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HOW DO SOCIAL MEDIA SHAPE THE INFORMATION ENVIRONMENT IN THE FINANCIAL MARKET?

Completed Research Paper

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Abstract

Internet users create social media that enable information to be transferred more efficiently. In this work we focus on a typical social media platform Wikipedia and examine how management's voluntary disclosure reacts to information arrivals on Wikipedia. In doing so, we seek to answer the question of whether social media indeed improve the information environment for investors in the financial market. Our analysis is based on a unique dataset collected from the modification history of firm entries on Wikipedia, and thus we are able to identify information arrivals on Wikipedia. We find that information arrivals on Wikipedia affect the timing of management disclosure of bad news, and the effect is in sharp contrast to the way in which traditional media affect management disclosure. Further, we find consistent evidence that information arrivals on Wikipedia preempt the negative reaction of the market to bad news. In contrast, more news coverage in traditional media exacerbates the problem of optimistic analyst forecasts. Together these findings emphasize that social media have an identifiable effect on both the management side and the investor side in the financial market.

Keywords: Social media, information environment, financial market, voluntary disclosure, analyst bias, analyst dispersion, traditional media, Web 2.0, Wikipedia

Introduction

Recent years have witnessed an explosive growth of user-generated content on the Internet. Aggregately, individual Internet users create social media that change the landscape of information acquisition in various contexts. Represented by Wikipedia, Blogs, Flickr, YouTube, and Twitter, social media tools allow users to search, organize, share, annotate and contribute to contents in a collaborative way, and as a result, enable information to be transferred more efficiently through social networks.

This paper studies how information in social media affects management decision on disclosing financial information, and how investors react to management's information disclosure in different information environments. We address three fundamental research questions: When social media become increasingly important information sources, how do managers react to such changes in the information environment? How do social media differ from traditional media, say, newspapers, in fulfilling the role of improving the information environment? Finally, if social media really inform investors, how would that change the market's reaction to management disclosure?

Financial systems play a crucial role in allocating resources in the economy. They channel household savings to the business sector, offer a way for firms and households to share risk, and allocate resources among firms. Information takes a center stage in the process for financial systems to play such a role. As a result, the way in which information is generated, distributed, and processed in financial markets has received considerable attention in the literature. In this paper, we are specifically interested to find out if the information environment for managers and investors has changed due to the advent of social media, which is often dubbed the "web 2.0" phenomenon.

Web 2.0 sites allow individual people to easily share their information with others, and effectively constitute a new way for people to get informed (Kane and Fichman 2009, Majchrzak et al. 2006, Majchrzak 2009). Information in social media is organized in a collaborative manner through "wisdom of crowds" (Surowiecki 2004), which relies heavily on the participation of individual contributors. If prediction markets (Forsythe et al. 1992, Wolfers and Zitzewitz 2004) can be considered as a quantitative way of aggregating information, social media offers a means of qualitative information aggregation. In models of the impact of investor sentiment on stock market prices, uninformed traders rely on various information sources in forming their beliefs. In equilibrium, their beliefs, albeit noisy, influence prices (De Long et al. 1990). The changing information environment would have a non-trivial impact on how investors obtain and process information. Although one cannot directly observe how investors obtain and process information, it is possible to infer the impact of improved investor information environment from managers' discretionary disclosure, as well as the market reaction to such disclosures.

This paper focuses on Wikipedia, a good representative for social media. It is a free online encyclopedia with millions of articles contributed collaboratively by volunteers using wiki software.¹ Specifically, we quantify the contributions to social media and the change in information environment with modifications to Wikipedia. Anecdotal evidence suggests an increasingly important role played by social media in general and Wikipedia in specific. For example, in 2007, a software program called Wikipedia Scanner revealed that many companies had edited entries related to their business.² It is also found that Microsoft tried to cover up the XBOX 360 failure rate; ChevronTexaco, an oil company, deleted a paragraph regarding to fines against the company; Sony removed paragraphs against its blu-ray systems. This paper seeks to develop our understanding, beyond the qualitative evidence, about whether and how Wikipedia and traditional media may play different roles in shaping the information environment in capital markets.

Theoretical Background

The role of disclosure in capital markets

We start with briefly examining the role of disclosure in modern capital markets, in which there are two fundamental flows, capital flow and information flow (Healy and Palepu 2001). In the financial market, households invest

¹ A wiki is a technology that allows people to use a kind of markup language to modify the content of a Web page.

² <http://skewe.wordpress.com/2007/08/25/wiki-scandal-discovered-by-students-program/>, accessed March 2009.

savings to firms and obtain returns (through the capital flow); firms communicate to households about their profitability, either directly or via information intermediaries (through the information flow).

Information flow plays a key role in the functioning of capital markets. Investors, in making investment decisions, need information about firms' profitability. However, there is usually information asymmetry. Once households invest their savings in a business, they typically delegate responsibility to managers (Jensen and Meckling 1976). Managers have superior information to outside investors about firm profitability. At the same time, investors lack perfect information about managers' activities, such as making accounting decisions to manage reported performance.

While it is of paramount importance for investors to learn about firms' profitability, managers may not always want to disclose truthfully. When the managers selectively disclose information, there arises a typical agency problem. When managers maximize their own utility, they may pay little or even no regard to the welfare of investors (Jensen and Meckling 1976). In the case of discretionary disclosure, managers may attempt to release (withhold) information that may affect the stock market performance favorably (unfavorably). Doing so, they may increase the funds under their control, pay excessive compensation, and maintain their professional reputation.

Because of the agency problem, there is a demand for information intermediaries to reveal managers' superior information. In the stock market, a major information intermediary is financial analysts, who collect information from various sources, evaluate the current performance of firms, make forecasts about future firm profitability, and recommend investors to buy/sell stock (Francis et al. 1997, Roulstone 2003). Other intermediaries include individual journalists (Foster 1987) and business press (Frankel and Li 2004, Mitchell and Mulherin 1994). More recently, information sources on the Internet start to play an increasingly important role in disseminating information about firms (Antweiler and Frank 2004). This study aims to identify how the advent of social media has changed the information environment for investors and how managers react to such changes.

In addition to the information intermediaries, managers may voluntarily disclose information about firm profitability, which can be another source from which investors obtain information about firms (Dye 1985, Verrecchia 1983, also see Healy and Palepu (2001) and Verrecchia (2001) for literature reviews). Managers choose to disclose their private information, sometimes bad news, to serve their self-interests (Healy and Palepu 2001).

