

## IMPACT OF WIKIPEDIA ON MARKET INFORMATION ENVIRONMENT: EVIDENCE ON MANAGEMENT DISCLOSURE AND INVESTMENT REACTION<sup>1</sup>

Sean Xin Xu

School of Economics and Management, Tsinghua University  
Beijing, CHINA {xuxin@sem.tsinghua.edu.cn}

Xiaoquan (Michael) Zhang

School of Business and Management, Hong Kong University of Science and Technology,  
Clear Water Bay, HONG KONG {zhang@ust.hk}

*In this paper, we seek to determine whether a typical social media platform, Wikipedia, improves the information environment for investors in the financial market. Our theoretical lens leads us to expect that information aggregation about public companies on Wikipedia may influence how management's voluntary information disclosure reacts to market uncertainty with respect to investors' information about these companies. Our empirical analysis is based on a unique data set collected from financial records, management disclosure records, news article coverage, and a Wikipedia modification history of public companies. On the supply side of information, we find that information aggregation on Wikipedia can moderate the timing of managers' voluntary disclosure of companies' earnings disappointments, or bad news. On the demand side of information, we find that Wikipedia's information aggregation moderates investors' negative reaction to bad news. Taken together, these findings support the view that Wikipedia improves the information environment in the financial market and underscore the value of information aggregation through the use of information technology.*

**Keywords:** Social media, Wikipedia, information environment, financial market, management disclosure, information aggregation

### Introduction

One primary function of markets is to aggregate information. When market participants cannot communicate with each other freely, they collect their information piecemeal and it “never exists in concentrated or integrated form” (Hayek

1945, p. 519). In this context, market price makes important contributions to information transmission, but such markets may still be inefficient, with price dispersion often observed in practice (Ba et al. 2012; Brynjolfsson and Smith 2000). Researchers thus ask whether market participants can use any explicit mechanism to directly exchange and aggregate information (e.g., Chen et al. 2011; Dellarocas and Wood 2008; Fan et al. 2000; Granados et al. 2010; Sun 2011; Sun and Tyagi 2012; Zhu and Zhang 2010).

A burgeoning literature examines whether social media can serve as such a mechanism (e.g., Gu et al. 2007; Tetlock et al.

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The appendix for this paper is located in the “Online Supplements” section of the *MIS Quarterly*'s website (<http://www.misq.org>).

1 2008). Social media are Internet-based applications “that  
 2 allow the creation and exchange of user-generated content”  
 3 (Kaplan and Haenlein 2010, p. X). On social media, users are  
 4 not only consumers, but also active contributors of content.  
 5 Following this line of research, we focus on Wikipedia, a  
 6 typical social media platform (Greenstein and Zhu 2012a,  
 7 2012b; Kane and Fichman 2009; Ransbotham and Kane  
 8 2011). Wikipedia is an online encyclopedia based on the  
 9 “wiki” technology that allows individuals to make collabora-  
 10 tive contributions to web pages through a web browser  
 11 (Kane and Fichman 2009). This technology allows people  
 12 who have access to the Internet to freely contribute and  
 13 modify the content of its web pages. Volunteers contributed  
 14 all of the entries in the encyclopedia. After its creation in  
 15 January 2001, Wikipedia quickly developed to become one of  
 16 the largest reference websites, with currently 400 million  
 17 unique visitors monthly and more than 90,000 active contribu-  
 18 tors.<sup>2</sup> The English version of Wikipedia, the most popular of  
 19 the 270 different language versions, attracts hundreds of thou-  
 20 sands of visitors who make tens of thousands of modifications  
 21 every day. As of September 2011, Wikipedia is the seventh-  
 22 most-popular website worldwide, receiving 2.7 billion page  
 23 views every month.

