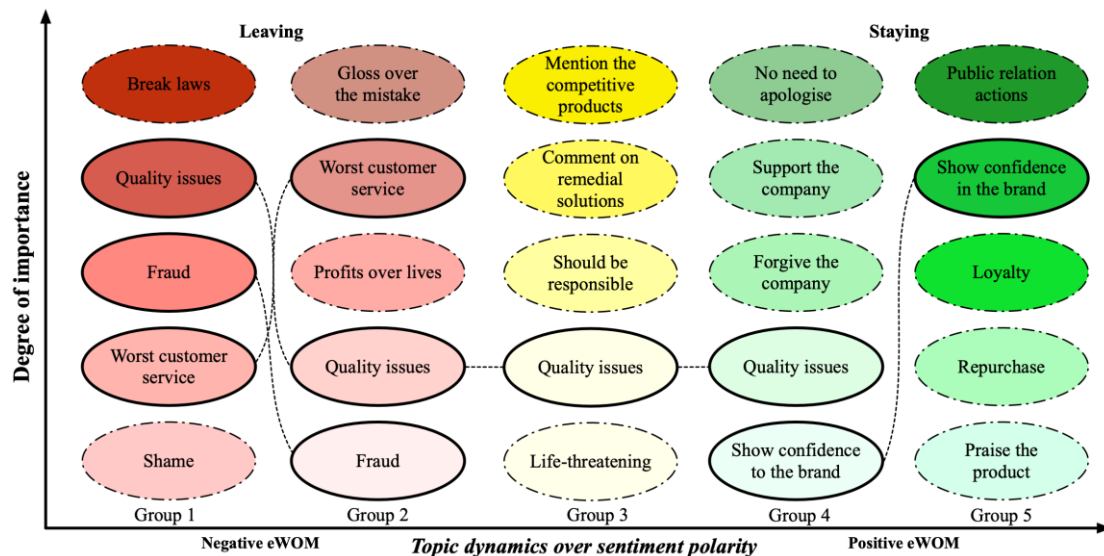
Figure 3. Themes in different eWOM groups.

Theme 1- Break laws

The theme 'Break laws' remains highest among all themes in group 1. It is interesting to find that this theme arises first in the most negative sentiment group. Comments like '*You will not win back my trust. Sorry. Most corporations can at least disguise their questionable ethics in legal loopholes and not actually premeditatively break the law outright and lie about it*' and '*…If they were willing to break the EPA rules, I wonder what other rules they broke…*' under Volkswagen's response post revealing how customers think. In the case of Volkswagen's emissions recall, Volkswagen intentionally installed 'defeat devices' on their diesel cars to pass the EPA's emission tests. There was great public anger when Volkswagen finally admitted their illegal behaviour. Such recall crises caused by deliberate illegal behaviours make customers infuriated and increase their perception of risk. As Wei et al. (2016) stated, risk perception will decrease customers' pro-firm behavioural intentions. In line with Byun and her colleagues' work (2020), customers in group 1 are 'leaving' the brand and showing evident hostility to the company. The discussion of this theme showed an explicitly negative expectation of customers toward the product recall.

Theme 2 - Gloss over the mistake

'Gloss over the mistake' emerged as a primary customer concern in group 2. Comments like '*Criminally deceptive behaviour. It boggles the imagination. This cannot be glossed over with mealy-mouthed platitudes.*' showed that many customers believe that the company's response to the recall crisis is deceiving customers. A similar theme 'Fraud' also appeared in both negative eWOM groups. Customers' trust has a crucial impact on

their purchase intentions (Limbu, Wolf, and Lunsford 2012). However, it is difficult for companies to win back customers' trust after the recall. Even an honest response may be mistaken for cheating if customers don't trust a company. Therefore, we suggested companies that are involved in a recall crisis must show their empressement when responding on social media.

Theme 3 - Mention the competitive products

It is worth noting that the theme 'Mention the competitive products' weigh the highest in the third group where customers hold a neutral attitude toward companies' response. People in this group love to compare the recalled product with its competitive product. For example, under Samsung's post responding to their recalled Note 7 product, the word 'iPhone' was frequently mentioned by people in comments like '*Despite all this I do believe that the note 7 is still going to outsell the iPhone 7 guarantee*'. Some of the customers believed that the recalled products were better than their competitors even if they were defective, while others thought that the recalled products did have serious flaws compared to their competitors.

Theme 4 - No need to apologise

In group 4, the theme 'No need to apologise' remained important for customers. Product recall crisis tests customer loyalty (Byun, Duhan, and Dass 2020). The brand's loyal customers are demonstrated to be less sensitive to negative information than those who are not committed to the brand (Ahluwalia, Unnava, and Burnkrant 2001). The positive expectations and forgiveness shown by customers in this group verified the point of view that loyal customers are not seriously affected by product recall (Ma et al. 2010). Comments like '*...I still think it's one of the best cars you can buy. I couldn't be happier with it!* or '*I will always be loyal to this brand. They produce the safest and most beautiful cars in the world.*' supported the view of Dawar and Pillutla (2000) who believed that loyal customers will protect the brand and show higher purchase intention to the product after the recall.

Product recall crises have a long-term impact on the involved company considering customer loyalty and resilience of repurchasing (Byun, Duhan, and Dass 2020). Customers' favourable response matters a lot in protecting the brand. The extant literature provided evidence that customer loyalty has a positive impact on rebuilding the brand during a product recall crisis (Ahluwalia, Unnava, and Burnkrant 2001; Byun, Duhan, and Dass 2020). It became clear that companies should make great efforts to build up customer loyalty in order to overcome the difficulties and quickly recover from a recall crisis.

