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Negative Social Media Sentiments and Capital Structure

Samuel Jebaraj Benjamin[1*], Zhuoan Feng[1] & Pallab Kumar Biswas[2]
[1]*School of Accounting, Finance and Economics, University of Waikato, New Zealand.*
[2]*Department of Accountancy & Finance, University of Otago, New Zealand.*

Abstract: Research Question: Does negative social media sentiments have implications for a firm's capital structure? **Motivation:** Little is known about how social media sentiments affect capital structure, although previous studies have provided information on the detrimental consequences of negative SMS on firm performance, value, financial hardship, and revenue. However, choosing a capital structure is regarded as one of the crucial choices for every organisation. **Idea:** This study investigates the role of negative social media sentiments (SMS) in shaping the capital structure of firms; namely leverage, cost of debts, and the term to maturity. **Data:** We sample the United States (US) Fortune 500 firms between 2010 – 2017. The data for this study is collected from the Infegy Atlas social media database (a US company that gathers data from social media conversations), Thomson Reuters' Asset4 and Compustat. **Method/Tools:** The pooled ordinary least squares (OLS) regression with robust standard errors technique and the Propensity score matching (PSM) analysis are deployed. **Findings:** We first study how negative social media sentiments effects capital structure by examining the level of leverage, cost of debts, and the term to maturity of firms. Our results suggest that firms that receive a significant amount of negative SMS will have a higher leverage, cost of debt and term to maturity. We further offer evidence that shows how Corporate Social Responsibility performance and firm size influence the negative SMS-capital structure nexus. **Contributions:** This the first study to examine the impact of negative SMS on capital structure. Our findings from this research add to the emerging debate on the role of SMS in affecting firm financial outcomes and performances. Our findings provide novel perspectives that carry notable implications for corporate strategies concerning capital structure and enhance the comprehension of stakeholders, including investors and creditors, regarding the factors influencing a firm's capital structure.

Keywords: Negative social media sentiments, capital structure, leverage, cost of debts, term to maturity, Fortune 500.
JEL Classification: O33, G39, M14

[*] Corresponding author: Samuel Jebaraj Benjamin. Tel.: +64-78379578.
Email: samuel.benjamin@waikato.ac.nz

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1. Introduction

Social media encompasses internet-based applications and enables individuals to create, communicate, and exchange information or opinions on electronic platforms and networks.[1] In contrast to conventional media (e.g., newspapers, TV, and radio), social media is widely reachable and allows anybody to share information and views (Lee *et al.*, 2015). The attractiveness of social media has increased dramatically in recent years. Out of the worldwide population of 7.83 billion in 2021, about 4.2 billion people use social media (Digital 2021: Global Overview Report: https://datareportal.com/reports/digital-2021-global-overview-report).[2] Given the immense acceptance and popularity of social media, sentiments expressed in social media can reach broad audiences and have considerable influence on stakeholder perspectives of firms as well as on firms' operating and financing decisions (Schmidt *et al.*, 2020).

As the use of social media has become increasingly prevalent in people's daily lives, a stream of research has begun to investigate whether and how social media sentiments (SMS) effect a firm's financial outcomes such as its value and performance. These studies have demonstrated the usefulness of social media sentiments in affecting firm value, performance, financial distress, and revenue (Benjamin *et al.*, 2022; Dunham *et al.*, 2021; Nguyen *et al.*, 2020; Bartov *et al.*, 2018; Sonnier *et al.*, 2011; Luo, 2007; Chevalier and Mayzlin, 2006). Both academic research and the trade press suggest that it is more important to investigate negative SMS than positive SMS. Negative SMS is more important in influencing financial markets (Agrawal *et al.*, 2018), impairing corporate reputations (Luo *et al.*, 2013) and causing more financial damage (Luo, 2009; Chevalier and Mayzlin, 2006) than the corresponding benefits of positive SMS. Hence, firms may prioritise attention towards understanding the implications of negative SMS and adjust their strategies and decisions accordingly. Interestingly, while prior studies provide information on the unfavourable effects of negative SMS on firm performance, value, financial distress and revenue, little is known about the effect of social media sentiments on capital structure. Yet capital structure determination is considered one of the key decisions for any corporations (Akhtar, 2005).

This study investigates how negative SMS affects the capital structure of firms. Following prior studies (e.g., Garcia and Herrero, 2021), we examine the following capital structure attributes: leverage, cost of debt, and debt maturity. We argue that the implications of negative SMS on capital structure are threefold. First, investors and creditors are becoming increasingly aware of the value of SMS and recognise the connection between social media communication and the effect on companies' business performance (Dunham *et al.*, 2021; Luo, 2009). Therefore, negative SMS may influence shareholders unfavourably and reduce their support, limiting firms from accessing external financial resources and decreasing a firm's proportion of external equity in the capital structure. As a result, these firms need to seek alternative external financial resources, such as debts, and this could lead to higher leverage. Second, creditors may consider the increased risk to firms emanating from negative SMS when determining the cost of debt capital. As a result, firms with more negative SMS may have a higher cost of debt. Third, we consider how negative SMS affects debt maturity. On the one hand, negative SMS can impair financial performance and reduce cash flows (Luo, 2009). On the other hand, short-term debt is subject to more frequent renewals and refinancing (Li and Zhang, 2019). Hence, firms with more negative SMS, which are predisposed to performance and cash flow risk, may be less likely to use short-term debt, given that creditors may regularly incorporate the unfavorableness of negative SMS into their lending decisions. Thus, firms with more negative SMS may have a higher debt maturity.

[1] Mainstream social media platforms include Facebook, Twitter, Instagram, Pinterest, Reddit, Weibo, and TikTok.
[2] This equates to 53.6% of the global population being active social media users.

Next, we bear comparison with studies on the implications of Corporate social responsibility (CSR) performance and capital structure and instinctively investigate their links with negative SMS. [3] CSR has emerged as a dominant topic and top priority for businesses in current times (Zolotoy *et al.*, 2019; Lu *et al.*, 2014). Over the last decade, CSR initiatives are increasingly being considered as an important consideration for investors and creditors (Benlemlih *et al.*, 2018). Prior literature presents mixed evidence on the implications of CSR on leverage, cost of debt, and debt maturity (Garcia and Herrero, 2021; Lemma *et al.*, 2021; La Rosa *et al.*, 2018; Attig *et al.*, 2013; Wang *et al.*, 2008). Our research delves further by exploring whether CSR performance influences the association between negative SMS with leverage, cost of debt, and debt maturity. We surmise that CSR could either attenuate or amplify investor and creditor concerns over negative SMS and this could have an impact on the capital structure choices of firms. Empirically, this continues to be an interesting, and yet unanswered question. Lastly, we examine whether firm size will influence the association between negative SMS and capital structure. Firm size is empirically documented to have an important bearing on capital structure decisions (González and González, 2012; Kurshev and Strebulaev, 2015). Large firms generally have more opportunities to access external equity capital, more bargaining power to negotiate lower interest rates, and prefer short-term debt (Dennis and Sharpe, 2005; Titman and Wessels, 1988). These strands of evidence would imply that investor and creditor concerns over negative SMS could be lower for larger firms. Hence, the influence of negative SMS on leverage, cost of debt, and debt maturity may be influenced by firm size. However, empirically, this remains unexplored.