Why do managers release bad news?

In our study, *bad news* refers to the fact that a firm's earnings per share (EPS) in one fiscal quarter are below the expected value in the market (Matsumoto 2002, Francis et al. 1997, Skinner 1994, 1997). After a fiscal quarter ends, managers know both the actual quarterly EPS and the market expectation. Before officially announcing EPS on the official announcement date as required by SEC, managers have the discretion to decide whether to release or withhold bad news. They confront a tradeoff in making this decision.

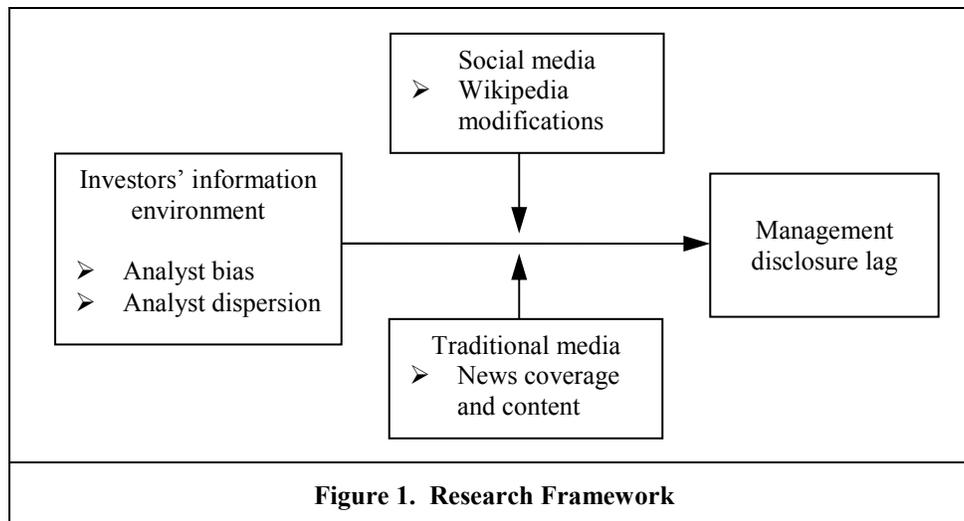
On the one hand, managers are concerned with overreaction of the market to bad-news disclosure. For instance, one concern is that, after seeing a warning of bad news, investors may lose confidence in a firm's long-term competitiveness (Kasznik and Lev 1995). The classical models of Dye (1985) and Verrecchia (1983) suggest that managers choose to reveal information that favorably affects stock price, and withhold information that adversely affect price. Empirical evidence also suggests that "bad news come late" (Healy and Palepu 2001). Patell and Wolfson (1982) document that managers tend to delay announcements when actual earnings are below market expectations. Conversely, managers tend to increase the level of disclosure when earnings performance improves (Miller 2002).

On the other hand, managers confront a dilemma if the forthcoming EPS figure on the official announcement date will be bad news. There is evidence suggesting that market reactions to bad news on the official announcement date may be more negative than earlier dates; thus, managers may attempt to guide down market expectation by releasing bad news, prior to the announcement date (Matsumoto 2002, Richardson et al. 2004). In particular, analysts' forecasts are often biased in that they may over-estimate a firm's EPS (Dechow et al. 2000), resulting in an expectation gap (i.e., investors' expectations exceed a firm's actual EPS) (Francis et al., 1997, Brown 1997, Jacob et al. 1999). If that happens, managers may want to use voluntary disclosure to correct for market expectation.

A second incentive to disclose bad news is to avoid litigation risks (that is, investors may sue for stock market loss due to managers' failure to disclose adverse information promptly) (Skinner 1994, 1997). Because voluntary disclosure prior to the official announcement date may spread stock price declines over multiple dates, it helps

prevent the market price from plummeting on the official announcement date. Voluntary disclosure thus reduces the likelihood of investors' lawsuit due to stock market loss. It also serves as an opportunity to explain away poor earnings performance (Francis et al. 1997).

In sum, managers trade off between suppressing bad news for certain self-interests and avoiding litigation risks. Given this tradeoff, managers would have incentive in the first place to manage accounting performance to "hide" bad news (Kasznik 1999). If they find that they are unable to successfully suppress bad news, then they will choose to disclose to avoid litigation risks. The central argument of this study is that *social media may shape the tradeoff and thus affect management's voluntary disclosure*. We empirically address this argument using a framework presented in Figure 1, which also allows us to compare social media and traditional media. We next elaborate variables in the framework and data used in the empirical analysis.



Methodology

We collect data from several sources: (1) The First Call Historical Database (FCHD); (2) editing history data from Wikipedia; (3) stock return data from CRSP; (4) firm data from COMPUSTAT; (5) news coverage data from Lexis-Nexis.

FCHD reports the history of First Call's Real Time Earnings Estimates. In addition to actual quarterly and annual earnings data, the database also contains firm pro forma earnings announcements (i.e., Company Issued Guidelines), analyst estimate-revision history, and other company and broker data. FCHD contains quarterly earnings information for 8,500 U.S. securities, and we limit our attention to 6,648 common stocks. For each company, we search Wikipedia for the corresponding entry, and obtain 375 Wikipedia entries of public companies. We leverage the "revision history" feature of Wikipedia to obtain the complete history of modifications to these entries. Overall, for the period between March 21, 2001 and May 19, 2006, 8,789 registered users and 5,450 unregistered users contributed a total of 77,921 edits.

We choose Wikipedia as our research context for several reasons. First, it satisfies four conditions: Diversity, Independence, Decentralization, and Aggregation, the conditions for a crowd to be smart (Surowiecki 2004). With these properties, Wikipedia is able to adopt the neutral-point-of-view (NPOV) stance, which makes it less susceptible to media bias.³ Second, unlike Blog posts or Twitter messages, it is possible to obtain the whole history of modifications to all Wikipedia articles. We are then able to construct measures for information arrival in social media. Third, although Wikipedia is not traditionally considered to be a source for people to look for investment information, entries for public companies are often very frequently edited and read to reflect arrival of new information.⁴ A new website called Wikinvest (<http://wikinvest.com>) uses wiki technology to help investors to understand the market and supports them to make better decisions when they purchase a particular stock or invest in

³ <http://en.wikipedia.org/wiki/NPOV>, accessed March 2009.