Theme 5 - Public relation actions

The chief customer concern in group 5 is 'Public relation actions'. Comments like '*A marketing tactic that's suitably effective in current times...centering on emotion and compassion.*' and '*... I too appreciate your marketing strategies and state hereby that I fully trust your aircrafts because I really feel like you're good guys.*' represented that a section of customers is very sensitive to the public relations actions adopted by the company. Here, the theme 'Public relation actions' refers to a set of integrated actions taken by the organisation to influence customers and investors' crisis perceptions (Coombs 2007; Raithel and Hock 2021). When facing a product recall, the involved company will adopt different strategies to respond to their customers in consideration of various reasons (Bundy and Pfarrer 2015). Some involved companies choose an accommodative response strategy to win back their customers' trust (Johnen and Schnittka 2019). However, exceeding customers' expectations does not always have positive effects during the recall crisis (Raithel and Hock 2021). For example, comments like '*I always apologise when I get caught cheating also.*' suggested that customers are not satisfied with the company's response and believed that the company is obliged to do so. Therefore, choosing an appropriate response strategy is essential for companies facing a recall crisis.

Theme 6 - Quality issues

'Quality issues' is a theme that crosses positive and negative eWOM. Quality management in the supply chain has been considered a crucial approach for a company's management of product recalls (Zhang, Hu, and Zhao 2020). The continuous discussion of this theme reveals that many recall crises have to do with companies' unqualified quality management which causes product-related dangers to customers. The quality of the service or the product can influence customer perception. According to Frank et al. (2014), risk-related recall with potential danger will decrease customers' perceptions of product quality. For example, in Volkswagen's recall, comments like '*That's because their quality monitoring group is doing nothing but watching paint dry on the walls.*' showed a great dissatisfaction toward the quality monitoring department's inaction. Defective products will pose a threat to a company's reputation and profile (Sharma, Garg, and Agarwal 2014). Therefore, we suggested that more regulations should be formulated on the company's quality management process. And managers who are in charge of quality monitoring should pay more attention and solve the recall accidents caused by product quality problems at its source.

Overall, this topic modelling result had important implications for companies when repairing the damaged reputation in a recall crisis. By analysing vast amounts of unstructured social media data from different eWOM levels, we provide insights for

managers in the following aspects. First, the investigation of the themes behind eWOM reveals customers' main concern facing a product recall. Managers can counteract the potential negative effects of negative eWOM with their knowledge of customers' concerns (Vermeer et al. 2019). A further crisis can be prevented if the company can precisely decrease failure attributions from the 'leaving' customers (Weitzl, Hutzinger, and Einwiller 2018). The topic dynamics over sentiment polarity can help companies make corresponding crisis response plans that match customer concerns during product recall outbreaks. Second, it is recommended that companies should abide by regulations and not take advantage of legitimate loopholes for profit. Several themes in the negative eWOM groups (e.g., break laws, fraud, shame, profits over lives) have confirmed this finding. It can therefore be assumed that companies' eWOM would be negatively affected if they violate the law. These findings, while preliminary, suggest that more attention should be paid to monitor eWOM on social media platforms. Otherwise, companies involved in the recall crisis would suffer from public accusations and loss of sales.

Study 2 The impact of different crisis response strategies

In study 2, to explore customers' attitude toward the company's different response strategies, we first did a general investigation using sentiment analysis technique. Next, a regression analysis was implemented to explore the precise impact of different strategies on eWOM and firm value.

Specifically, we have divided the company's response strategy into three types, namely (i) accommodative response strategy, (ii) defensive response strategy and (iii) indifferent response strategy. Accommodative response strategy refers to a responsible response, explicit acknowledgement, acceptance and apology of the recall crisis (Weitzl and Hutzinger 2017). Companies with accommodative response strategies tend to be responsible for the recall (Lee and Song 2010) to restore customers' positive evaluation and attitude toward the brand (Lee and Song 2010). This response approach also benefits companies in enhancing customers' trust and future purchase behaviour (Lee 2005). In contrast, the defensive approach suggests companies' denial of responsibility (Weitzl and Hutzinger 2017). Companies with defensive approaches always attack accusers, find excuses to minimise responsibility and assert that nothing happened (Coombs 2007). Using a defensive approach may risk triggering negative customer perception (Lee 2005) or damaging the company's reputation (Lee and Song 2010). Both accommodative and defensive approaches represented that the company understood the situation and engaged in a timely response. However, some organisations avoided the crisis and halted further elaborations (Herhausen et al. 2019) when discussion breaks out on social media platforms. We defined this disengaging behaviour as indifferent strategy when companies offer no substantive comment or

take no overt action (Lee and Song 2010; Lee and Cranage 2014). Approaches like blocking further elaborations, remaining silent, or 'suggesting a communication channel change' (Herhausen et al. 2019, 4) are in this category. Following the definition of three response strategies, companies' response posts on Facebook were manually and independently coded by four trained research assistants. Eleven response posts were recognised as accommodative for their explicit, responsible and apologetic reply. Three of the posts were identified to be defensive due to irresponsible or carefree speech. The remaining eight posts were divided into indifferent strategies considering they offered no overt response. Some examples are given below in Table 2: In the case of Volkswagen's recall, the company used statements like 'offer our deepest apologies', 'will remedy the issue', and 'win back the trust' in one of their posts. This post was coded as an accommodative response by our research assistants. As for the defensive approach, we used Johnson & Johnson's post as an example. In their response post, the company made excuses that their products were safe to use and refused to admit the potential harm of the ingredients. Such behaviour was defined as defensive. Regarding the indifferent approach, Whirlpool's response evoked a channel change that took the conversation away from Facebook. Hence, their response was coded as an indifferent approach in the study.