Based on a group of Fortune 500 corporations between the period 2010 - 2017, we examine how negative SMS influence capital structure by examining the level of leverage, cost of debt, and debt maturity. Our results show that negative SMS is significantly associated with higher leverage, cost of debt and debt maturity. Nevertheless, our findings are mixed when we explore the influence of CSR performance and firm size on the relationship between negative SMS and capital structure. Our findings indicate that the relationship between negative SMS and leverage is significant only in firms with high CSR performance. We also show that the significant and positive relationship between negative SMS and cost of debt stays consistent in firms with low and high CSR performance but the association between negative SMS and debt maturity becomes insignificant for both sub-sample groups. When we divide our sample into firms with small and large size, we discover that the association between negative SMS and leverage is significant only in small firms. However, the effects of negative SMS on cost of debt and debt maturity are consistently significant across the sub-samples tests. Our results are strengthened by a battery of robust estimations.

Our study contributes to the literature in several ways. First, the results from this research add to the emerging debate on the role of SMS in affecting firm financial outcomes and performances (Nguyen *et al.*, 2020; Schmidt *et al.*, 2020; Bartov *et al.*, 2018). In this study, we investigate another important firm attribute: capital structure. Our findings, which show that negative SMS can significantly increase leverage and the cost of debt, complement the findings from prior literature on SMS and capital structure (Benjamin *et al.*, 2022; García and Herrero 2021; Nguyen *et al.*, 2020; Dunham *et al.*, 2021; McAlister *et al.*, 2012). Prior research in this area has largely emphasized on the adverse effects of negative SMS (Luo *et al.*, 2013; Luo, 2007, 2009) and our study broadens this strand of literature by examining how negative SMS affects the capital structure decisions of firms. Second, we also extend the literature on CSR by investigating how the role of negative SMS, which shapes firm capital structure, varies with firms' CSR performance levels. Our findings highlight the significance of CSR in influencing firm capital structure, and also add a further dimension to the existing

[3] In this research, we employ the terms 'CSR' interchangeably with environmental, and social and governance (ESG) performance similar to Lu *et al.* (2014), Fatemi *et al.* (2018) and Choi *et al.* (2018).

literature on CSR and capital structure (Lemma *et al.*, 2021; Benlemlih *et al.*, 2018; La Rosa *et al.*, 2018; Attig *et al.*, 2013; Wang *et al.*, 2008). Finally, our research connects the importance of firm size to capital structure with negative SMS. We provide important insights by demonstrating how the effects of negative SMS on capital structure is differs between smaller-sized and larger-sized firms. In sum, Our findings suggest that negative SMS, and the influence of CSR and firm size, play important roles in determining firm capital structure. Therefore, our findings can also inform investors and creditors in making important financial decisions.

The rest of the paper is organized into four sections. The following section provides the review of related literature and the development of our hypotheses. Next we discuss our methodology and data. This is followed by the presentation of our results and our conclusion, noting also the limitations of our study and the future research opportunities it presents.

2. Literature Review and Hypotheses Development

2.1 Capital Structure

An appropriate capital structure is a critical decision for any business organization. Some of the main theories that have been put forward in the extant literature on capital structure are trade-off theory (Modigliani and Miller, 1963), pecking order theory (Myers & Majluf, 1984; Myers, 1984), and agency theory (Jensen, 1986). Although most studies have primarily concentrated on a single capital structure attribute, namely leverage, cost of debt, or debt maturity, Garcia and Herrero (2021) argue that these attributes or proxies are related and should be examined alongside each other. Hence, future studies are encouraged to consider all three proxies to provide a more complete picture of a firm's capital structure. The consideration of social media sentiments in the realm of capital structure studies is relatively new and in its infancy. In this regard, although there is no prevailing theory that directly addresses this new line of research, the choice of capital structure attributes (leverage, cost of debt, and debt maturity structure) may be influenced by social media sentiments. Because social media sentiments can equip market participants, such as investors and creditors with clues about a firm's prospects, potential future performance, risks, and its stakeholder and customer support, SMS may serve as an important indicator of capital structure. This study specifically examines whether negative social media sentiments influence the capital structure of firms.

2.2 Social Media Sentiments

Since the last decade, a stream of research has investigated how social media platforms affect firm financial outcomes and strategies. Recently, social media analytics have enabled researchers to collect data from social media applications, and to analyze, decode, and comprehend users' perspectives of firms. Prior literature reveals that approximately 20% of all social media content is regarding corporations (Jansen *et al.*, 2009). Social media often contains regular discussions regarding the actions of corporations, such as changes in strategies, restructuring, handling of public policies, and reactions to current events (IBM, 2017). Compared with conventional media such as radio and television, social media is increasingly emerging as the favored platform for public and customers to share their thoughts and views and source for information (Bartov *et al.*, 2018). Accordingly, researchers have paid increasing attention to the observability and measurement of SMS to study the effects of these sentiments on firms' financial performance and decisions such as capital structure.

The 'Wisdom of Crowds' concept is relevant in understanding how SMS may influence the capital structure of firms (Surowiecki, 2004).[4] Social media platforms are resources for

[4] The 'Wisdom of Crowds' notion implies that information accumulated from a big sample of non-experts provides better predictive capability than information from any individual expert. For example, Surowiecki (2004) presents

stakeholders such as shareholders, creditors, and social media analysts to access the wisdom of crowds. They believe that the accumulation of information generated by social media users frequently forecasts outcomes more accurately than predictions by experts (Bartov *et al.*, 2018). Views and comments expressed in social media have been increasingly regarded as an important pool of contemporary information for shareholders and creditors to predict firm financial outcomes (Chen and Xie, 2008; Gu *et al.*, 2012). For example, previous literature document that comments and opinions voiced on social media effect a corporation's financial performance such as sales, cash flows, the price of products or services, stock returns, and volatilities (McAlister *et al.*, 2012; Luo, 2009; Dhar and Chang, 2009). Shareholders and creditors realize how the wisdom of crowds may contribute to interpreting the association between SMS and firm financial performance. As financial market participants endeavour to benefit from the wisdom of crowds, sentiments expressed in social media provides a vital source of information for investors and creditors that may shape a firm's capital structure.

2.3 Negative Social Media Sentiments and Capital Structure

Negative social media sentiment is a demonstration of criticisms or representations of displeasure by the public or customers of social media about a corporation, in which experiences of being displeased with the company are shared (Luo, 2007). As discussed previously, investigation of negative SMS is particularly important as it appears to have greater implications for corporations than positive SMS (Agrawal *et al.*, 2018; Luo *et al.*, 2007, 2013). Negative SMS is typically recognized from words or phrases such as "angry" and statements like "I hate it" (Nguyen *et al.*, 2020) and it has an adverse and contagion effect on the wider stakeholder group (Haidt, 2001). Prior studies have demonstrated the unfavourable effects of negative SMS on stock returns and financial markets (Nguyen *et al.*, 2020; Yu *et al.*, 2013; Luo *et al.*, 2013, 2009). Negative customer reviews online have also been found to be forceful in reducing sales (Chevalier and Mayzlin, 2006). Likewise, some studies find that negative sentiments impair firms' future equity returns (Chen *et al.*, 2014; Luo, 2007). That said, there are also a handful of studies which find that negative SMS does not exhibit significant effects on a firm's financial distress (Dunham *et al.*, 2021) and stock returns (Chen *et al.*, 2012).

We surmise that the consequences of negative SMS on the capital structure of firms are threefold. First, shareholders are growing ever more aware of the value of SMS and recognize its influence on firms' business performance (Luo, 2009). Therefore, shareholders use SMS as proxies for unobserved revenue, cash flows, and firm value (McAlister *et al.*, 2012; Luo, 2009). The intuition is that when firms receive a considerable amount of negative SMS, shareholders may consider such firms as less attractive investments. Along this line, we argue that negative SMS will hinder the efforts of firms to access external equity financing and decrease a firm's proportion of external equity in the capital structure. As a result, firms eliciting a great deal of negative SMS may need to seek alternative external financial resources, such as debts, leading to a higher level of leverage.