⁴ <http://stats.grok.se/en/200903/Microsoft>, and <http://stats.grok.se/en/200903/DELL>, accessed March 2009.

information environment (e.g., Kasznik and Lev 1995, Lang and Lundholm 1996, Skinner 1994, 1997, Francis et al. 1997, Abarbanell et al. 1995, Healy and Palepu 2001, Roulstone 2003).

Following this literature, we measure two analyst characteristics: analyst bias (*BIAS*) and analyst dispersion (*DISP*). Analyst bias is measured by the absolute value of the difference between a firm's actual EPS in a quarter and the mean forecast made by analysts in the quarter (Francis et al. 1997). To investigate management disclosure where EPS is lower than expected, prior research focuses on the scenario when the forthcoming EPS is below analysts' mean forecast (Kasznik and Lev 1995). Following this line of research, we require EPS to be lower than the mean of analyst's forecasts (that is, $BIAS > 0$). The greater the *BIAS*, the larger the difference between the actual EPS and the mean of analysts forecast.

Analyst dispersion is measured by the standard deviation of analyst forecasts about a firm's EPS in one fiscal quarter (Roulstone 2003). The variable *DISP* represents the agreement of the projected EPS among the analysts. That is, greater dispersion in forecasts results from less precise information available about the firm with which analysts can form their reports (Roulstone 2003). Also, forecast dispersion may reflect differences in information owned by individual analysts (Abarbanell et al. 1995). The disclosure literature assumes that managers have a set of private information (Dye 1985). It is likely that different analysts obtain different portions of the set of information, resulting in higher forecast dispersion. Together these prior studies suggest that, the greater the value of *DISP*, the less precise and the more piecemeal the information owned by analysts. Following prior research (Roulstone 2003), we scale *BIAS* and *DISP* by the mean analyst forecast.

Facing higher analyst bias, managers are more likely to release bad news to preempt the negative earnings surprise to the market (Skinner 1994, 1997). Everything else being equal, the greater the gap between the market expectation and the actual EPS, the more difficult it is to manage the forthcoming earnings report to align it with the market expectation. Therefore, it is less likely for managers to withhold bad news. By disclosing earlier, managers reduce the litigation risks and preempt large, negative earnings surprise. Consequently, we expect *LAG* to be negatively related to *BIAS*.

Analyst dispersion may affect managers' disclosure behavior because managers may consider greater dispersion as a signal suggesting a poor information environment for outside investors (Lang and Lundholm 1996). If outside investors have less precise information, then their expectation about a firm's EPS has a greater range around the mean EPS forecast. Everything else being equal, it is easier for managers to perform earnings management so that the forthcoming EPS announcement will fall into that range. As such, high analyst dispersion may encourage managers to try to suppress bad news, thus delaying disclosure. Therefore, we expect *LAG* to be positively related to *DISP*.

This discussion leads to the following regression equation:

$$LAG = \alpha + \beta_1 BIAS + \beta_2 DISP + \gamma_1 VAR + \gamma_2 MV + \gamma_3 HIGHTECH + \gamma_4 REG + \text{quarter dummies} \quad (1)$$

Model (1) follows prior studies and includes the following several control variables: *VAR*, variability of earnings (Kothari et al. 2002, Healy and Palepu 2001); *MV*, firms' market value (Kasznik and Lev 1995); *HIGHTECH* and *REG*, dummy variables indicating a high tech industry and a regulated industry, respectively (Kasznik and Lev 1995, Dewan et al. 2007); and three dummies indicating fiscal quarters 1-3 (Baginski et al. 1994).

The regression result is reported in Table 1. The estimated coefficients on controls (not tabulated) are consistent with the literature.⁶

The two primary effects for analyst bias and analyst dispersion have expected signs. Analyst dispersion is significantly positively related to disclosure lag. Greater dispersion in forecasts shows that the analysts do not have accurate information about the earnings. As a result, managers tend to delay the disclosure under this situation. Analyst bias, although not significant, is negatively associated with disclosure lag. Managers are more likely to

⁶ The regression results show that disclosure lag is shorter for firms with a history of volatile earnings, suggesting that firms in our sample wanted to offer more information in voluntary disclosure to help reduce costs of capital. The dummies for high-tech (although not significant) and regulated firms are both positive, suggesting that managers in these industries tend to withhold information longer. The three quarter dummies are negative, suggesting that managers become less willing to release bad news in the fourth quarter, probably in fear of affecting the performance of the whole fiscal year.

disclose bad news to preempt the negative earnings surprise when analysts are too far off in estimating the correct earnings. The reason for *BIAS*' lack of significance could be because its effect may be moderated by social media, as analyzed below.

Why can social media improve the information environment?

Social media and Wikipedia in particular may improve the information environment of investors. First, Wikipedia provides detailed information about firms, such as the success or failure of new products and the changes in top management. This is in contrast to the summative EPS forecast issued by analysts. Indeed, investors need detailed information about various aspects of a firm's operations in order to estimate the firm's value, a thesis drawing upon the "mosaic" perspective of information in the disclosure literature (Francis et al. 1997, Loss and Seligman 1995). Examples in practice support the "mosaic" view of information. The Report of the Financial Analysts Federation (FAF) Corporate Information Committee clearly states that FAF's rating of information transparency between a firm and investors involves evaluation of aspects other than disclosing the summative EPS, e.g., the clarity and candor of the financial highlights and president's letter, the amount of detail about the corporate officers, the corporation's goals and product and geographic segments, etc. (Lang and Lundholm 1996). Another study on corporate presentations to the New York Society of Securities Analysts (NYSSA) argues that "managers (analysts) view presentations as opportunities to provide (seek out) qualitative information about the firm's management, strategies and prospects. Such disclosures, when combined with existing information, could lead to significant market reactions even though the disclosures are not material if viewed in isolation" (Francis et al. 1997, p.367). In the same vein, we consider Wikipedia as a platform to provide detailed corporate information to the public, which cannot be replaced by EPS forecasts as generated by analysts.

Second, the information on Wikipedia is public, while investors pay analysts to acquire private information. Contributors on Wikipedia modify public information about a firm through rounds of addition, deletion, and re-organization. This process generates synthesized information based on the available information in the market. In contrast, analysts obtain their information from various sources. They subsequently pass the different information to their clients, which still remains private and piecemeal at the hands of investors.