24  
 25 On Wikipedia, several thousand articles are about traded com-  
 26 panies. For these companies, Wikipedia keeps a good record  
 27 of their significant events. Appendix A depicts a section of  
 28 the Wikipedia entry for Dell. All sentences in this section  
 29 follow the format “On [Month Day, Year], Dell [did some-  
 30 thing].” As such, Wikipedia effectively maintains a virtual  
 31 memory where qualitative information exists in a concen-  
 32 trated and integrated form (Hayek 1945, Kankanhalli et al.  
 33 2005; Stein and Zwass 1995). Visitors thereby can obtain  
 34 aggregated, timely information about the firm’s products,  
 35 management structure, operations, marketing, sales, and other  
 36 important firm events. With this rich information, Wikipedia  
 37 has become an important source of knowledge about com-  
 38 panies. In September 2011, for example, Wikipedia entries  
 39 for Microsoft and Google received 400,000 and 2,000,000  
 40 visits, respectively.<sup>3</sup> In particular, there is some evidence that  
 41 Wikipedia has substantial impact on active seekers of infor-  
 42 mation. According to HitWise, an Internet traffic-monitoring  
 43 service, more than 70 percent of Wikipedia’s incoming traffic

comes from search engines.<sup>4</sup> Because of Wikipedia’s impor-  
 tance in search engines, Wikipedia pages for listed companies  
 are often ranked among the highest in search results. As such,  
 when investors conduct research online, Wikipedia entries of  
 listed companies are highly visible and accessible to them.  
 As noted by *Financial Times*, “the capital market is looking  
 for information from companies in various social media  
 channels and at a greater extent than we anticipated...Wikipedia  
 is the most popular social media site for individuals  
 looking for such information, used by more than three  
 quarters of respondents.”<sup>5</sup>

Our research examines the value of Wikipedia for aggregating  
 firm information, and we choose the modern financial market  
 as our research context. The market’s information environ-  
 ment consists of *quantified* information provided by financial  
 analysts (mainly their forecasts of firm earnings) and *qualita-*  
*tive* descriptions of firms’ business environments, operations,  
 and prospects published by media. These linguistic descrip-  
 tions are a valuable complement to analyst forecasts, because  
 summative earnings forecasts cannot entirely convey the  
 limitless variety of firms’ financial standings (Tetlock et al.  
 2008) and because analyst forecasts are often incomplete or  
 even biased measures of firm performance (Jacob et al. 1999;  
 Karamanou and Vafeas 2005). The accounting and finance  
 literatures thus emphasize a mosaic notion of investors’ infor-  
 mation environment (Francis et al. 1997; Lang and Lundholm  
 1996; Loss and Seligman 1995). The central tenet of the  
*mosaic* perspective, that information is multifaceted and that  
 both quantified and qualitative types of information are use-  
 ful, implies that the advent of detailed, linguistic information  
 on Wikipedia would profoundly change investors’ informa-  
 tion environment. Data on qualitative information aggrega-  
 tion have been hard to come by, however, and the value of  
 linguistic descriptions of a firm’s environments, operations,  
 and prospects has been severely neglected in prior studies.

Fortunately, Wikipedia offers not only a practical means for  
 information aggregation, but also a way for scholars to inves-  
 tigate the process of information aggregation. On Wikipedia,  
 the history of user contributions is open to the public. This  
 gives us a unique opportunity to develop a proxy for *informa-*  
*tion aggregation on Wikipedia*—that is, the number of user  
 modifications of public firms’ Wikipedia entries (called  
 “Wikipedia modifications” hereafter). Through collaborative

<sup>2</sup>Statistics in this paragraph are from <http://en.wikipedia.org/wiki/Wikipedia>  
 (accessed October 2011).

<sup>3</sup><http://stats.grok.se/en/201109/microsoft>, and <http://stats.grok.se/en/201109/google>, respectively.

<sup>4</sup>[http://weblogs.hitwise.com/leeann-prescott/2007/02/wikipedia\\_traffic\\_sources.html](http://weblogs.hitwise.com/leeann-prescott/2007/02/wikipedia_traffic_sources.html).

<sup>5</sup><http://www.ft.com/intl/cms/s/0/c9d0271a-bf49-11dd-ae63-0000779fd18c.html>.