Next, we expect that firms with more negative SMS will incur higher cost of debts. As argued earlier, negative SMS can unfavourably impact a corporation's business performance such as revenue, cash flows, price of products or services, equity returns and volatilities (McAlister *et al.*, 2012; Luo, 2009; Dhar and Chang, 2009). In particular, negative SMS can be a signal that firms may be facing greater financial risks. When determining the cost of debt capital, creditors will assess risks comprehensively and consider negative SMS as an indication that the borrower carries greater risk (Chen *et al.*, 2012; Luo *et al.*, 2013). As a

scenarios and examples to describe the 'Wisdom of Crowds' idea. A typical illustration of this idea is the discovery by Sir Francis Galton in the 20th century that the average estimate of a group at a country fair more precisely projected the weight of an ox, as opposed to the projections made by cattle experts (Van Dolder and Van den Assem, 2018).

result, we can expect that firms with more negative SMS would incur a higher cost of debt. Furthermore, if negative SMS also leads to higher leverage in general, such a scenario would likewise influence creditors' decisions on the cost of debt. Indeed, prior literature suggests that a higher level of leverage poses greater risks, such as risks of failure or bankruptcy (García and Herrero, 2021).

Finally, we examine the impact of negative SMS on debt maturity. Debt maturity decision may be defined as the choice that has to be made between short-term and long-term debt (La Rocca *et al.*, 2020) and is typically measured as the proportion of long-term debt to the total debt of a firm. Prior studies suggest that safer firms, which have less risk and more stable cash flows, are likely to choose short-term debt over long-term debt to signal their high quality to the market (Diamond, 1991; Flannery, 1986).[5] However, debts with short maturities are subject to more frequent renewal and refinancing (Li and Zhang, 2019). Short-term creditors can review a firm's performance and decisions more frequently (Demirguc-Kunt and Maksimovic, 1999) given that they are subject to more regular renewals. Since negative SMS is a signal of poor corporate reputation (Luo *et al.*, 2013) and can reduce cash flows, short-term debt becomes a less attractive source of financing for firms with negative SMS as it exposes these firms to higher liquidity and credit risk (Luo, 2009; Diamond, 1991). All else being the same, firms that receive large amounts of negative SMS will be less inclined to use short-term debts as their source of finance given that creditors could regularly give consideration to negative SMS in their lending decisions. As a result, firms attracting significant negative SMS are more likely to use long term debt. Given that direct prior evidence on these associations are not available, we propose the following hypotheses in the null format below:

H1a: There is no association between negative SMS and leverage.
H1b: There is no association between negative SMS and cost of debt.
H1c: There is no association between negative SMS and term to maturity.

2.4 The Influence of CSR on the SMS-Capital Structure Relation

In this section, we examine the influence of CSR on the relationship between SMS and capital structure. In relation to leverage, some prior studies argue that investors regard CSR as a valuable pursuit for businesses and an appeal of greater customer and stakeholder support, profitability, and shareholder wealth (Benjamin *et al.*, 2022; Radhouane *et al.*, 2018; Castaldo *et al.*, 2009; Bendixen and Abratt 2007; Porter and Kramer, 2006; McWilliams and Siegel, 2001; Sen and Bhattacharya, 2001; Berman *et al.*, 1999). Following this line of evidence would imply that the concerns of investors over negative SMS, as explained earlier, could be eased in firms with better CSR and, hence, encourage investors to invest in these firms. This may enable firms to seek higher equity financing and, as a result, the positive relationship between negative SMS and leverage might be statistically insignificant in firms with high CSR performance but significant in firms with low CSR performance. However, some studies argue that investors may consider CSR a costly pursuit that reduces shareholder value (Benjamin *et al.*, 2022; Kruger, 2015; Navarro, 1988). In this case, concerns over negative SMS may be intensified with better CSR, further limiting investor support and further elevating the need for firms to decrease their proportion of equity in the capital structure. As a result, the positive relationship between negative SMS and leverage might be statistically insignificant in firms with low CSR performance but significant in firms with high CSR performance.

[5] The terms 'high-quality' and 'low-quality' firms denote low credit risk firms and high credit risk firms respectively (Diamond, 1991).

There is mixed evidence around how CSR influences the cost of debt. Some studies find that better CSR reduces information asymmetry and increases demand for debt issues, thereby facilitating firm access to lower-cost external financing and lowering costs of debt (La Rosa *et al.*, 2018; Fishman and Hagerty, 1989; Verrechia, 1983). While firms with high CSR ratings have been reported to experience higher customer support, profitability, growth, and sales (Radhouane *et al.*, 2018; Lins *et al.*, 2017), poor CSR records may present significant risks in future clean-ups or compliance costs that threaten the ability of firms to meet their repayments to creditors (Bhuiyan and Nguyen, 2020; Schneider, 2011). Superior CSR is argued to be able to reduce firm operational risk exposure, lower cash flow volatility, risk, and consequently, the cost of debt (Erragragui *et al.*, 2018). Given this line of evidence, creditors' assessment of added risk from negative SMS, when determining the cost of debt, may be mitigated in firms with better CSR. Hence, the positive relationship between negative SMS and cost of debt might be statistically insignificant in firms with high CSR performance but significant in firms with low CSR performance. However, some studies do not find superior CSR to benefit firms in the form of a lower cost of debt (Wang *et al.*, 2008; Armitage and Marston, 2008). The assessment of negative SMS as a signal of a firm's additional riskiness by creditors may not necessarily be eased by the firm's strong CSR performance. As a result, the positive relationship between negative SMS and leverage might be statistically significant, both in firms with high and low CSR performance.

Finally, we explore possible explanations of the role of CSR performance on the relationship between SMS and debt maturity. The influence CSR wields on debt maturity continues to be an area that is under researched and one which has produced mixed findings. Some studies find that firms with better CSR exhibit higher stability and lesser risk and, hence, are more likely to use short-term debt (Benlemlih *et al.*, 2018; Attig *et al.*, 2013; Goss and Roberts, 2011). Additionally, as high-quality firms are more likely to assume more short-term debt to indicate their high quality to the market and to make the most of their high credit rating (Diamond, 1991), firms with better CSR, which are typically perceived as less risky, may be more likely to be associated with the use of short-term debt (Benlemlih *et al.*, 2018). This line of argument would suggest that the added risk from negative SMS to firms may, as explained earlier, be eased in firms with better CSR. As a result, the positive relationship between negative SMS and debt maturity might be statistically insignificant in firms with high CSR performance but significant in firms with low CSR performance. That said, some studies argue that firms which are highly committed to the disclosure of CSR have improved transparency and, hence, have a reduced need to issue short-term debts to signal their quality (Lemma *et al.*, 2021) and could prefer long term debts that is subject to less regular renewals. In this case, the positive relationship between negative SMS and debt maturity might be statistically insignificant in firms with low CSR performance but significant in firms with high CSR performance.

In sum, it is unclear how CSR performance influences the association between negative SMS and capital structure since there is no prior evidence on these associations. Hence, the following hypotheses are proposed in the null format below:

H2a: The effect of negative SMS on leverage does not differ between firms with low and high CSR performance.

H2b: The effect of negative SMS on cost of debt does not differ between firms with low and high CSR performance.

H2c: The effect of negative SMS on debt maturity does not differ between firms with low and high CSR performance.