Third, due to the NPOV policy as described earlier, Wikipedia encourages its contributors to publish unbiased information only. This is in sharp contrast to analysts' recommendation, which is often found biased (Francis et al., 1997, Brown 1997, Jacob et al. 1999). Finally, the use of search-related technologies significantly facilitates information search and promotes information diffusion (Hodge et al. 2004, Wasko and Faraj 2005). As such, Wikipedia can potentially shape investors' information environment.

Empirical analysis – How do managers react to social media?

As social media improves the information environment for investors, managers may view Wikipedia as a window to assess the availability of public information in the market. We use Wikipedia modification (*WikiMOD*) to represent information arrival on Wikipedia, measured as the number of modifications made on Wikipedia about the firm in one quarter. Because Wikipedia information is unbiased, it may offset the biased expectation about the firm's EPS as introduced by analysts. When managers notice that there is an increasing amount of unbiased information on Wikipedia, they may consider the outside information about their firms as less biased. This may weaken their motivation to release bad news to guide down market expectation. Therefore, we expect that *WikiMOD* may mitigate the impact of analyst bias on the disclosure lag, such that the negative relation between *BIAS* and the disclosure lag is less severe in the presence of higher *WikiMOD*.

Wikipedia modification also represents a process to aggregate information from Wikipedia contributors. This information aggregation process filters out noise and combines different viewpoints/estimates about the firm's performance. This process will generate more precise information about the firm, hence offsetting the influence of the range of estimates on firm performance. When managers observe greater *WikiMOD*, they may consider the information in the outside market to become more precise. Facing a narrower range of EPS expectation in the market, it is more difficult for managers to manipulate earnings to make the forthcoming EPS report into that range. As such, the effect of analyst dispersion may be mitigated by Wikipedia information. We thus propose that *WikiMOD* may weaken the impact of analyst dispersion on disclosure lag, such that the positive relation between *DISP* and the disclosure lag is less conspicuous in the presence of higher *WikiMOD*. We propose to test:

$$LAG = \alpha + \beta_1 BIAS + \beta_2 DISP + \delta_1 WikiMOD + \delta_2 WikiMOD*BIAS + \delta_3 WikiMOD*DISP + \gamma_1 VAR + \gamma_2 MV + \gamma_3 HIGHTECH + \gamma_4 REG + quarter\ dummies \quad (2)$$

Results are reported in Table 1. The two interaction terms are significant. The coefficient of Wikipedia modifications (*WikiMOD*) shows the effect of *WikiMOD* when both analyst dispersion and analyst bias are at zero (Aiken and West 1991). Similarly, the coefficients of *BIAS* and *DESPERSION* show their effects when *WikiMOD* is zero. The interaction terms *WikiMOD*DISP* and *WikiMOD*BIAS* are significant, indicating that Wikipedia modifications and analysts forecasts interact to affect management disclosure.

Table 1. How does Management Disclosure React to Social Media?					
R ²	Independent variables				
	<i>DISP</i>	<i>BIAS</i>	<i>WikiMOD</i>	<i>WikiMOD*DISP</i>	<i>WikiMOD*BIAS</i>
Model (1)					
0.21	0.164* [0.088]	-0.018 [0.024]			
Model (2)					
0.26	0.365*** [0.130]	-0.099*** [0.021]	-0.109 [0.073]	-0.129** [0.066]	0.056*** [0.011]
<i>Note.</i> Regressions are based on models (1) and (2). Control variables are not tabulated. Standard errors are reported in parentheses, based on Newey-West robust estimator. ***p<0.01; **p<0.05; *p<0.10.					

(1) The role of Wikipedia in management disclosure

The positive coefficient on analyst dispersion (0.365, p<0.01) suggests that, in the presence of high dispersion, managers tend to delay the disclosure because they can enjoy an information advantage. The interaction term with Wikipedia modification (-0.129, p<0.05), however, moderates the effect. The *negative* sign of the interaction term suggests that, in the presence of more Wikipedia modifications, the extent to which the managers leverage the information advantage is weakened.

The interaction between *WikiMOD* and *BIAS* (0.056, p<0.01) suggests that *WikiMOD* also moderates the effect of analyst bias on disclosure lag. When analysts are too optimistic in estimating the earnings, managers typically shorten the lag to offer more information. When there are many Wikipedia modifications, however, managers are not as worried as before. If the reason behind earlier release of bad news is due to fear of negative earnings surprise (Skinner 1994, 1997), then Wikipedia modifications play the role of releasing information to the public.

(2) The role of Wikipedia conditional on analyst forecasts

The interaction terms (*WikiMOD*BIAS*, *WikiMOD*DISP*) also indicate how the effect of Wikipedia modifications (*WikiMOD*) changes with a one-unit increase in *DISP* and *BIAS*. To quantify the effect of *WikiMOD*, we further condition *BIAS* and *DISP* at levels of one standard deviation above and below mean. We call these levels High and Low respectively. Specifically, if we subtract one standard deviation from *BIAS* in model (2), then the coefficient of *WikiMOD* represents its effect expected at the High level of *BIAS* (Aiken and West 1991). Using this method, we carry out separate regressions and obtain first order effect of *WikiMOD* conditioning on high and low levels of *BIAS* and *DISP*. We depict the results in Figure 3 and discuss in turn below.

Figure 3.1 examines changes in *WikiMOD* for different levels (High vs. Low) of *BIAS*:

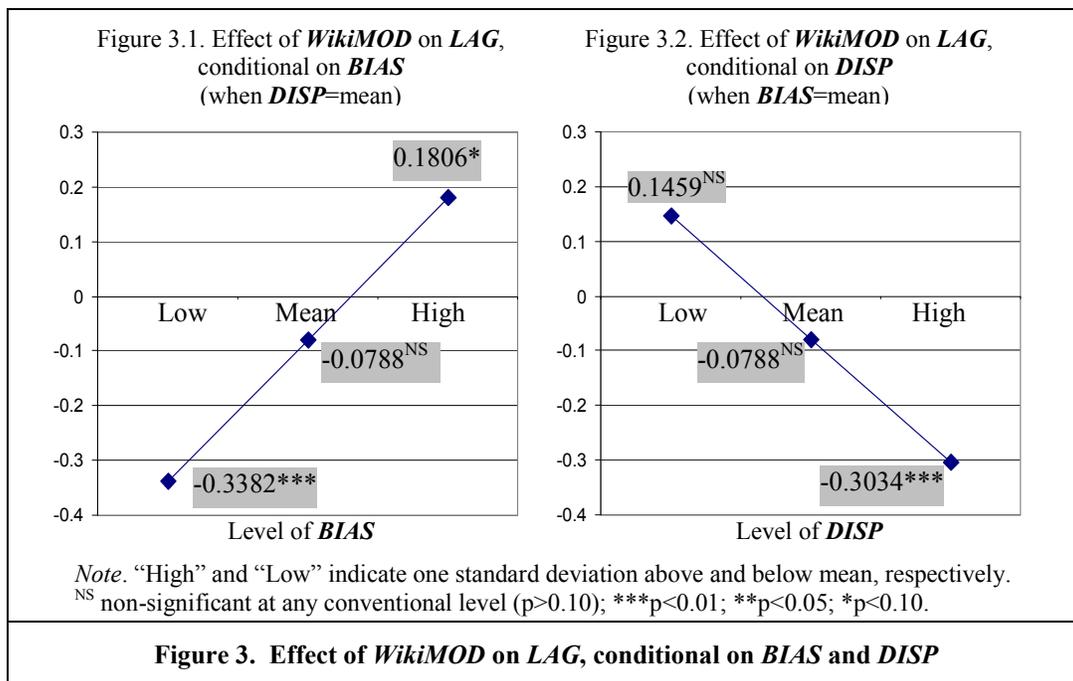
- If Wikipedia affects managers’ disclosure behavior by mitigating their concerns on litigation risks (Skinner 1994, 1997), this effect should be salient when the market expectation is substantially deviated from the actual EPS (i.e., high *BIAS*). That is, when managers are particularly concerned about the litigation risks, Wikipedia modifications will play a significant role to mitigate the concerns and, as a result, managers may feel less urgent to guide down market expectation. Figure 3.1 shows that, when *BIAS* is high, *WikiMOD* is significantly positive (0.1806). This suggests that information arrival in Wikipedia may help reduce the litigation risk.

- In contrast, when managers face a small expectation gap (i.e., low *BIAS*), they may be reluctant to admit bad news prior to the official announcement because earnings management is more tempting. But, the availability of public information improves the information environment of investors and, thus, limits the degree of freedom by which managers can manipulate the forthcoming earnings report. Figure 3.1 shows that, when *BIAS* is low, *WikiMOD* is significantly negative (-0.3382), suggesting that if analysts have inferior information, Wikipedia plays the role to weaken the information asymmetry and forces the managers to disclose information early.

Figure 3.2 examines changes in *WikiMOD* for different levels (High vs. Low) of *DISP*:

- Wikipedia may reduce the disclosure lag by synthesizing information from various sources, and this effect may be particularly salient when the market features highly dispersed expectations about firm performance. Figure 3.2 shows that, when *DISP* is high, *WikiMOD* is significantly negative (-0.3034), suggesting its role to shorten the disclosure lag. As the social media help weaken the information advantage of managers, managers become more prudent and disclose bad news significantly earlier.
- Conversely, if investors already have precise information, then there is less need for social media such as Wikipedia to aggregate information. Figure 3.2 shows a non-significant effect of *WikiMOD* expected at the low and mean levels of *DISP*. This is consistent with the notion that, the greater the analyst dispersion, the more negative the relation between Wikipedia modifications and the disclosure lag.

In sum, we find evidence supporting that Wikipedia empowers investors and we identify corresponding reactions from managers. On one hand, managers become more prudent as their information advantage is undermined by Wikipedia, and on the other hand, Wikipedia plays a role to disseminate information to investors, and mitigates the problem of negative surprise.



How Do Social Media Differ from Traditional Media?

Comparing Wikipedia with news arrival in traditional media

We proceed to a comparison of social media and tradition media. We augment our model (2) by including news coverage (*NEWS*), measured as the number of news stories about a firm appearing in traditional business press in one quarter (as documented in Lexis-Nexis). This can be useful to partial out the role of Wikipedia because modifications on Wikipedia and news in traditional media may co-vary, triggered by common events. After controlling for information arrival in traditional media, coefficients on *WikiMOD* and the interactions with analyst forecasts better represent the salient effect of Wikipedia modifications. We examine:

$$\begin{aligned}
 LAG = & \alpha + \beta_1 BIAS + \beta_2 DISP \\
 & + \delta_1 WikiMOD + \delta_2 WikiMOD*BIAS + \delta_3 WikiMOD*DISP \\
 & + \eta_1 NEWS + \eta_2 NEWS*BIAS + \eta_3 NEWS*DISP \\
 & + \gamma_1 VAR + \gamma_2 MV + \gamma_3 HIGHTECH + \gamma_4 REG + \text{quarter dummies}
 \end{aligned}
 \tag{3}$$

Table 2 reports the result. Adding news coverage and its interaction terms with *DISP* and *BIAS* has minimal impact on the model; the two interactions involving *WikiMOD* remain significant. In contrast, the number of news stories does not affect management disclosure.⁷ These results suggest that Wikipedia modifications and news coverage play different roles in changing the information environment for investors. As a core message from this test, the moderating effect of Wikipedia modifications is not likely to be driven by news arrival only.

Comparing Wikipedia with news content in traditional media

We further address news content in traditional media, because companies appear in the news only when there are newsworthy stories about them. A company doing very well or doing very badly is more likely to be in the news. Hence, addressing news content, along with counting the number of news arrival, better captures the whole picture of information arrival in traditional media.