Table 2 Examples of company's response on Facebook

Type	Recalled product	Content of Facebook post
Accommodative	Volkswagen's 2.0L TDI vehicle	Volkswagen would like to **offer our deepest apologies** to those affected by our violation of CARB and EPA emissions standards. **We will remedy the issue**, and we will make things right in order to **win back the trust of you**, our customers, our dealers, the government, the public, and our employees. We kindly ask for your patience as we work very hard to address this complex issue, and we will share more information as soon as we can.
Defensive	Johnson & Johnson's Baby powder product	Have questions about talc? We can help. Baby Powder made from cosmetic talc is one of Johnson's oldest products and a **longtime part of baby care rituals**. Johnson's Baby Powder continues to be popular with adults as well, and **in many parts of the world, it remains an essential part** of makeup and skin care routines. With more than 100 years of use, **few ingredients have the same demonstrated performance, mildness and safety profile as**

		cosmetic talc. Johnson & Johnson has no higher responsibility than the health and safety of you and your family. Learn more about talc safety here.
Indifferent	**Whirlpool's electronic radiant cooktops**	To learn more about the recent voluntary recall of certain electronic radiant cooktops with touch controls and a glass cooking surface sold under the Whirlpool, KitchenAid and JennAir brands, **visit repair.whirlpoolcorp.com or call 888-900-7897.**

Hypothesis development

Sentiment analysis of different strategies

Sentiment analysis provides an overview of the impact of different crisis response strategies by showing the overall sentiment performance of each corpus. The results will help to understand the overall consumer reactions. Therefore, we could propose the hypotheses accordingly.

We utilised topic modelling to extract topics from posts, followed by performing sentiment analysis on the topics and supporting documents to roughly understand the sentimental tendency of the customers. Data were cleaned by removing comments not written in English or with meaningless URLs and characters. Posts and comments are divided into three categories corresponding to the previous classification. The topic modelling programme outputs four topics (each topic has three explanatory documents) for each strategy. To simplify the process, we suppose that the extracted topic documents represent the sentimental tendency of the sample to a certain extent. Therefore, we applied sentiment analysis on the topic modelling explanatory documents to investigate the magnitude and score of customers' sentiments. The results of sentiment analysis are listed in Table 3.

Table 3-1 presented the sentiment magnitude of each corpus. The magnitude of sentiment indicated how much emotional content exists in the documents. The higher the sentiment magnitude, the stronger the emotion of a document. The last column described the overall sentiment magnitude of the corpora by combining the text from twelve documents when adopting sentiment analysis. The results showed that the sentiment magnitude of customer comments related to the indifferent strategy is the strongest among all strategies, which indicated that the indifferent strategy might be mostly ineffective in alleviating customer sentiment.

Table 3-2 showed the sentiment score of each corpus. The colour green represents positive emotions, red represents negative emotions, and yellow represents neutral emotions. The last column described the overall sentiment score of the corpora using a similar calculation as above. The results in the last column revealed that, compared with the indifferent strategy (sentiment score=-0.3), adopting an accommodative strategy leads to better eWOM (sentiment score=0.0), and adopting a defensive strategy leads to worse eWOM (sentiment score=-0.4) to some extent.

Table 3-1 Results: Magnitude of sentiment

Response strategy	Topic 0	Topic 1	Topic 2	Topic 3	Overall
Accommodative strategy	5.1	7.7	4	2.6	20

Response strategy	Topic 0	Topic 1	Topic 2	Topic 3	Overall
Defensive strategy	8.4	6.7	3.4	8.1	27.5

Response strategy	Topic 0	Topic 1	Topic 2	Topic 3	Overall
Indifferent strategy	4.3	12	5.6	7	29.9

Table 3-2 Results: Sentiment score

Response strategy	Topic 0	Topic 1	Topic 2	Topic 3	Overall
Accommodative strategy	0.6	-0.3	-0.4	0.0	0.0

Response strategy	Topic 0	Topic 1	Topic 2	Topic 3	Overall
Defensive strategy	-0.4	-0.3	-0.6	-0.5	-0.4

Response strategy	Topic 0	Topic 1	Topic 2	Topic 3	Overall
Indifferent strategy	-0.3	-0.6	0.0	-0.4	-0.3

The above results of sentiment analysis provided us with the direction to propose some research hypotheses. Building on the this, we integrated insights from the literature on crisis response strategy and eWOM into our hypotheses in the following sections.

Crisis response strategy and eWOM

The emergence of social media has changed the relationship between stakeholders and shareholders. Stakeholders are also users of social media, which appears to transfer the way in which a company communicates with them. Being an important element of company's business strategy (Zheng, Youn, and Kincaid 2009), company's response to a certain incident has a significant effect on customers' behaviour and perceptions (Van Noort and Willemsen 2012). Companies that adopted an accommodative approach proactively took responsibility for the recall crisis. This approach usually comes with amendments, apologies, and compensation (Chang et al. 2015), which satisfy customers and improve eWOM (Xia 2013; Johnen and Schnittka 2019). A conforming response like the accommodative approach will moderate the potential damage to negative eWOM (Willemsen, Neijens, and Bronner 2013). Cheng and Loi (2014) also argued that a response that meets customer expectations can bring good customer reactions, such as an increase in customers' loyalty behaviour and the possibility to recommend other customers (Xie et al. 2016). Herhausen et al. (2019) suggested the best approach to eliminate negative eWOM is to provide a more explanatory response to customers. The transformation from negative eWOM to positive eWOM may also happen when customers receive satisfactory managerial response (Lee and Song 2010).

In contrast, the indifferent approach is believed to be less effective than accommodative strategies (Herhausen et al., 2019). The company is perceived very negatively if they ignore the rumour or keep silent (Pfeffer, Zorbach, and Carley 2014). The avoidance of the company will arouse customers' negative eWOM and risk damaging the company's reputation (Lee and Song 2010). Therefore, remaining silent is not suggested, as only very loyal customers will accept this response strategy (Pfeffer, Zorbach, and Carley 2014; Lee and Song 2010). In addition to an accommodative or indifferent approach, using a defensive strategy suggests the company is denying responsibility and shifting blame onto someone else (Coombs 2007). When the company's intentional excuses are detected by customers, a defensive approach may bring an unfavourable impression (Lee and Cranage 2014).

Some researchers have verified that an active engaging response strategy is the most appropriate to reduce negative eWOM (Herhausen et al., 2019) when facing a crisis. Therefore, we were of the opinion that, compared with the indifferent strategy, an accommodative approach will enhance positive customer perceptions and relieve negative eWOM. The defensive response strategy signals untruthfulness of the

company (Xia 2013) compared with indifferent approaches, which arouse customers' negative eWOM. The results of sentiment analysis also provide supportive evidence that adopting an accommodative strategy leads to better eWOM, while adopting a defensive strategy leads to worse eWOM. Thus, we hypothesised:

H1a: In comparison to an indifferent response strategy, an accommodative response strategy has a positive effect on improving eWOM during a product recall crisis.