2.5 The Influence of Firm Size on the SMS-Capital Structure Relation

Our sample for this study encompasses large-sized Fortune 500 firms on the basis of their total assets are. However, even within this group, the largest firms on average, are more than fifty times the size of the smallest firms (https://fortune.com/fortune500/). Prior literature widely documents that firm size has an important influence on capital structure (González and González, 2012; Kurshev and Strebulaev, 2015). The intersection of prior literature on firm size and capital structure with our previous arguments for the baseline hypotheses in Section 2.3 above, suggest that the relationship between negative social media sentiments and capital structure could be influenced by firm size. First, the literature reveals that larger firms are more diversified and have easier access to the equity markets (Titman and Wessels, 1988). Therefore, large firms are more likely to have lower leverage levels since they have more opportunities to access the equity capital. Second, large firms usually have more bargaining power to negotiate lower interest rates (Dennis and Sharpe, 2005). In addition, lenders are more likely to offer lower interest rates to large firms, because lenders consider large firms as low-risk borrowers (Ferri and Jones, 1979). As a result, large firms can borrow at more favourable interest rates. Finally, large firms usually have high credit ratings and prefer short-term debt because their exposure to the risk of not obtaining refinancing when their debt matures is relatively low (Dennis and Sharpe, 2005). Hence, concerns of investors and creditors over negative SMS may, as explained earlier, be eased in larger firms, and possibly enable firms to have lower leverage, cost of debt, and debt maturity. As a result, the positive relationship between negative SMS with leverage, cost of debt, and debt maturity might be statistically insignificant in larger-sized firms but significant in firms with smaller-sized. However, since there is no prior evidence on these direct associations, the following hypotheses are proposed in the null format below:

H3a: The effect of negative SMS on leverage does not differ between smaller-sized and larger-sized firms.

H3b: The effect of negative SMS on cost of debt does not differ between smaller-sized and larger-sized firms.

H3c: The effect of negative SMS on debt maturity does not differ between smaller-sized and larger-sized firms.

3. Data and Sample Selections

3.1 Sample

The sample for this study consisted of Fortune 500 firms over an 8-year period from 2010 to 2017. We exclude companies from the financial industry because they exhibit different characteristics as compared to firms from other industries. The final firm-year observations amounted to 2,331 after further excluding any observations with missing data. Our sample is compiled from three sources: the Infegy Atlas social media database, the Thomson Reuters' Asset4 database, and the Compustat database. Infegy Atlas is a U.S.-based company that utilizes data gathering techniques to scour billions of conversations from various social media sites, news, online reviews, blogs, and forums. Examples of social media sites include Facebook, Twitter, Instagram, Snapchat, Tumblr, TikTok, and Weibo. Infegy uses algorithms to identify data patterns in order search, classify, cluster, and relate social media conversations and subsequently perform sentiment analysis using natural language processing techniques. The use of Infegy database in research is gaining popularity and examples of recent studies that use Infegy include Benjamin *et al.* (2022) and Nguyen *et al.* (2020). CSR is are sourced from DataStream's Asset4 database. All the financial data, such as the dependent variables and control variables, are retrieved from the Compustat database. The definition of all the variables is shown in Table 1.

3.2 Variables Measurement

The outcome variables in this study are the capital structure of the firm (leverage, cost of debt, and debt maturity). Leverage (*LEV*) is measured as the total book value of debt (long-term and short-term debt) divided by total assets, cost of debt (*COD*) is computed as the ratio of financial expenses to total debt, and term to maturity (*MAT*) is calculated as the fraction of long-term debt to total debt, consistent with Garcia and Herrero, (2021).

Infegy utilizes Artificial Intelligence in gathering the social media sentiments data. Similarly, the Natural Language Understanding (NLU) technique, alongside the lexicon analysis are employed in extracting and classifying the social media data into positive and negative sentiments. Infegy derives social media sentiments through the following procedures: (a) extraction of social media data with Python software; (b) cleansing of data to eliminate non-operational words such as spaces, website links, etc., to recognize the source or essence of the words; (c) recognising social media sentiments into positive and negative sentiments via lexicon analysis; and (d) further recognizing and decoding more complicated word patterns into positive and negative sentiments employing natural language processing techniques.[6] For instance, words or phrases such as "furious" and "I hate it" are classified as negative SMS (Nguyen *et al.*, 2020). The variable of interest from social media for this study is negative SMS. Negative SMS (*NEGATIVE*) is calculated as the ratio of the number of negative SMS to total number of negative and positive SMS expressed in social media about a firm.

In line with prior literature, we control for a number of variables commonly used in research on capital structure and social media sentiments (Garcia and Herrero, 2021; Benjamin *et al.*, 2022; Nguyen *et al.*, 2020; Schmidt *et al.*, 2020). These variables are ESG scores (*CSR*), firm size, measured as the natural logarithm of total assets (*SIZE*), net income before interest, tax, depreciation and amortization divided to total assets (*ROA*), growth opportunities calculated as the market-to-book ratio (*M2B*), capital intensity computed as the ratio of a firm's capital expenditure to total assets (*CAPIN*), liquidity calculated as working capital divided by total assets (*LIQ*), variability of *ROA* computed as the standard deviation of ROA for the past 5 years (SD_{ROA}) and asset tangibility computed as plant, and equipment to total assets (*TAN*).

The CSR data – composite environmental, social and governance performance (ESG) scores (*ENV)* -- are retrieved from the Thomson Reuters' Asset4 database. Asset4's ESG scores are customary and suitable proxies for a firm's CSR performance (Choi *et al.*, 2018; Luo *et al.*, 2015). Thomson Reuters' Asset4 yearly formulates its *ESG* scores that are equally weighted by gathering information from multiple sources (e.g., annual reports, websites, CSR reports, news) (Benjamin and Biswas, 2022). The aggregate ESG score is comprised of 90 indicators from the environmental dimension, 63 indicators from the social dimension *(ENV)* and 54 indicators from the governance dimension. The score for ESG ranges from zero for the lowest ratings to 100 for the maximum ratings.

[6] For instance, consider the following two words/phrases that mention the word "like": "I like Campbell Soup" and "That tastes like Campbell Soup". The first phrase reflects an sentiment, whereas the second phrase latter does not. Infegy uses data mining techniques where the terms are clustered and association rules are applied to ascertain the patterns.

Table 1: Variable definitions

Variable	Definition
Dependent variables	
LEV	*Leverage*: total book value of debt (long-term and short-term debt) divided by total assets
COD	*Cost of debt*: ratio of financial expenses to total debt
MAT	*Term to maturity*: fraction of long-term debt to total debt
Main variable	
NEGATIVE	*Negative SMS*: calculated as the ratio of the number of negative SMS to total number of negative and positive SMS expressed in social media.
Control variables	
SIZE	*Firm size*: natural logarithm of total assets
LIQ	*Liquidity*: working capital divided by total assets
ROA	*Profitability*: EBITDA divided by total assets
CAPIN	*Capital intensity*: ratio of a firm's capital expenditure to total assets
M2B	*Growth opportunities*: market-to-book ratio
SD_{ROA}	*Variability of ROA*: standard deviation of ROA for the past 5 years prior to the current period)
CSR	Composite Environmental, Social and Governance scores of Thomson Reuters' Asset4 based on 178 key indicators and more than 750 data points.
TAN	*Tangible assets*: net property, plant, and equipment divided by total assets