Following Tetlock et al. (2008), we control for proportions of positive and negative words in news stories. *NEGATIVE* is a standardized measure of the proportion of negative words appeared in all news stories related to a firm. Specifically, we calculate proportion of negative words (*NEG%*), the total number of negative words for a firm in a fiscal quarter divided by the total number of words for that firm in that quarter. We then calculate the mean (*Mean_NEG*) and the standard deviation (*Sd_NEG*) of the proportion of negative words for the *prior* calendar year, and define $NEG = (NEG\% - Mean_NEG) / Sd_NEG$ (Tetlock et al., 2008). Similarly, we compute $POS = (POS\% - Mean_POS) / Sd_POS$. Then, we expand model (3) by including *NEG* and *POS*, resulting in the following model:

$$\begin{aligned}
 LAG = & \alpha + \beta_1 BIAS + \beta_2 DISP \\
 & + \delta_1 WikiMOD + \delta_2 WikiMOD*BIAS + \delta_3 WikiMOD*DISP \\
 & + \eta_1 NEWS + \eta_2 NEWS*BIAS + \eta_3 NEWS*DISP \\
 & + \theta_1 POS + \theta_2 POS*BIAS + \theta_3 POS*DISP \\
 & + \lambda_1 NEG + \lambda_2 NEG*BIAS + \lambda_3 NEG*DISP \\
 & + \gamma_1 VAR + \gamma_2 MV + \gamma_3 HIGHTECH + \gamma_4 REG + \text{quarter dummies}
 \end{aligned}
 \tag{4}$$

Table 2 reports regression results of model (4), adding *NETGATIVE* and *POS* one by one. Compared to results of model (3), the effects of *WikiMOD* remain robust in the new models. They not only remain statistically significant, but also increased in magnitude. As to the number of news stories (*NEWS*), overall, its effect is non-significant.

Table 2. How do Social Media Differ from Traditional Media?														
R ²	Independent variables													
	<i>DISP</i>	<i>BIAS</i>	<i>WikiMOD</i>	<i>WikiMOD*DISP</i>	<i>WikiMOD*BIAS</i>	<i>NEWS</i>	<i>NEWS*DISP</i>	<i>NEWS*BIAS</i>	<i>NEG</i>	<i>NEG*DISP</i>	<i>NEG*BIAS</i>	<i>POS</i>	<i>POS*DISP</i>	<i>POS*BIAS</i>
Model (3)														
0.27	0.354** [0.146]	-0.110** [0.043]	-0.088 [0.071]	-0.133** [0.063]	0.052*** [0.013]	-0.081 [0.072]	0.016 [0.0361]	0.007 [0.016]						
Model (4)														
0.29	0.166 [0.174]	-0.066 [0.057]	-0.083 [0.072]	-0.256*** [0.073]	0.074*** [0.017]	-0.091 [0.073]	0.124* [0.067]	-0.018 [0.023]	-0.071** [0.035]	0.179** [0.074]	-0.045 [0.029]			
0.29	0.166 [0.223]	-0.065 [0.078]	-0.077 [0.072]	-0.257*** [0.068]	0.0721** [0.018]	-0.089 [0.073]	0.114 [0.072]	-0.017 [0.023]	-0.072** [0.037]	0.155* [0.088]	-0.039 [0.033]	-0.036 [0.047]	-0.045 [0.108]	0.002 [0.034]

Note. Regressions are based on models (3) and (4). Control variables are not tabulated. Standard errors are reported in parentheses, based on Newey-West robust estimator. ***p<0.01; **p<0.05; *p<0.10.

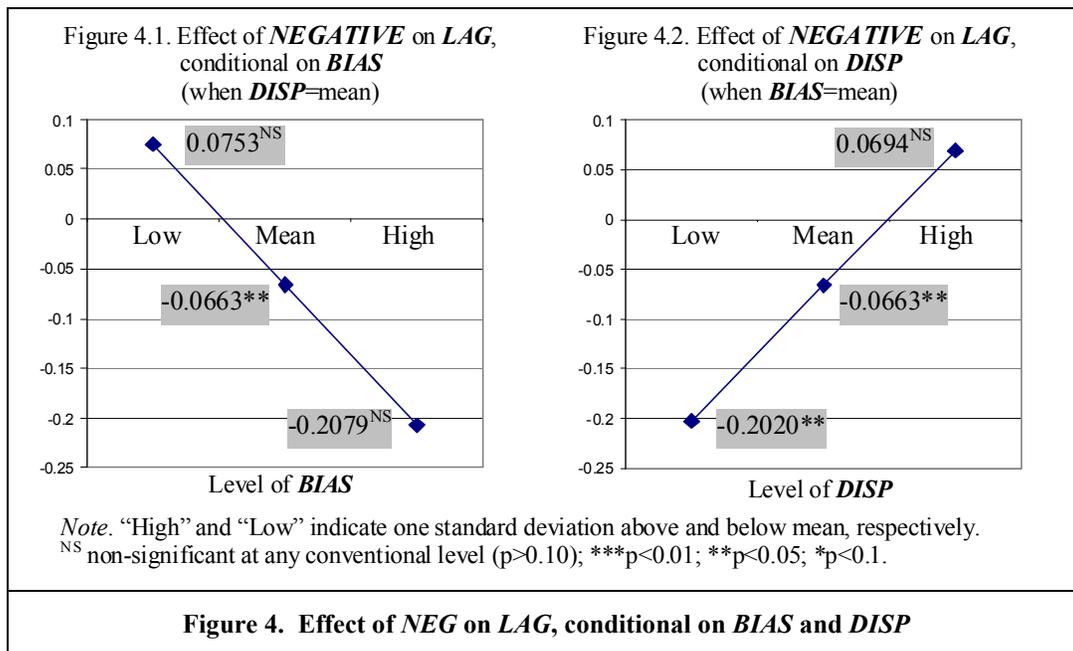
⁷ We conducted post hoc statistical power analysis. Using 0.05 as the cutoff for type I error, we found that the statistical power of each of the regressions is above 0.95.

In contrast, *NEG* has a strong first-order effect on *LAG*, that is, when there are more negative words about a company, the manager tend to disclose earlier. The interaction between *NEG* and *DISP* is significant and positive, suggesting that the first-order effect of *NEG* is weakened by analyst dispersion. If analysts cannot agree with each other, the manager is less worried about negative news coverage of the company. Adding *POS* to the model (the last row of Table 2) does not change our results. Managers seem to pay attention to negative instead of positive ones.

To better reveal how traditional media differs from social media, we quantify the effect of *NEG* on *LAG*, conditioning on *BIAS* and *DISP*. In Figure 4, the slopes of the curves are reversed from those in Figure 3:

- In Figure 4.1, *NEG* is generally negative, which means that managers respond to negative news by reducing the disclosure lag, out of concerns of litigation risks associated with media coverage. Interestingly, Figure 3.1 shows a different effect of Wikipedia. In the presence of high *BIAS*, *WikiMOD* seems to reduce the litigation risk (by informing investors and thus preempting bad news).
- In Figure 4.2, again, *NEG* is generally negative. When *DISP* increases, *NEG* becomes less negative. Thus the litigation risks associated with negative media coverage decreases in the uncertainty (*DISP*) of the true EPS. At the high level of *DISP*, *NEG* becomes non-significant. This is in sharp contrast to Figure 3.2 where the role of Wikipedia is significantly negative just when *DISP* is high. As articulated above, social media help aggregate information and thus reduce managers' information advantage, resulting in earlier disclosure.