1 modifications, people contribute their information to the same  
2 common Wikipedia entries. The aggregation takes place not  
3 only in that there is a comprehensive memory of the firms'  
4 events, but also in that individuals' information can be pooled  
5 together (as illustrated in Appendix A).

6  
7 With this proxy for information aggregation on Wikipedia,  
8 our approach to identify its impact is based on a rich literature  
9 on management disclosure (for literature reviews, see Dye  
10 2001; Healy and Palepu 2001). We examine how information  
11 aggregation on Wikipedia may influence managers' and in-  
12 vestors' behaviors. From the disclosure literature, the timing  
13 of management disclosure about firms' unfavorable news is  
14 related to investors' information set about the firms (Healy  
15 and Palepu 2001). The intuition is that, driven by self-  
16 interest, managers decide whether to admit unfavorable news  
17 based on what investors already know (Dye 1985, 2001). So  
18 far, the literature widely recognizes the quantified information  
19 provided by analysts as the foremost source of information for  
20 investors,<sup>6</sup> and, accordingly, relates management disclosure  
21 to characteristics of the quantified information. Our overall  
22 prediction, motivated by research on media impact, is that  
23 "linguistic media content captures otherwise hard-to-quantify  
24 aspects of firms' fundamentals" (Tetlock et al. 2008, p. 1437).  
25 If Wikipedia's qualitative information really informs in-  
26 vestors, then it has a potential to alter how management  
27 discourse is conditioned on characteristics of the quantified  
28 information.

29  
30 We address the following research questions: (1) Does Wiki-  
31 pedia's aggregation of *qualitative* information affect how  
32 management disclosure is conditioned on *quantified* infor-  
33 mation in the market about firm earnings? (2) If Wikipedia  
34 can really inform investors in the market, how would that  
35 change investors' reactions when managers disclose unfavor-  
36 able news?

## 37 Theoretical Background

### 38 *Investigative Context*

39  
40  
41 Our investigative context is the information environment of  
42 the modern financial market. Investors need information  
43 about firm performance in order to make investment deci-  
44 sions. The Securities and Exchange Commission (SEC) sets

official announcement dates when public firms must disclose  
their performance. Before an official announcement, man-  
agers have discretion to disclose performance information  
voluntarily. These voluntary disclosures are named *manage-  
ment disclosures* in the literature (Healy and Palepu 2001).  
The literature on management disclosure argues that managers  
make disclosure decisions to serve their self-interest, and this  
argument is based on two assumptions, as follows.

The first assumption is about information asymmetries in the  
financial market. That is, managers have an information  
advantage relative to investors; managers have more complete  
information about their firm's economic reality (Healy and  
Palepu 2001).

The second assumption is that managers observe (at least  
partially) what investors know.<sup>7</sup> There is evidence that  
managers announce news about cash flows "to meet investor  
demand for cash flow information" (Wasley and Wu 2006, p.  
391). What is implied is that managers know investors'  
information demand and what investors already know, so that  
managers can leverage disclosure to meet investors' informa-  
tion demand. Prior studies also document evidence "consis-  
tent with managers being concerned with the risk for litigation  
and issuing preemptive earnings forecasts to adjust investor  
expectations" (Wasley and Wu 2006, p. 390). This, again,  
implies that managers are aware of investor expectations, so  
that they can use preemptive forecasts to influence investors.  
The literature on media coverage also assumes that con-  
sumers' prior beliefs are not proprietary information; rather,  
firms know it (Gentzkow and Shapiro 2006).

In particular, it is arguable that managers are aware that  
investors use Wikipedia to get information about their firms.  
A article in *Financial Times* reported how Klaus Kleinfeld,  
the former CEO of Siemens, described his reaction to the  
growing influence of Wikipedia and argued that "Wikipedia,  
the peer-produced online encyclopedia, is a popular way for  
people to gain information about companies and business  
people."<sup>8</sup> Steve Goodman, CEO of PacketTrap, believed that  
"if our potential customers want to learn about something,  
they either go to...Wikipedia, or to Google. And Google  
search results often lead right back to Wikipedia" (Zetlin  
2010). A recent survey, by Webranking, found that 81 per-  
cent of surveyed companies cared about their information  
released to investors via Wikipedia; the survey suggested that

<sup>7</sup>We thank an anonymous reviewer for pointing out this key assumption.