3.3 Modelling Capital Structure and Negative SMS

We examine the impact of negative SMS of firms on capital structure using the following empirical models:

$$\begin{aligned} LEV_{i,t} &= \alpha + \beta_1 NEGATIVE_{i,t-1} + \beta_2 CSR_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 LIQ_{i,t-1} \\ &+ \beta_5 ROA_{i,t-1} + \beta_6 CAPIN_{i,t} + \beta_7 M2B_{i,t-1} + \beta_8 SDROA_{i,t-1} \\ &+ \beta_9 TAN_{i,t-1} + INDUSTRY_i + YEAR_t + \varepsilon_{i,t} \end{aligned} \quad (1)$$

$$\begin{aligned} COD_{i,t} &= \alpha + \beta_1 NEGATIVE_{i,t-1} + \beta_2 CSR_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 LIQ_{i,t-1} \\ &+ \beta_5 ROA_{i,t-1} + \beta_6 CAPIN_{i,t} + \beta_7 M2B_{i,t-1} + \beta_8 SDROA_{i,t-1} \\ &+ \beta_9 TAN_{i,t-1} + INDUSTRY_i + YEAR_t + \varepsilon_{i,t} \end{aligned} \quad (2)$$

$$\begin{aligned} MAT_{i,t} &= \alpha + \beta_1 NEGATIVE_{i,t-1} + \beta_2 CSR_{i,t-1} + \beta_3 SIZE_{i,t-1} + \beta_4 LIQ_{i,t-1} \\ &+ \beta_5 ROA_{i,t-1} + \beta_6 CAPIN_{i,t} + \beta_7 M2B_{i,t-1} + \beta_8 SDROA_{i,t-1} \\ &+ \beta_9 TAN_{i,t-1} + INDUSTRY_i + YEAR_t + \varepsilon_{i,t} \end{aligned} \quad (3)$$

where *LEV*, *COD* and *MAT* represent leverage, debt maturity, and cost of debt, respectively, for firm *i* at year *t*. Eqs. (1), (2) and (3) are estimated based on the pooled ordinary least squares (OLS) regression with robust standard errors technique. The outcomes variables and firm-specific financial control variables are winsorized at the 1st and 99th percentiles. All our regressions also contain indicator variables for industry effects based on the two-digit Global Industry Classification Standard (GICS) codes and year effects.

In order to assess the influence of *CSR* performance on the effect of negative SMS on capital structure, we divide the sample into two sub-groups and rerun Eq. (1), (2) and (3). Specifically, firms with ESG scores below the median are classified as 'Low CSR' group and firms with ESG scores above the median are classified as 'High CSR' group. Similarly, in order to examine the influence of firm size on the effect of negative SMS of firms on capital structure, we divide the sample into two sub-groups and rerun Eq. (1), (2) and (3). Specifically, firms with the values of *SIZE* below the median are classified as 'Small Size' group and firms with the values of *SIZE* above the median are classified as 'Large Size' group.

Table 2: Descriptive statistics

Variable	N	Mean	SD	p25	Median	p75	Min	Max
LEV	2331	0.289	0.177	0.164	0.262	0.391	0.000	0.847
MAT	2279	0.882	0.164	0.841	0.940	0.989	0.014	1.000
COD	2255	0.052	0.046	0.033	0.046	0.059	0.008	0.484
NEGATIVE	2331	0.284	0.113	0.206	0.274	0.350	0.000	1.000
CSR	2331	48.595	17.784	35.300	48.330	61.840	5.650	92.530
SIZE	2331	9.581	1.133	8.775	9.486	10.348	5.956	13.004
LIQ	2331	0.146	0.146	0.038	0.125	0.241	-0.134	0.592
ROA	2331	0.065	0.061	0.033	0.062	0.096	-0.212	0.227
CAPIN	2331	0.046	0.040	0.020	0.035	0.058	0.003	0.233
M2B	2331	4.273	6.778	1.833	3.002	5.022	-19.903	35.727
SD_{ROA}	2331	0.032	0.034	0.012	0.021	0.037	0.001	0.211
TAN	2331	0.269	0.214	0.095	0.201	0.392	0.014	0.857

Notes: p25 and p75 = 25th and 75th percentile of the variables, respectively. SD and N denotes standard deviation and number of observations, respectively. Definitions of all variables are presented in Table 1.

4. Empirical Results

4.1 Descriptive Statistics and Correlation Analysis

The descriptive statistics is presented in Table 2. The mean (median) value of *LEV* is 0.289 (0.262). The average *COD* of the sample firms is 0.052 and ranges between 0.008 and 0.484. Term to maturity (*MAT*) constitutes 88.2% of the total debt. *NEGATIVE* has a mean of 0.284 and median of 0.274. Other control variables such as *CSR* and *SIZE* have means of 48.595, and 9.581 respectively. Next, the results of the correlation matrix between all the variables are presented is presented in Table 3. Results indicate that multicollinearity is not likely to be a main concern, as none of the independent variables have correlations higher than 0.8. Next, we present the results of the tests of our multivariate analyses.

4.2 Multivariate Analysis

Table 4 presents the results regarding the influence of negative social media sentiments on leverage (Column 1), cost of debt (Column 2), and term to maturity (Column 3). These results show a significant and positive relationship (*LEV*; coefficient = 0.063, $p<0.10$), (*COD*; coefficient = 0.029, $p< 0.01$) and (*MAT*; coefficient = 0.064, $p<0.5$) and support the conjecture that: a firm's capital structure is adversely affected by negative social media sentiments. Specifically, a one standard deviation increase in *NEGATIVE* is associated with a 0.025 (=0.063*0.113/0.289) increase in the *LEV* at the mean. Similarly, a one standard deviation increase in *NEGATIVE* is associated with a 0.063 (=0.029*0.113/0.052) and 0.008 (=0.064*0.113/0.882) increase in *COD* and *MAT* at the means, respectively). Therefore, the null hypothesis *H1a* could be rejected, as our results suggest that negative SMS influences shareholders unfavorably, restricts firms' access to external financial resources, and reduces a firm's proportion of external equity in the capital structure, leading to higher levels of leverage. Likewise, *H1b* could be rejected as the results suggest that negative SMS signals greater financial risks and affects creditors' risk assessment of firms unfavorably, leading to a higher cost of debt. Finally, *H1c* could be rejected as the result indicates that short-term debt becomes less attractive for firms that are more exposed to negative SMS and, hence, are more likely to use long-term debt.In terms of the control variables, the coefficient of *SIZE* is negative and significant across all three measures of capital structure while *TAN* is positive and significant across all three measures of capital structure. CAPIN is only negative and significant in Column (1) for *LEV* and in Column (3) for *MAT*. Similarly, SD_{ROA} is only positive and significant in Column (3) for *MAT*.

Table 3: Correlations table

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1] *LEV*	1.00											
[2] *MAT*	0.09***	1.00										
[3] *COD*	-0.19***	-0.07***	1.00									
[4] *NEGATIVE*	0.02	0.03	0.00	1.00								
[5] *CSR*	-0.04*	0.01	-0.11***	-0.00	1.00							
[6] *SIZE*	-0.01	-0.04*	-0.19***	0.33***	0.22***	1.00						
[7] *LIQ*	-0.30***	0.01	0.09***	-0.05**	-0.06***	-0.29***	1.00					
[8] *ROA*	-0.22***	-0.05**	0.01	-0.05***	0.14***	-0.00	0.19***	1.00				
[9] *CAPIN*	0.06***	0.09***	0.06***	0.06***	-0.05**	0.01	-0.22***	-0.05***	1.00			
[10] *M2B*	0.03	-0.02	-0.04**	0.02	0.04**	-0.01	-0.03	0.14***	0.01	1.00		
[11] SD_{ROA}	-0.00	0.09***	0.02	0.09***	0.02	0.03	0.08***	-0.18***	0.25***	-0.03	1.00	
[12] *TAN*	0.18***	0.14***	0.04*	0.08***	0.01	0.12***	-0.36***	-0.11***	0.73***	-0.05**	0.14***	1.00

Notes: *,** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Definitions of all variables are presented in Table 1.