H1b: In comparison to an indifferent response strategy, a defensive response strategy has a negative effect on improving eWOM during a product recall crisis.

Crisis response strategy and stock price volatility

Many researchers have investigated the potential relationship between media information and stock market reaction (Tetlock 2007; Engelberg and Parsons 2011; Medovikov 2016; Walker 2016; Seng and Yang 2017). Changes in stock prices reflect investors' attitude and expectations of a company's future profitability. These changes can be caused by any information or actions provided by the company. There is strong evidence that company's crisis responses strategy on social media have certain impacts on their stock market performance. For example, Knight and Pretty (1996) stated companies with effective response strategies suffered a slight stock fall after a crisis, while the mis-handled company lost twice as much as the former. An accommodative response strategy suggests a positive attitude of the involved company which exceeds stakeholders' expectations. Therefore, Garcia (2006) claimed that using an accommodative strategy allows companies' stock prices to recover quickly from the chaos. In addition, Coombs (2015) clarified that an unfriendly response approach increases the risk of stock price damage. In general, a company's conformity during a recall crisis will have a positive effect on stock price volatility. On the contrary, a defensive response strategy will have a negative effect on investors' sentiment and worsen the stock price volatility. Hence, this study hypothesised:

H2a: In comparison to an indifferent response strategy, an accommodative response strategy has a positive effect on stabilising a company's stock price volatility during a product recall crisis.

H2b: In comparison to an indifferent response strategy, a defensive response strategy has a negative effect on stabilising a company's stock price volatility during a product recall crisis.

Regression analysis

Social media data collected from Facebook were used to examine the proposed

hypotheses, as social media platforms provide large amounts of compelling data and enable timely feedback in response to active commenting by customers (Feldman 2013). The comments from Facebook were analysed using sentiment analysis tools provided by Google Natural Language API. The Google Natural Language API uses prebuilt models to enable users to extract information from unstructured text based on thousands of pre-trained classifications without extra training or validation (White and Rege 2020). Some related studies have relied on Google's Natural Language API when adopting sentiment analysis to carry out research on news data or Facebook comments (e.g., Garvey and Maskal 2020; Jalbani et al. 2018). Hence, the researchers believed that Google Natural Language API is credible to a certain degree. The sentiment tendency is integrated into a model comprising manually classified variables and company financial variables to enable a systematic study of the associations between companies' response strategies and stock price volatility. Python was also adopted in this research.

This study aimed to examine the effects of different response strategies on customers' eWOM and companies' financial performance in the context of a product recall crisis. Therefore, customers' sentiment, stock price volatility, and companies' response strategies were the variables to be examined.

Dependent variables

The first dependent variable is electronic word-of-mouth (eWOM). Using sentiment metrics to measure eWOM has been widely used in previous research (e.g., Kim and Choi 2019; Liu 2006; Tang et al. 2016). In this study, we measured eWOM by sentiment score. Google Natural Language API was used to calculate the overall sentiment score. Another dependent variable is stock price volatility. Stock price volatility was used to measure the potential financial damage to an involved company. Several researchers have confirmed that stock prices can reflect recent events, public information (Vega 2006; Seng and Yang 2017) and social media trends (Smailović et al., 2014; Walker 2016). Therefore, stock price volatility was selected as one of the variables to assess the consequence of a product recall crisis.

Independent variables

Response strategy was the independent variable in this research. The response strategy of each Facebook post was manually classified following the definitions. Accommodative response strategy refers to the 'acknowledgement and acceptance of the existence of a dissatisfying event caused by the company' (Weitzl and Hutzinger 2017, 165). In contrast, the defensive response strategy appears to deny a company's responsibility and usually includes 'an attack on the complainant, or a shift of blame to the complainant or third parties' (Weitzl and Hutzinger 2017, 165). The main criterion

used here is whether the company is liable. In addition, an indifferent response strategy was identified as a 'no action' strategy if the company offers no substantive comment, takes no overt action (Lee and Song 2010; Lee and Cranage 2014) or suggests a communication channel change (Herhausen et al. 2019).

Four trained research assistants completed the coding manually and independently. Posts were coded as accommodative, defensive or indifferent. After this process, the author looked through the results. Finally, eleven accommodative response strategies, three defensive strategies and eight indifferent strategies were identified from the 22 social media posts.

Control variables

For control variables, prior organisational reputation, traditional media, likes of comments and firm characteristics were selected for this research. Prior organisational reputation indicates how well or poorly a company treats its stakeholders (Coombs 2007). Coombs (2007) believed that prior relationship reputation will have some impact on reputation threats brought about by crises. Therefore, the prior reputation of the involved company was adopted as one of the control variables. The measurement of this variable is borrowed from Deephouse's work (2000) and is calculated using the 'negative news' metric in the Orbis Global database.

According to Lee, Hutton, and Shu (2015), the analysis concerned corporate use of social media needs to control for the overall effects of traditional media activity during the event window. Therefore, this study used the natural logarithm of the daily number of press articles searched on Factiva with the company's name mentioned in headlines or lead paragraph (Lee, Hutton, and Shu 2015) on the day that the involved company gave a response on Facebook. In addition, this variable was divided into two dimensions. 'Traditional media-Dow Jones' refers to the number of related news on Factiva's Dow Jones section, and 'traditional media-All' refers to the number of related news on all Factiva sections.

Customers' reaction to a recall response is likely to vary in accordance with several characteristics of companies (Lee, Hutton, and Shu 2015). Here, this study selected firm size and sales growth as two variables with which to measure a firm's characteristics. For firm size, log of sales revenue was measured at the end of the prior fiscal year to measure firm size. Sales growth is measured by sales at the end of the prior fiscal year (t−1) minus sales at the end of year t−2, divided by sales at the end of year.