Overall, a comparison of the slope in Figure 4.1 (Figure 4.2) with that in Figure 3.1 (Figure 3.2) clearly shows the different roles played by Wikipedia and the newspapers. It seems that traditional media force managers to disclose when the external information is already precise (low *DISP*), while social media reduce disclosure lag by synthesizing information especially when analysts information is dispersed (high *DISP*).



How Do Investors React to Management Disclosure?

So far, our analysis draws upon the assumption that the public information from Wikipedia may preempt investors' reaction to bad news disclosure. We conclude that managers change their action due to the changes in the information environment. Managers are fundamentally concerned about how informed the investors are, not about how Wikipedia portrays the firm. Do Wikipedia modifications really improve the information environment for investors? Or is it simply a belief of the managers? We now investigate investor reaction to disclosures in this section. We are able to further examine the different roles played by the social media and the traditional media.

To quantify investors' reaction to the bad news disclosure, the literature suggests combining investors' reaction in two windows (Kaszniak and Lev 1995): one is a five-day window around the official EPS announcement date, and the other is a five-day window around the date of voluntary disclosure. Following the literature (MacKinlay 1997), we estimate the regression equation: $R_t = \text{intercept} + \text{slope} * R_{mt}$, where R_t denotes a firm's actual returns on day t

and R_{mt} is the returns on the market on the same day as proxied by the equally weighted CRSP index. The difference between R_t and the predicted value based on the equation is the firm's abnormal returns (AR_t) on day t . Then, we compute cumulative abnormal returns (CAR), which are the sum of AR_t over the combined official announcement and voluntary disclosure windows. The market reaction (CAR) may be associated with analyst bias, in that greater $BIAS$ results in more negative CAR (Kaszniak and Lev 1995). The relation between CAR and $BIAS$ may be moderated by firm size (MV), such that the greater the firm size, the less negative the relationship between CAR and $BIAS$. Poor performance in one quarter may have less impact on the long-term economic variability for large firms than for small firms.

If Wikipedia information has preempted market reaction to bad news, then the relation between CAR and $BIAS$ may be mitigated by $WikiMOD$. We expect that the greater the $WikiMOD$, the less negative the CAR - $BIAS$ relation. Also, we control for the other source of information, business press, by including $NEWS$ and results of the content analysis. The purpose is to control for the possibility that Wikipedia modifications may co-vary with information arrival in traditional media. We estimate the following regression model:

$$\begin{aligned}
 CAR = & \alpha + \beta BIAS + \gamma_1 MV + \gamma_2 MV*BIAS \\
 & + \delta_1 WikiMOD + \delta_2 WikiMOD*BIAS \\
 & + \eta_1 NEWS + \eta_2 NEWS*BIAS \\
 & + \theta_1 POS + \theta_2 POS*BIAS \\
 & + \lambda_1 NEG + \lambda_2 NEG*BIAS
 \end{aligned}
 \tag{5}$$

Table 3 presents regression results, examining CAR over a 5-day window. As indicated by the negative coefficient on $BIAS$, the more optimistic the analysts are, the more disappointed the investors. Firm size (market value – MV) moderates the effect of $BIAS$, so investors are more tolerant to upward analyst bias for larger firms. $WikiMOD*BIAS$ has a positive sign, suggesting that the effect of Wikipedia modification indeed preempts market reaction to bad news. Had there existed a medium that fully discloses information to the public, this medium would have completely offset the surprise caused by $BIAS$. $WikiMOD$ at least partially does the job.

Now we turn to the variables for traditional media, $NEWS$, measuring the number of news stories covering a firm, and NEG , measuring the qualitative tone of these news stories. The moderating effects on $BIAS$ for both measures are significantly negative. These results suggest that (1) more news coverage exacerbates the problem of overly optimistic analyst estimates, and (2) when there is upward analyst bias, the investors are more disappointed if traditional media actually used a lot of negative words to describe a firm in the previous fiscal quarter.

The first effect is intuitive; it is likely that the message of news coverage for a firm is consistent with analyst reports. As a result, news stories merely magnify the effect of analyst bias. Judging from the sign, we can at least say that more news coverage does not offer more information to reduce the bias. The second effect is somewhat counterintuitive. If the traditional media have used a lot of negative words to describe a company, shouldn't the investors have been warned about the bad news already? Why NEG would strengthen the surprise caused by $BIAS$? Note that an increase in $BIAS$ means overestimate of the EPS, and an increase in NEG means the newspapers more severely slash the firm. This situation only happens when the analysts and the newspapers are inconsistent about the performance of the firm. Given the significant and negative first order effect of $BIAS$, and the insignificant effect of NEG , it is plausible to believe that investors trust analysts more than newspapers. When analysts are wrong, the optimistic estimates backfire. This may explain why the interaction between NEG and $BIAS$ is negative.

Table 3. How do Investors React to Management Disclosure?

R ²	Independent variables										
	<i>BIAS</i>	<i>MV</i>	<i>MV</i> <i>*BIAS</i>	<i>WikiMOD</i>	<i>WikiMOD</i> <i>*BIAS</i>	<i>NEWS</i>	<i>NEWS</i> <i>*BIAS</i>	<i>NEG</i>	<i>NEG</i> <i>*BIAS</i>	<i>POS</i>	<i>POS</i> <i>*BIAS</i>
Model (5)											
0.15	-0.083*** [0.032]	0.006 [0.010]	0.005*** [0.002]	-0.008 [0.010]	0.004** [0.002]	0.008 [0.009]	-0.004*** [0.001]	0.003 [0.005]	-0.010** [0.004]	-0.002 [0.004]	0.000 [0.003]

Note. Standard errors are reported in parentheses, based on Newey-West robust estimator. ***p<0.01; **p<0.05; *p<0.10.