Table 4: Negative social media sentiments and capital structure

Dependent variable	*LEV*	*COD*	*MAT*
	(1)	(2)	(3)
NEGATIVE	0.063*	0.029***	0.064**
	(1.93)	(3.65)	(2.14)
CSR	-0.001***	-0.000	0.000**
	(-2.68)	(-1.32)	(2.17)
SIZE	-0.012***	-0.008***	-0.013***
	(-3.52)	(-7.82)	(-3.27)
LIQ	-0.294***	0.006	0.073**
	(-10.19)	(0.80)	(2.24)
ROA	-0.529***	0.010	-0.081
	(-7.22)	(0.54)	(-1.41)
CAPIN	-0.543***	-0.009	-0.210**
	(-3.86)	(-0.24)	(-2.09)
M2B	0.001	-0.000***	-0.000
	(0.94)	(-2.85)	(-0.40)
SD_{ROA}	0.052	0.029	0.344***
	(0.46)	(1.12)	(3.73)
TAN	0.213***	0.015***	0.151***
	(8.06)	(3.25)	(8.21)
Constant	0.438***	0.125***	0.943***
	(12.98)	(13.90)	(22.28)
Year dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Adj R^2	0.214	0.077	0.051
F-statistic	32.106	15.054	8.831
N	2,331	2,255	2,279

Notes: This table presents the estimation results of the relationship between social media sentiments (SMS) and capital structure. *t*-statistics are based on robust standard errors and are in parentheses. *,** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Definitions of all variables are presented in Table 1.

Table 5 shows the results for the sub-sample analysis for Hypotheses *2a* - *2c*. Columns (1) and (2) report the sub-sample analysis for the influence of CSR performance on the relationship between *NEGATIVE* with leverage (*H2a*). The results show that in the case of firms with low CSR performance (Column 1), the relationship between *NEGATIVE* and *LEV* is not significant. However, in firms with high CSR performance, the coefficient of *NEGATIVE* on *LEV* loads positively and significantly at the 5% level. Hence, the null hypothesis *H2a* could be rejected as the results show that the effect of negative SMS on leverage does differ between firms with low and high CSR performance. Overall, these results are supportive of the conjecture that investors view CSR as a costly pursuit (Benjamin *et al.*, 2022), and hence, their concerns over negative SMS are intensified in firms with high CSR performance, further limiting investors' support and elevating the need for firms to decrease their proportion of equity in the capital structure. Financial professionals should recognize the impact of CSR performance on investor perceptions and consider proactive strategies to manage negative SMS, especially for firms with a strong CSR focus, to maintain favorable leverage choices and investor support.

The results of the Low CSR and High CSR sub-sample analyses for Hypothesis *2b* are reported in Columns (3) and (4) of Table 5, respectively. It is notable that the associations between *NEGATIVE* and *COD* remain positive and significant at the minimum, with a significance level of 5% in both sub-samples. Therefore, the null hypothesis of *H2b*, could not be rejected as the results show that effect of negative SMS on cost of debt does differ between firms with low and high CSR performance. Overall, these results are consistent with the notion that superior CSR performance does not benefit firms in the form of a lower cost of debt. Hence, the concerns of creditors over negative SMS result in a higher cost of debt, regardless of whether firms have high or low CSR performance. These results underscore the

significance of managing negative perceptions and maintaining a positive reputation among creditors to secure favorable debt financing, irrespective of CSR performance levels.

The results of the *Low CSR* and *High CSR* sub-samples analyses for Hypothesis *2c* are reported in Columns (5) and (6) of Table 5, respectively. The results show that in the case of firms in both sub-samples, the relationship between *NEGATIVE* and *MAT* are not significant. Therefore, the null hypothesis of *H2c* which states that the effect of negative SMS on leverage does not differ between smaller-sized and larger-sized firms, could not be rejected. As mentioned earlier, since evidence on this area is still limited, we contend that more studies should be carried out in this area to further understand why effect of negative SMS on term to maturity is insignificant in firms with low and high CSR performance. Financial professionals should consider these nuances when making debt-related decisions and assess how investor perceptions may differ based on firm size and CSR performance.

Table 5: Negative social media sentiments and capital structure – the influence of CSR

Dependent variable	*LEV*		*COD*		*MAT*	
	Low CSR	*High CSR*	*Low CSR*	*High CSR*	*Low CSR*	*High CSR*
	(1)	(2)	(3)	(4)	(5)	(6)
NEGATIVE	0.030	0.099**	0.036***	0.026**	0.070	0.062
	(0.63)	(2.29)	(2.97)	(2.50)	(1.57)	(1.61)
SIZE	-0.011**	-0.018***	-0.008***	-0.008***	-0.013**	-0.013**
	(-2.27)	(-3.73)	(-5.88)	(-4.95)	(-2.42)	(-2.33)
LIQ	-0.327***	-0.261***	0.003	0.009	-0.013	0.146***
	(-7.98)	(-6.63)	(0.28)	(0.88)	(-0.25)	(4.10)
ROA	-0.608***	-0.504***	0.027	-0.012	-0.068	-0.050
	(-6.01)	(-5.00)	(0.90)	(-0.59)	(-0.74)	(-0.68)
CAPIN	-0.868***	-0.280	0.016	-0.022	-0.353**	-0.086
	(-4.39)	(-1.50)	(0.33)	(-0.39)	(-2.48)	(-0.58)
M2B	0.001	0.001	-0.000***	0.000	0.001	-0.001
	(0.86)	(0.66)	(-3.64)	(0.65)	(1.38)	(-1.20)
SD_{ROA}	-0.009	0.199	0.039	0.021	0.454***	0.270*
	(-0.06)	(1.19)	(0.99)	(0.59)	(3.64)	(1.79)
TAN	0.331***	0.094***	0.009	0.017***	0.154***	0.145***
	(7.78)	(3.03)	(1.36)	(3.05)	(5.37)	(5.76)
Constant	0.304***	0.345***	0.139***	0.142***	0.984***	0.960***
	(5.56)	(6.10)	(11.25)	(8.86)	(17.75)	(15.01)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	0.247	0.202	0.064	0.086	0.049	0.075
F-statistic	21.768	18.728	8.030	13.842	6.084	6.318
N	1,166	1,165	1,107	1,148	1,126	1,153

Notes: This table presents the estimation results of the relationship between negative social media sentiments (SMS) and capital structure amongst firms with low versus high ESG scores. *t*-statistics are based on robust standard errors and are in parentheses. *,** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Definitions of all variables are presented in Table 1.

In Table 6, we present the results of the sub-sample analysis for Hypotheses *3a* - *3c*. Columns (1) and (2) report the sub-sample analysis for the influence of firm size on the relationship between *NEGATIVE* with leverage (*H3a*). The results show that in the case of *Small Size* firms (Column 1), the relationship between *NEGATIVE* and *LEV* is positive and significant at the 1% level. However, in *Large Size* firms (Column 2), the coefficient of *NEGATIVE* on *LEV* is not significant. Thus, the null hypothesis *H3a* could be rejected because the results show that effect of negative SMS on leverage does differ between smaller-sized and larger-sized firms. Collectively, these results show that, unlike smaller-sized firms, concerns of investors over negative SMS are eased in larger-sized firms, leading to an insignificant relationship between *NEGATIVE* on *LEV*. The contrasting relationships between negative SMS and leverage observed in smaller-sized and larger-sized firms highlight the

significance of firm size in shaping the impact of negative SMS on capital structure decisions. Financial professionals and managers should take these differences into account when managing investor perceptions and optimizing leverage choices to achieve favorable financial outcomes based on their firm's size and investor concerns related to negative SMS.