<sup>8</sup><http://blogs.ft.com/businessblog/2008/01/wikipedia-is-pohtml/#axzz1mPeEZxIW>.

<sup>6</sup>A large body of literature supports this notion (e.g., Abarbanell et al. 1995; Francis et al. 1997; Healy and Palepu 2001; Kasznik and Lev 1995; Lang and Lundholm 1996; Roulstone 2003; Skinner 1994, 1997).

1 “companies should definitely have some method for scanning  
2 different social media... You have to know what is being said  
3 about you.”<sup>9</sup>

#### 4 **Management Disclosure**

5  
6 Based on the assumption that managers are aware of what  
7 investors know, the literature offers two perspectives to  
8 explain why managers choose to withhold or release  
9 information.

10  
11 **Withholding Perspective:** When there is a high level of infor-  
12 mation asymmetry between managers and investors, managers  
13 tend to suppress or withhold unfavorable information (Dye  
14 2001). A seminal model explains why managers’ withholding  
15 of bad news hinges on information asymmetry between  
16 managers and investors (Dye 1985). The underlying rationale  
17 is that withholding bad news may give managers the neces-  
18 sary time to wait for the arrival of more favorable news or to  
19 make adjustments to accounting measures. Managers are  
20 better placed to do this when firm information is opaque to  
21 investors. By contrast, when there is lower information  
22 asymmetry between managers and investors, there is less  
23 room for managers to manipulate information.<sup>10</sup>

24  
25 **Preemption Perspective:** When the market holds an overly  
26 optimistic view about firm performance, managers face  
27 several risks; to alleviate these risks, managers may choose to  
28 release information promptly to adjust market expectation  
29 (Healy and Palepu 2001). First, if the market has an overly  
30 optimistic expectation about firm performance, firm dis-  
31 closure on the official announcement date would trigger a  
32 downward movement of stock price (Bartov et al. 2002).  
33 Managers may be held accountable for poor stock perfor-

<sup>9</sup><http://www.webranking.eu/Articles/Articles/2008/New-HH-Webranking-report/>.

<sup>10</sup>Dye’s (1985) model describes that, when investors can correctly infer management withholding of unfavorable information, investors will revise the stock price downward, and a downward price change signals to the market that the firm’s value has been overestimated, which may trigger the stock price to cascade further downward. But if investors are unsure about whether a manager has received any news, the manager can withhold bad news, because investors cannot tell whether the manager has received news (but chosen not to release it). In another case, if investors know that the manager has received news but they do not know the rest of the manager’s information set, then, the manager can still choose nondisclosure of bad news, because investors are unable to assess whether the stock price in the market is overestimated or underestimated (Dye 1985; Jung and Kwon 1988). In both cases of information asymmetry, withholding bad news would not induce the firm’s stock price to plummet, and thus managers are tempted to withhold bad news.

mance.<sup>11</sup> Because market reactions to bad news may be more negative on the official announcement date than on earlier dates, managers may use timely voluntary disclosure to reduce the likelihood of undervaluation and to explain away poor earnings performance (Brennan 1999; Healy and Palepu 2001). Second, managers may be subject to litigation risks. If delaying bad news until official announcement dates results in large stock-price declines, stockholders may sue, because they can allege that managers failed to disclose adverse news promptly. Given the time lag between the end of the fiscal quarter and the official announcement date, it is difficult for managers to argue credibly that they had no information about the bad news beforehand (Skinner 1994). As such, managers may resort to voluntary disclosures in order to reduce the likelihood of stockholder lawsuits. Third, the investment community (e.g., money managers, security analysts, trading institutions, etc.) dislikes negative earnings surprises and prefers firms whose managers are candid about potential earnings problems (Skinner 1994). Withholding bad news may render managers a bad reputation for failing to release adverse information in a timely manner. The investment community has long appeared to impose costs on firms when their managers have such an undesirable reputation (King 1988; Rose 1991). For example, their stocks are less likely to be followed by analysts and traded by money managers, resulting in reduced liquidity (Roulstone 2003). Candid and timely disclosure helps mitigate these negative consequences.