Concluding Remarks

This study addresses the question of whether social media improve the information environment for investors, and if so, how managers may react in their voluntary disclosure of bad news. It adds to the literature by showing that, although managers tend to delay disclosure of bad news in the presence of high analysts dispersion, the delay is shortened by information arrivals on Wikipedia. This finding suggests the role of Wikipedia to weaken information asymmetry between managers and investors. In addition, although managers tend to release bad news early if facing high analyst bias, information arrivals on Wikipedia may help alleviate managers' concerns on litigation risks, thus making management's disclosure timing less dependent on analysts bias. Together these results support that Wikipedia plays the role of releasing information to the public.

We further find consistent evidence by examining how investors react to management disclosure of bad news. We find that the negative reaction of investors to bad news is preempted by Wikipedia modifications. Moreover, we find stark contrast between social media and traditional media. Although the negative content of news stories in traditional media generally forces management to disclose bad news earlier, such effect of the traditional media is salient in the presence of less dispersed external information (indicated by low analysts dispersion). The effect becomes non-significant when the external information environment features high analysts dispersion and thus managers seem to enjoy an information advantage. In such a scenario, social media like Wikipedia play the role to shorten management's disclosure lag. This effect taps into the unique role of social media, that is, aggregating information from various sources and thus reducing information uncertainty in the market.

We hope these findings trigger related investigations. First, Wikipedia may not be the only means for investors to enjoy the benefits of social media. Although in this paper we cannot rule out other possible channels (blogs, twitters, etc.) in informing investors, our results suggest market adjustment associated with information arrivals on Wikipedia before a firm announces bad news. One way to extend this study is to examine other Web 2.0 sites. Second, it would be interesting to gauge whether information update on Wikipedia is done by managers to unofficially leak information to "soften the blow" of bad news. Managers' such intention is consistent with our conclusion that social media can serve as a useful tool to impact the external information environment, so evidence about such management intention, if found, will offer further support to our conclusion. Third, future studies can conduct in-depth case research to examine how managers leverage social media and how management disclosure is affected by information arrivals in the external environment. Such qualitative findings would provide additional, powerful support for the arguments of the research.

In conclusion, the findings in this study show evidence that social media have an identifiable impact on both the manager side and the investor side and the impact differs from that of the traditional media. The evidence sheds light on the role of social media in shaping the information environment in the financial market.

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Appendix 1. Variable Definitions	
Variable	Computation
LAG (disclosure lag)	The number of calendar days between fiscal quarter end and the date when management voluntarily discloses bad news about EPS (between T2 and T3 in Figure 2), log-transformed
BIAS (analysts bias)	The absolute value of the difference between a firm's actual EPS in a quarter and the mean EPS forecast made by analysts in the quarter (between T1 and T2 in Figure 2), scaled by the mean EPS forecast
DISP (analysts dispersion)	The standard deviation of analyst forecasts about a firm's EPS in a fiscal quarter (between T1 and T2 in Figure 2), scaled by mean EPS forecast
WikiMOD (Wikipedia modifications)	The logarithm of number of Wikipedia revisions for a company in a fiscal quarter (from T1 to T2 in Figure 2).
NEWS (news coverage)	The number of news articles covering a company in a fiscal quarter (between T1 and T2 in Figure 2), as documented in Lexis-Nexis.
POS (positive news)	Standardized proportion of positive words. Proportion of positive words (<i>POS%</i>) is calculated as total number of positive words for a company in a fiscal quarter divided by total number of words for that company in that quarter. We calculate the mean (<i>Mean_POS</i>) and the standard deviation (<i>Sd_POS</i>) of the proportion of positive words for the prior calendar year, $POS = (POS\% - Mean_POS) / Sd_POS$.
NEG (negative news)	<i>NEG</i> is calculated similar to <i>POS</i> , with the proportion of negative words.
VAR (earnings variability)	The standard deviation of quarterly earnings across eight fiscal quarters before the quarter under examination (prior to T1 in Figure 2)
MV (market value)	Logarithm of total market value of the firm at the beginning of the fiscal quarter (i.e., at T1 in Figure 2)
HIGHTECH (high tech industries)	Equals 1 when the firm belongs to Drugs (SIC 2833-2836), R&D Services (8731-8734), Programming (7371-7379), Computers (3570-3577), or Electronics (3600-3674), and 0 otherwise
REG (regulated industries)	Equals 1 when the firm belongs to Telephone (SIC 4812-4813), TV (4833), Cable (4841), Communications (4811-4899), Gas (4922-4924), Electricity (4931), Water (4941), or Financial sectors (6021-6023, 6035-6036, 6141, 6311, 6321, 6331), and 0 otherwise.
CAR (cumulative abnormal returns)	Sum of abnormal returns in a combined window including 5 days around voluntary disclosure (T3 in Figure 2) and 5 days around the official earnings announcement (T4 in Figure 2)

Appendix 2. Correlations												
	<i>LAG</i>	<i>VAR</i>	<i>HIGHTECH</i>	<i>REG</i>	<i>MV</i>	<i>DISP</i>	<i>BIAS</i>	<i>WikiMOD</i>	<i>NEWS</i>	<i>NEG</i>	<i>POS</i>	<i>CAR</i>
<i>LAG</i>	1.000											
<i>VAR</i>	-0.139	1.000										
<i>HIGTECH</i>	0.088	0.253	1.000									
<i>REG</i>	0.030	-0.040	-0.101	1.000								
<i>MV</i>	-0.267	-0.241	-0.212	0.011	1.000							
<i>DISP</i>	0.143	0.235	0.313	-0.053	-0.262	1.000						
<i>BIAS</i>	0.006	0.423	0.256	-0.047	-0.281	0.486	1.000					
<i>WikiMOD</i>	-0.156	-0.165	-0.193	-0.150	0.348	-0.149	-0.088	1.000				
<i>NEWS</i>	-0.249	0.073	-0.251	0.004	0.434	-0.155	0.021	0.320	1.000			
<i>NEG</i>	-0.033	0.047	-0.068	0.018	-0.097	0.128	0.003	0.003	0.031	1.000		
<i>POS</i>	-0.149	0.093	0.104	0.037	-0.113	0.053	0.049	-0.067	-0.077	-0.103	1.000	
<i>CAR</i>	-0.046	-0.210	-0.237	0.000	0.210	-0.253	-0.290	-0.001	0.048	-0.048	-0.082	1.000

Note. Significant correlations are in bold.

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