Another control variable is 'likes of comments'. The higher the number of likes, the greater the influence the comment has. In this way, it was considered that the

influence of comments would affect the dependent variables. Table 4 presents the variables and measurement used.

Table 4 Variables, characteristics, and database

Variables		Characteristic	Source
Dependent variables	eWOM	Overall sentiment score calculated by using Google Natural Language API.	Facebook
	Stock price volatility	Percentage change of the stock price.	investing.com
Independent variables	Response strategy	Indifferent response strategy.	Manually classified
		Accommodative response strategy.	Manually classified
		Defensive response strategy.	Manually classified
Control variables	Organisational reputation	Prior reputation of a company. Calculated using the metric 'negative news' in the database.	Orbis Global database
	Media-DJ	Daily number of press articles found on Factiva-Dow Jones with the firm's name mentioned in the headline or the lead paragraph in the event period.	Factiva database
	Media-All	Daily number of press articles found on Factiva with the firm's name mentioned in the headline or the lead paragraph in the event period.	Factiva database
	Firm size	Log of sales revenue (sale), measured at the end of the prior fiscal year.	Orbis Global database

	Sales growth	Sales (sale) at the end of the prior fiscal year (t−1) minus sales at the end of year t−2, divided by sales at the end of year.	Orbis Global database
	Likes	The number of likes of each comment.	Facebook

Models of regression

To test whether a company's different response strategy on social media has an effect on eWOM, model (1) was employed with the independent variable response strategy and control variables. Regarding H2, stock price volatility is the dependent variable and thus model (2) was constructed. The hypotheses were supported if coefficients of independent variables are significant.

$$EWOM = \beta_0 + \beta_1 Strategy + \beta_2 Reputation + \beta_3 \log TradiMedia\_DJ + \beta_4 \log TradiMedia\_All + \beta_5 FirmSize + \beta_6 Salesgrowth + \beta_7 Likes + \varepsilon \quad (1)$$

$$Volatility = \beta_0 + \beta_1 Strategy + \beta_2 Reputation + \beta_3 \log TradiMedia\_DJ + \beta_4 \log TradiMedia\_All + \beta_5 FirmSize + \beta_6 Salesgrowth + \beta_7 Likes + \varepsilon \quad (2)$$

Data analysis and empirical results

Response strategy and eWOM

We ran OLS regression equations with the robustness of standard errors using Stata 15.0 software. The independent variable in this research is a categorical variable. Hence, we coded the independent variable as dummy variables as Alkharusi (2012) suggested. The indifferent strategy group was set as the reference group. In other words, the test of significance is equal to the test of the difference between the treatment group and the reference group (Alkharusi 2012). Our social media data contains 32697 comments under 22 posts. Hence, we have 32697 observations in the regression models.

Table 5 presents the outcomes of H1 and H2. In the first column, the coefficient of the accommodative strategy is significantly positive. As mentioned above, the indifferent strategy group was set to be the benchmark in the regression. Therefore, the regression coefficient associated with accommodative strategy indicated that, in comparison to an indifferent strategy, an accommodative strategy in a product recall crisis has a positive effect on improving eWOM. However, the defensive response strategy appeared to have no significant impact on improving eWOM compared with indifferent strategy. These findings are in line with Zavyalova et al. (2012) who believed that accommodative strategy led to less negative media reaction after a recall crisis. The results also echo the literature findings that when a company's response was careless or

defensive, stakeholders' initial perception of the crisis will be challenged (Bundy and Pfarrer 2015) and result in worse eWOM. However, this finding is against Coombs and Holladay's (2004) conclusion that neither accepting or rejecting the crisis responsibility led to less social approval loss. The discrepancy might be relevant to the characteristics of the recall itself. Future research can be carried out based on this divergence.

We included several variables in order to control their effects on eWOM. The coefficient of the company's prior reputation appeared to be not significant. Therefore, companies' reputation established before the crisis has no impact on their eWOM when facing a recall. Other control variables such as traditional media, firm size, sales growth and number of likes all have significant coefficients in the regression models.

Response strategy and stock price volatility

The second column in Table 5 explains the relationship between companies' response strategy and their stock price volatility. The regression coefficient associated with accommodative strategy is significantly positive, which indicates adopting accommodative response strategy has a positive effect on stabilising companies' stock price during product recall crises, therefore, positively affecting the company's stock market performance. In this way, H2a is supported. This result is in line with Knight and Pretty (1996) and Garcia (2006) that accommodative strategies help companies overcome difficulties on the stock market. However, the regression coefficient associated with defensive strategy is negative, indicating that the defensive approach has a negative impact on stock price volatility compared with indifferent strategy. The coefficients of control variables in H2 appeared to be significant except for the number of likes. Therefore, both H2a and H2b are supported. The results of the two comparisons in H2 show that the accommodative strategy is more effective than the indifferent strategy, and the indifferent strategy is more effective than the defensive response strategy. Hence, we concluded that the accommodative approach is the most effective, and the defensive approach is the worst.

The results revealed that if the company aims at stabilising their stock price in the short term, adopting an accommodative response strategy is the best choice. However, the short-term financial performance may not be consistent with consumers' reactions on the market. In the long run, the impact of the response strategy on the stock price volatility still needs further exploration.

Table 5 Results of linear regressions

Hypothesis	H1	H2
Dependent variable	eWOM	Stock price volatility
Accommodative	0.092*** (10.02)	0.062*** (90.28)
Defensive	-0.030 (-1.88)	-0.027*** (-13.08)
Reputation	-0.017 (-0.37)	-0.281*** (-59.25)
TradMediaDJ	-0.160*** (-10.31)	-0.233*** (-151.80)
TradMediaALL	0.295*** (10.93)	0.263*** (93.09)
Firmsize	0.066*** (24.83)	-0.016*** (-40.71)
Salesgrowth	0.490*** (7.38)	-0.229*** (-25.78)
Likes	0.009*** (2.78)	0.000 (0.88)
Constant	-1.087*** (-40.05)	0.044*** (13.37)
R-squared	0.063	0.752
Number of Obs	32697	32697

*** p<.01, ** p<.05, * p<.1. Number of observations is the number of comments in the sample.

Additional test

To comprehensively understand the effects of response strategy on customers' emotions but not affect our main hypotheses, we conducted an additional test here using sentiment magnitude as the dependent variable. The dependent variable eWOM in the main test is measured by the value of sentiment score, with the value representing an overall emotional tendency of the text. When the sentiment score equals zero, whether the sentiment of the text is neutral requires further analysis. There are two possible reasons why a sentence may have a zero score (or approximately 0): (i) either the text lacks emotional expression, or (ii) it represents a mixed value that has

both positive and negative emotional tendencies to offset each other. In circumstances in which the comment lacks emotional expressions (i.e., the first reason given above), the sentiment magnitude will be lower than if it has both positive and negative emotional tendencies. In order to distinguish between these two situations, we provided an additional test considering the relationship between crisis response strategy and the magnitude of customers' sentiment in this section.