The results of the *Small Size* and *Large Size* sub-samples analyses for Hypothesis *3b* are reported in Columns (3) and (4) of Table 5, respectively. It is notable that, at the minimum, the associations between *NEGATIVE* and *COD* remain positive and significant with a significance level of 5% in both sub-samples. Hence, the null hypothesis *H3b* could not be rejected as results reveal that the effect of negative SMS on cost of debt does differ between smaller-sized and larger-sized firms. Hence, we find no support for the argument that concerns of creditors over negative SMS is more elevated in smaller-sized firms, as compared to larger-sized firms. These findings challenge the notion that concerns of creditors over negative SMS are more pronounced in smaller-sized firms compared to larger-sized firms, highlighting the need for all firms, regardless of size, to carefully manage negative perceptions to maintain favorable debt costs and creditor support.

Table 6: Negative social media sentiments and capital structure – the influence of firm size

	LEV		*COD*		*MAT*	
	Small size	*Large size*	*Small size*	*Large size*	*Small size*	*Large size*
	(1)	(2)	(3)	(4)	(5)	(6)
NEGATIVE	0.145***	-0.003	0.035**	0.021***	0.090*	0.075**
	(2.96)	(-0.08)	(2.41)	(2.71)	(1.68)	(2.26)
CSR	-0.001***	-0.001***	-0.000	-0.000	0.001	-0.000
	(-2.62)	(-3.31)	(-0.48)	(-1.34)	(1.43)	(-0.16)
SIZE	0.055***	-0.037***	-0.016***	-0.006***	0.026*	-0.039***
	(5.25)	(-6.75)	(-3.28)	(-7.25)	(1.91)	(-7.09)
LIQ	-0.418***	-0.116***	0.029**	-0.020**	0.215***	-0.030
	(-10.95)	(-2.63)	(2.40)	(-2.58)	(4.43)	(-0.67)
ROA	-0.616***	-0.295***	0.041	-0.023	-0.098	0.033
	(-6.54)	(-2.89)	(1.16)	(-1.52)	(-1.00)	(0.48)
CAPIN	-0.890***	0.006	0.069	-0.088***	0.408**	-0.327***
	(-3.66)	(0.03)	(0.93)	(-4.10)	(2.05)	(-2.76)
M2B	0.001	0.002	-0.000**	-0.000	-0.001	-0.000
	(0.46)	(1.52)	(-2.35)	(-1.59)	(-0.97)	(-0.32)
SD_{ROA}	0.355*	-0.204*	0.035	0.032*	0.631***	0.218**
	(1.76)	(-1.65)	(0.54)	(1.76)	(3.33)	(2.11)
TAN	0.267***	0.192***	0.009	0.019***	0.083*	0.144***
	(5.00)	(6.32)	(0.84)	(5.25)	(1.90)	(7.31)
Constant	-0.245**	0.621***	0.199***	0.128***	0.525***	1.250***
	(-2.45)	(10.67)	(4.80)	(12.66)	(4.09)	(22.20)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	0.341	0.211	0.063	0.110	0.049	0.115
F-statistic	35.219	16.917	4.223	21.712	3.380	9.487
N	1,079	1,252	1,023	1,232	1,044	1,235

Notes: This table presents the estimation results of the relationship between negative social media sentiments (SMS) and capital structure amongst firms with low versus high firm size. *t*-statistics are based on robust standard errors and are in parentheses. *,** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Definitions of all variables are presented in Table 1.

Columns (5) and (6) of Table 6 present the results of the *Small Size* and *Large Size* sub-samples analyses, respectively of Hypothesis *3c*. The results indicate that for firms in both sub-samples, the relationship between *NEGATIVE* and *MAT* is consistently positive and significant, with a minimum significance level of 10%. Hence, the null hypothesis *H3c* could not be rejected as the results show that effect of negative SMS on term to maturity does not differ between smaller-sized and larger-sized firms. Hence, we find no support for the idea that, unlike smaller-sized firms, the higher credit ratings and preference for short term debt

among larger-sized firms leads to insignificant relationship between *NEGATIVE* and *MAT*. The consistent and significant influence of negative SMS on term to maturity (MAT) for firms of various sizes has important implications for practitioners. Regardless of a firm' size or credit ratings, it is crucial for financial professionals and decision-makers to recognize the potential impact of negative SMS on the maturity of their debt. This highlights the need for proactive risk management strategies and effective communication strategies to address negative perceptions and maintain a favorable debt structure. Understanding and addressing the influence of negative SMS on *MAT* can help firms enhance their financial stability and reputation among investors and creditors, ultimately contributing to improved financial performance and long-term sustainability.

4.3 Further Robustness Tests

In this part, we perform three robustness tests to assess our main findings. First, we employ the two-stage least squares (2SLS) regression analysis to address possible endogeneity issues. We use one-year lagged value of *NEGATIVE* (excluding the focal firm) as the instrumental variable for the 2SLS. This instrument is named as *LAG_NEGATIVE* in our analysis and identified based on prior studies (Benjamin *et al.*, 2020; Al-Hadi *et al.*, 2017) that had used the one-year lagged value of the main variable of interest as the instrument. Initially, *NEGATIVE* is regressed on the instrumental variable, i.e., *LAG_NEGATIVE* and control variables in the first-stage regression to estimate the fitted value of negative SMS. The fitted value of negative is names *PRED_NEGATIVE*. In the second-stage of the 2SLS, *PRED_NEGATIVE* is employed as the independent variable of interest. In Table 7, the first-stage regressions are presented in Models (1), (3) and (5). It can be seen that *LAG_NEGATIVE*, is positively associated at the 1% levels with *NEGATIVE* for all three models. Several post-estimation tests confirm the validity of our instrument. For example, the Kleibergen-Paap rk LM statistic of 25.88 (untabulated) is significant at the 0.01% level, suggesting that the instrument is relevant. Similarly, the results of the weak identification test suggest that our model does not suffer from weak identification because the Cragg-Donald F statistic is higher than the Stock and Yogo (2005) critical threshold of 16.38. Columns (2), (4) and (6) of Table 7 present the second-stage regressions and the coefficients of *PRED_ NEGATIVE* are significant and positive at the 10%, 1%, and 1% levels in explaining *LEV*, *COD* and *MAT*, respectively. Hence, the results of the 2SLS regressions technique are consistent with the earlier reported results and reinforce our findings which reveal positive and significant associations between negative SMS with leverage, cost of debt and debt maturity.

Next, we adopt the propensity score matching (PSM) estimator to address selection bias due to firm-related characteristics and functional misspecifications. We apply PSM to compare capital structure (leverage, debt maturity, and cost of debt) between a group of firms that have a high negative SMS value (treatment group) with a group of firms that have a low negative SMS value (control group). We classify a high (low) negative SMS as firms whose *NEGATIVE* value is above (below) the median of *NEGATIVE*. We choose the nearest neighbour technique with no replacement and with a caliper distance of 0.02 to ensure both groups are comparable, and no significant differences are detected between them.