The dependent variable 'magnitude of sentiment' is calculated by Google Natural Language API. This approach has been widely used (Schumaker, Jarmoszko, and Labedz Jr 2016; Stephen and Prabu 2019; Garvey and Maskal 2020) to indicate how much emotional content exists in the comment. The higher the sentiment magnitude, the stronger the emotion of a comment. In study 2, the sentiment magnitude of customers relating to the indifferent response is the strongest among all response strategies (see Table 3-1). Following this finding, we hypothesised:

H3a: In comparison to an indifferent response strategy, an accommodative response strategy has a positive effect on decreasing customers' sentiment magnitude during a product recall crisis.

H3b: In comparison to an indifferent response strategy, a defensive response strategy has a positive effect on decreasing customers' sentiment magnitude during a product recall crisis.

Results of Additional test

The table below illustrates the main characteristics of the analysis. The accommodative response strategy has no significant effect on customers' sentiment magnitude. No evidence was found for H3a. In contrast, the coefficient of defensive response strategy is negatively significant. A negative correlation was found between defensive response strategy and sentiment magnitude. In other words, compared with the indifferent response strategy, the defensive response strategy has positive effects on decreasing customers' sentiment magnitude. This result provided strong evidence for H3b. It suggested that when a company chose to respond with a defensive strategy, customers' extreme emotions were better relieved compared with using an indifferent strategy. Although this finding goes against our initial hypotheses in the main test, it is very valuable in practice.

The evidence here showed that using an accommodative response strategy is not necessarily better than using a defensive response strategy when the company wants to avoid extreme emotions in consumers. If the company hopes to extinguish the crisis from the beginning and prevent it from further developing into a firestorm and damaging their reputation, adopting a defensive strategy will be the best choice. While an accommodative response strategy seems ineffective in this context.

Combined with the findings in the main test, we discovered that each response strategy has their own benefits. To improve the overall eWOM and enhance reputation, an accommodative online response strategy is suggested for managers. If the company aims at preventing a recall crisis from turning into a firestorm, a defensive strategy is more appropriate. Moreover, the defensive strategy and accommodative strategy are not antagonistic to each other. The company can make flexible choices according to different stages of a crisis, and even use several strategies at the same time.

Table 6 Results of linear regressions in additional test

Hypothesis	H3
	Magnitude of sentiment
Accommodative	-0.021 (-7.90)
Defensive	-0.124*** (-2.82)
Reputation	-2.127*** (-12.89)
TradMediaDJ	-0.204*** (-4.20)
TradMediaALL	0.304*** (3.66)
Firmsize	0.011 (1.35)
Salesgrowth	-1.182*** (-6.30)
Likes	0.055*** (3.56)
Constant	2.553*** (23.32)
R-squared	0.029
Number of Obs	32697

*** p<.01, ** p<.05, * p<.1

Discussions and Conclusions

Discussion of results

Product recalls have devastating impacts on customers' confidence in the involved companies. For companies, the recall crises are usually accompanied by damaged reputation, negative word-of-mouth, and further financial losses. Therefore, understanding how company's communicative choices impact the eWOM and other important crisis outcomes is of great importance (Coombs 2015). In this research, we investigate the impact of adopting different crisis response strategies on eWOM in a product recall context, influences on stock price volatility and sentiment magnitude were also examined by using secondary social media data. The emergence of social media platforms has provided companies with new possibilities to communicate with customers (Jansen 2019). Especially when a recall crisis outbreaks, social media data that contains valuable emotional information can help companies better discern customers' eWOM and their concerns (Liu 2006) with the help of different analytical techniques. In order to obtain undetected information about customer concerns, topic modelling and sentiment analysis tools were undertaken to design two studies using 32,697 customer comment data collected from Facebook.

The investigation of eWOM topic dynamics in study 1 has revealed customers' uppermost concerns in different corpora. In group 1 and group 2, the primary customer concerns are 'break laws' and 'gloss over the mistake', suggesting that the recall crisis increases the level that customers perceive the companies' illegality and fraudulence. This result is in line with Byun and her colleagues (2020) who confirmed customers with the most negative eWOM prefer 'leaving' the brand and showing evident hostility to the company. The discussion of these themes showed an explicitly negative expectation of customers toward the product recall. As Byun et al. (2020) mentioned in their work, the feeling of disappointment and betrayal may lead to customer's discontinuation of purchasing the recalled product. In this situation, although the company had made some post-recall responses, customers may still believe that the problem is not well solved and turn to purchase alternative products in the future. In contrast, theme 4 and 5 revealed the fact that some loyal customers were still staying with the brand even after a recall happened. This finding is consistent with Ma et al. (2010) that loyal customers are not seriously affected and less sensitive to negative information than people who are not committed to the brand. They may also show higher purchase intention to the product after the recall to protect the brand (Dawar and Pillutla 2000). Byun et al. (2020) gave some explanations for these 'staying' behaviours. Some customers might believe that the recall will not affect them or only have a slight impact on them. Or, they might suppose the recall has been solved properly so that safety use can be assured. As for group 3, the themes represented a mild attitude of the customer.

In this group, customers hold a neutral attitude toward the recall and show no sign of staying or leaving.

We further empirically examined the effects of different crisis response strategies in study 2. We have divided the company's response strategy into three types and tested their impacts on eWOM and stock price volatility respectively. We observed that in comparison to an indifferent strategy, an accommodative strategy has a significantly positive effect on improving eWOM, whereas defensive strategy has no such effect. It aligns with the opinion of Zavyalova et al. (2012) that accommodative strategy led to less negative media reaction after a recall. Additionally, an accommodative response strategy is found to positively affect companies' stock prices during a recall. We also did an additional test and discovered that the defensive response strategy has a positive effect on decreasing customers' sentiment magnitude, surprisingly. Therefore, we came to the conclusion that using an accommodative response strategy is not always better than using a defensive response strategy, especially when the company wants to avoid extreme emotions of their consumers.

Theoretical implications

The research has contributed to current literature in the following aspects. First, the findings complement those of earlier studies and propose some compelling statements. Although much of the literature underlines the significant impact of product recall from shareholder perspective (Hsu and Lawrence 2016), there is less knowledge about how online stakeholders react to this (Coombs and Holladay 2012). Even fewer have considered this question from the lens of eWOM. In terms of this literature, eWOM is used to measure customer response. We support the work of Xia (2013) by demonstrating that being accommodative is more appropriate when companies try to build good relationships with customers and improve eWOM. Company's behaviours such as accepting responsibility or confessing to mistakes will improve customer satisfaction (Johnen and Schnittka 2019). We also drew interesting conclusions that contradict the previous research. Lee and Song (2010) argued that adopting a defensive response strategy may lead to negative customer perception toward the brand. However, we found that being defensive has unexpected positive effects on easing customers' sentiment magnitude compared with being indifferent. To prevent negative customer posts from evolving into online firestorms (Herhausen et al. 2019), adopting a defensive strategy might be suitable for the company. If the company hopes to extinguish the crisis from the beginning, adopting a defensive strategy rather than an accommodative strategy will be the best choice. Overall, the findings suggest a role for social media crisis communications in promoting eWOM when a recall happens. We believe that these findings may stem from the difference in research scenarios since we only focus on recalls that happened in manufacturing companies, and the mechanisms

behind need further examination (Bhandari and Rodgers 2018).

Second, the paucity of techniques appeared to be a primary research gap in this area. The study also advanced empirical investigation in the field by using multiple analytic tools and secondary data from social media. We combined both text mining techniques (i.e., topic modelling, sentiment analysis and Google natural language API) and statistical analysis that provide convincing evidence. Topic modelling enables researchers to explore and extract the nature behind eWOM. Sentiment analysis provides insights for understanding the attitude behind customer comments. Taken together, mining the meaning behind text documents has become possible via these techniques. Besides, we used secondary data gathered from Facebook other than interview or survey data in this study. Social media data contains valuable customer signals (Yadav and Rahman 2017). Customers expressed their opinions and attitude on social media freely. This unintended expression made social media data more authentic than data gathered from surveys or interviews with a certain research purpose (Boyd and Crawford 2012).

Third, this framework also explored how a company's engagement in social media decreases the impact of product recall crisis on its financial outcome. We adopted multiple data sources that contained conventional financial variables (e.g., stock price volatility) and novel social media variables (e.g., eWOM). As Hsu and Lawrence (2016) mentioned, research about the outcomes of product recall on firm value in the digital era are limited. Our examination on stock price volatility extends the extant research from the perspective of shareholders. The findings are similar with Knight and Pretty (1996) and Garcia (2006), indicating that accommodative strategies help companies overcome difficulties on the stock market in a short term. However, this study has yet to consider the long-term effect of crisis response strategy on firm value.

Managerial implications

We extracted some key lessons from examining whether a company's online response can promote or damage its eWOM in the context of a product recall crisis, as well as developed guidelines for managers to improve their crisis reactions. First, this study provides social commerce managers a thorough understanding of different eWOM levels and their unobserved themes in crisis situations. Customers showed obvious different attitudes toward a product recall crisis by making eWOM with bipolar sentiment. Those who are loyal to the brand are less sensitive to negative information than those who are not committed to the brand (Ahluwalia, Unnava, and Burnkrant 2001). Loyal customers tend to be supportive of the company and even express the willingness of repurchasing the products in the future. In contrast, customers in the 'leaving' group are resistant to the brand and its products. They produce a large number of negative eWOM on social media, including a series of accusations of the

company's suspicion of breaking laws, cheating customers and inadequate quality management. These unobserved themes behind eWOM revealed customers' concerns that few studies have systematically examined. Companies can incorporate and integrate into eWOM conversation (Bhandari and Rodgers 2018) and satisfy customers by construct reasonable mechanisms (Bu, Huang, and Zhao 2021) at the early stage of a crisis.

Second, we provide insights for managers in how to adopt text mining techniques to detect customers' concerns from eWOM. Natural language processing based on machine learning helps to demonstrate user-generated content such as eWOM (Rodgers and Wang 2011). After identifying and targeting the potential viral themes using text mining techniques, managers can counteract the potential negative effects of negative eWOM with their knowledge of customers' concerns (Vermeer et al. 2019) and repair the damaged reputation (S. Park and H.Park 2020). Detecting the themes in eWOM helps companies make corresponding crisis response plans that match customer concerns in a recall situation. We therefore suggest that more attention should be paid to monitoring eWOM on social media platforms. Otherwise, companies would suffer from public accusations and loss of sales.

Third, this study helps managers enhance their understanding of different response strategies and benefit companies in deciding which strategy to adopt when facing a recall crisis. We suggested that managers should consider the results they want when making decisions. When the company aims at enhancing its eWOM and reputation, an accommodative online response strategy is suggested for managers. Additionally, if the company aims at stabilising its stock price in the short term, adopting an accommodative response strategy is also recommended. However, the long-term impact needs further examination. It is worth noting that, if relieving customers' extreme emotions and preventing a recall crisis from turning into a firestorm are primary goals, a defensive strategy is more appropriate than the other two strategies.