Table 7: Two-stage least-squares (2SLS) results

	NEGATIVE	*LEV*	*NEGATIVE*	*COD*	*NEGATIVE*	*MAT*
	First stage	Second stage	First stage	Second stage	First stage	Second stage
	(1)	(2)	(3)	(4)	(5)	(6)
LAG_NEGATIVE	0.525***		0.526***		0.524***	
	(21.48)		(21.20)		(21.30)	
PRED_NEGATIVE		0.109*		0.041***		0.147***
		(1.74)		(3.34)		(2.60)
CSR	-0.000*	-0.001**	-0.000	-0.000	-0.000	0.000**
	(-1.70)	(-2.48)	(-1.34)	(-1.09)	(-1.57)	(2.29)
SIZE	0.015***	-0.012***	0.014***	-0.009***	0.014***	-0.018***
	(6.85)	(-3.06)	(6.44)	(-7.53)	(6.53)	(-4.21)
LIQ	0.030*	-0.286***	0.033**	0.004	0.034**	0.079**
	(1.87)	(-9.25)	(1.98)	(0.56)	(2.07)	(2.45)
ROA	-0.055*	-0.517***	-0.058*	0.012	-0.056*	-0.046
	(-1.70)	(-6.73)	(-1.76)	(0.65)	(-1.71)	(-0.79)
CAPIN	-0.020	-0.508***	0.008	-0.001	0.002	-0.200*
	(-0.26)	(-3.33)	(0.10)	(-0.04)	(0.02)	(-1.94)
M2B	0.000	0.001	0.000	-0.000**	0.000	-0.000
	(0.18)	(0.63)	(0.28)	(-2.54)	(0.27)	(-0.48)
SD_{ROA}	0.059	0.017	0.043	0.023	0.050	0.324***
	(1.02)	(0.15)	(0.75)	(0.82)	(0.86)	(3.43)
TAN	0.033*	0.205***	0.031*	0.015***	0.032*	0.142***
	(1.89)	(6.94)	(1.76)	(3.11)	(1.81)	(7.29)
Constant	-0.039**	0.499***	-0.035*	0.111***	-0.035*	0.974***
	(-1.98)	(13.76)	(-1.73)	(13.12)	(-1.76)	(24.98)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.438	0.193	0.430	0.068	0.431	0.048
Underidentification test	339.220		327.825***		332.661	
Weak Identification test	461.289		825.630		453.680	
F-statistic	66.635	26.327	61.14	13.181	63.280	8.293
N	2,065	2,065	2,000	2,000	2,023	2,023

Notes: This table presents the estimation results of our instrumental variable (2SLS) specification. In Columns (1), (3) and (5) the one-year lagged value of *NEGATIVE* (denoted as *LAG_ NEGATIVE*) serve as excluded instrument to generate *PRED_ NEGATIVE* that is used in Column (2), (4) and (6). *t*-statistics are in parenthesis. ***,**,* represents significance at the 1%, 5% and 10% level, respectively. Definitions of all variables are presented in Table 1.

Panel A of Table 8 presents the univariate mean comparisons between the treatment and control firms' characteristics using the same control variables included in Eqs. (1), (2) and (3). The *t*-stats reveal that the mean differences of each variable between the treated and control groups are not statistically significant and this show that there are no distinguishable differences between the two groups. Hence, this increases the likelihood that any differences in capital structure between the two groups is due to the differences in *NEGATIVE*. Models (1), (2) and (3) of Panel B in Table 8 report the re-estimation of our baseline regression using the propensity score-matched sample. The results show that the positive and significant associations between *NEGATIVE* with *LEV*, *COD* and *MAT* are at the 5%, 1% and 1% levels respectively. Hence, these PSM results are consistent with the results of our baseline results in Table 4.

Table 8: Propensity score matching (PSM) analysis

Panel A: Comparison of treatment and control firms

Variable	Obs.	Treated	Obs.	Control	Difference	*t*-stat
CSR	827	48.443	827	48.558	-0.115	-0.130
SIZE	827	9.443	827	9.493	-0.050	-1.090
LIQ	827	0.147	827	0.144	0.003	0.420
ROA	827	0.063	827	0.065	-0.001	-0.370
CAPIN	827	0.043	827	0.044	-0.001	-0.380
M2B	827	4.399	827	4.238	0.161	0.450
SD_{ROA}	827	0.030	827	0.030	0.000	0.180
TAN	827	0.267	827	0.268	-0.001	-0.120

Panel B: PSM regression

	LEV	*COD*	*MAT*
	(1)	(2)	(3)
NEGATIVE	0.095**	0.030***	0.107***
	(2.49)	(3.35)	(2.92)
CSR	-0.001***	-0.000	0.000
	(-3.60)	(-1.21)	(1.48)
SIZE	-0.003	-0.006***	-0.010*
	(-0.70)	(-4.39)	(-1.81)
LIQ	-0.273***	0.009	0.068
	(-7.42)	(1.08)	(1.64)
ROA	-0.514***	-0.021	-0.111*
	(-5.93)	(-1.14)	(-1.66)
CAPIN	-0.363**	-0.026	-0.242*
	(-2.03)	(-0.72)	(-1.96)
M2B	0.000	-0.000**	-0.000
	(0.45)	(-1.99)	(-0.73)
SD_{ROA}	0.058	0.002	0.222*
	(0.41)	(0.06)	(1.87)
TAN	0.233***	0.013**	0.151***
	(7.62)	(2.46)	(7.44)
Constant	0.253***	0.118***	0.914***
	(4.62)	(8.48)	(15.08)
Year dummies	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes
Adj R^2	0.213	0.070	0.055
F-statistic	22.824	11.464	6.699
N	1,654	1,612	1,620

Notes: This table presents the baseline results for the impact of negative social media sentiments (SMS) on capital structure, using PSM. *t*-statistics are based on robust standard errors and are in parentheses. *,** and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Definitions of all variables are presented in Table 1.

5. Conclusion

In this paper, we examine whether SMS affects firm capital structure. Our findings, based on a sample of Fortune 500 firms in the period between 2010 – 2017, reveal that negative SMS significantly increases leverage, cost of debt and term to maturity. However, when we examine the influence of CSR performance and firm size on the relationship between negative SMS and capital structure, the findings are mixed. Specifically, we find that the positive and significant relationship between negative SMS and leverage remains unchanged only in firms with high CSR performance. The corresponding results for the influence of low and high CSR sub-samples on the positive association between negative SMS with; (1) cost of debt produce significant results for both groups, and (2) term to maturity produce insignificant results for both groups. The sub-sample results small and large firms reveal the effects of negative SMS on leverage is positive and significant in small firms only. The corresponding sub-sample analysis for the effects of negative SMS on cost of debt and term to maturity show positive

and significant association across both sub-samples. The results are strengthened by several robustness tests.

We acknowledge that there are certain limitations in this present study and the potential opportunities for future research it presents. First, since our study is based on archival empirical analysis of large Fortune 500 firms, and hence our results may not necessarily be applicable to smaller and medium-sized firms. Secondly, steady growth in the usage of social media may strengthen the results obtained in this study in future periods. Future studies should examine the linkage between social media sentiments and the capital structure of firms in different time periods and other capital markets to deepen understandings of this topic. Future studies could also extend this research by empirically examining how social media sentiments affect other corporate financial outcomes outside of capital structure, such as firm risk and stock price crash risk.

Our findings will also help researchers and practitioners to understand the impact of negative sentiments on capital structure and how CSR performance and firm size are important influences on this nexus. Our research has potential global implications as corporations are now paying more attention to understanding how social media sentiments impact firm strategies and financial outcomes.

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