Although a company could not manipulate its eWOM in the social media driven world, they can get involved in the discussion and shape customers' comments in a favourable direction (Hsu and Lawrence 2016). The company can make flexible choices considering different stages of a crisis, and even use several strategies at the same time.

Conclusions

This study contributes to the crisis management and eWOM literature by exploring eWOM during product recall incidents. The first study was designed to understand customers' eWOM and examine the topic dynamics during recall incidents. The results of study 1 have revealed customers' concerns about product recall from undetected social media data. The second major work was to empirically investigate the effects of

three response strategies. The relevance between an accommodative strategy and positive eWOM is clearly supported by the current findings. However, in consideration of the results of the additional test, a defensive strategy is occasionally accepted if the company wants to avoid extreme emotions from consumers.

The importance and originality of this study are that it explores the effects of crisis response strategies through the lens of eWOM. Previous studies (Hsu and Lawrence 2016; Liu, Shankar and Yun 2017) generally considered the actions of involved firms to have a moderating role in the recall process and examine the direct or indirect impacts on a firm's stock performance. This work, however, contributes to the existing knowledge by utilising eWOM as the dependent variable in the framework. We adopted social media comment data to construct eWOM with sentiment analysis and topic modelling techniques. The combination of these techniques should help to improve the understanding of crisis management in a recall. Additionally, most product recall literature focused on a certain recall incident (e.g. Ma et al. 2021; Chun, Leem and Suh 2021) and measured the social media engagement of one specific company. This study is one of few pieces of research that provide a comprehensive investigation of multiple recall incidents. We collected five recalls from five different companies and established a quantitative framework. We believe the present study has been one of the first attempts and should make an important contribution to the field of crisis management in the social media era.

Limitations and future research

However, this study still has limitations that can be further considered. First, some researchers have claimed that situational factors such as firm type, crisis type, crisis involvement and message framing (Chen, Ganesan, and Liu 2009; Raithel and Hock 2021), can influence the effect of crisis response strategies. In this study, we focused primarily on manufacturing firms. However, given the growing importance of service-based and non-manufacturing industries in the global economy, there is an increasing need to include these sectors in the future study. It is worth noting that any company that offers products or services to consumers may face a recall if their productions are found to be unsafe or defective. The exclusion of non-manufacturing firms may lead to a limited applicability and generalisability of research findings.

Second, fitting response approaches with the crisis is a dynamic process. The Boeing company, for example, adopted various response strategies at different stages in the crisis. Companies are not suggested to stick to one type of response strategy throughout the crisis. Hence, studying the impact of using several strategies at the same time or alternately using different strategies can be a fruitful area for further work.

Third, the signalling theory can be incorporated in future research. As Bergh and Gibbons (2011) verified, the foundation of the signalling theory is closely related to the company's marketing communications actions with customers. When the crisis happens, the company will have inside information on their following response actions that customers don't possess, which will lead to information asymmetry (Karasek and Bryant 2012). The response given by the company on social media platforms is a signal sent to customers. And the resulting behaviour from the receiver (i.e., the customers) such as eWOM is the feedback. Thus, it is possible that the signalling theory can be adopted in future studies.

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Appendix

Year	Company	Recall incident	Description	Post	Strategy
2015	Volkswagen	2.0L TDI vehicles	Volkswagen installed software to control emissions when the cars are being checked. About 11 million vehicles are affected worldwide.	https://www.facebook.com/VW/photos/a.172364490789/10156127042000790	Accommodative
				https://www.facebook.com/VW/photos/a.172364490789/10156134608995790	Accommodative
				https://www.facebook.com/VW/photos/a.172364490789/10156190223600790	Accommodative
				https://www.facebook.com/VW/photos/a.172364490789/10156224444095790	Indifferent
				https://www.facebook.com/VW/photos/a.172364490789/10156281229850790	Accommodative
2019	The Boeing Company	Boeing 737 MAX airplanes	After two fatal accidents, Boeing confirmed issues that affect the backup power control unit and recommended that operators remove 737 MAX from service.	https://www.facebook.com/Boeing/posts/2542022709159584	Defensive
				https://www.facebook.com/BoeingSouthEastAsia/posts/1199829903517949	Indifferent
				https://www.facebook.com/Boeing/posts/2544011142294074	Defensive
				https://www.facebook.com/Boeing/posts/2552978524730669	Indifferent
				https://www.facebook.com/Boeing/posts/2578424978852690	Indifferent
				https://www.facebook.com/BoeingSouthEastAsia/posts/1214188368748769	Indifferent
				https://www.facebook.com/Boeing/posts/2600077080020813	Accommodative
				https://www.facebook.com/Boeing/photos/a.145219042173308/2983451285016722	Indifferent
2016	Johnson & Johnson	Baby powder	J&J recalled 33,000 bottles of baby powder after the FDA discovered traces of asbestos in the product, a mineral that was believed to cause cancer.	https://www.facebook.com/jnj/posts/10153302019065951	Defensive

Year	Company	Product	Description	Link	Response
2016	Samsung	Galaxy Note7	Samsung announced to recall the Galaxy Note7 phones and confirmed a design failure after several batteries catch fire and exploded.	https://www.facebook.com/SamsungUS/posts/10153675533131786	Accommodative
				https://www.facebook.com/SamsungUK/posts/1427957370554622	Indifferent
				https://www.facebook.com/SamsungUS/posts/10153685722986786	Accommodative
				https://www.facebook.com/SamsungUK/posts/1432475173436175	Accommodative
				https://www.facebook.com/SamsungUK/posts/1461642950519397	Accommodative
				https://www.facebook.com/SamsungUK/photos/a.166413170042388/1465317426818616	Accommodative
				https://www.facebook.com/SamsungUS/photos/a.59297021785/10153769793601786	Accommodative
2019	Whirlpool Corporation	Electronic radiant cooktops with touch controls and a glass cooking surface	Cooktops sold under three brands were recalled due to their surface elements can automatically turn on and cause fire hazards.	https://www.facebook.com/whirlpoolusa/photos/a.160654213971610/2313856841984659/	Indifferent