#### **Information Aggregation Mechanisms**

From each perspective above, management disclosure is conditioned on investors’ information. As mentioned in the “Introduction,” investors’ information environment consists of two major sources: One is *quantified* information provided by financial analysts, who collect information from various sources, evaluate firms’ current performance, and make quantitative forecasts about future firm profitability (Roulstone 2003). The other is *qualitative* information provided by media—that is, linguistic descriptions of firms’ current and future profit-generating activities. Qualitative information sources include traditional media, such as individual journalists and the business press (Frankel and Li 2004; Mitchell and Mulherin 1994), and, more recently, social media, which plays an increasingly important role in disseminating firm information on the Internet (Gu et al. 2007; Tetlock et al. 2008).

<sup>11</sup>Prior studies find poor stock performance to be associated with management changes (Dahya et al. 2002; Warner et al. 1988; Weisbach 1988), as well as hostile takeovers, which in turn result in high CEO turnover (Franks and Mayer 1996; Morck et al. 1990).

1 With these various information sources, it is important to  
 2 examine mechanisms that can help aggregate information for  
 3 investors.<sup>12</sup> Prior studies suggest several mechanisms.

4  
 5 First, given the quantitative nature of analyst forecasts about  
 6 firm earnings, it is convenient to combine analyst forecasts  
 7 and create an aggregate measure (e.g., average analyst fore-  
 8 casts; Francis et al. 1997; Karamanou and Vafeas 2005; Lang  
 9 and Lundholm 1996; Roulstone 2003). Such aggregation,  
 10 however, may still result in inaccurate and incomplete infor-  
 11 mation for investors. Analysts' forecasts are often biased in  
 12 that they may overestimate a firm's earnings, resulting in an  
 13 upward analyst bias (Jacob et al. 1999; Karamanou and  
 14 Vafeas 2005). Analysts have incentives to make optimistic  
 15 forecasts because they may be rewarded for providing  
 16 information that generates trading volume and investment  
 17 banking fees for their brokerage houses (Dechow et al. 2000;  
 18 Lin and McNichols 1998). Also, analysts' summative  
 19 earnings forecasts cannot entirely convey the limitless variety  
 20 of firms' financial standings (Tetlock et al. 2008). Investors,  
 21 however, need detailed, qualitative information about various  
 22 aspects of firm operations in order to assess firm value,  
 23 according to the "mosaic" perspective. The disclosure litera-  
 24 ture documents evidence in support of this mosaic view (e.g.,  
 25 Francis et al. 1997; Lang and Lundholm 1996).<sup>13</sup> We thus  
 26 need to address mechanisms that can aggregate qualitative  
 27 information for investors.

28  
 29 An approach to aggregate qualitative information is to store  
 30 and present news articles and investor discussions in a unified  
 31 depository. Mitchell and Mulherin (1994) find that the num-  
 32 ber of news articles reported by Dow Jones & Company is  
 33 related to trading volume in the market, suggesting that  
 34 investors become informed and thus buy and sell stocks.  
 35 Antweiler and Frank (2004) find that stock-market discus-  
 36 sions posted on Yahoo! Finance help predict market volatility.

<sup>12</sup>We thank an anonymous reviewer for pointing this out and for suggesting a relevant literature review.

<sup>13</sup>For instance, the Financial Analysts Federation (FAF) Corporate Information Committee clearly states that FAF's rating of information transparency between a firm and investors involves evaluating aspects other than disclosing the summative earnings-per-share. Such additional factors include the clarity and candor of the financial highlights and president's letter, the amount of detail provided about 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 market participants may view the presentations as opportunities to 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).

The huge number of articles, however, may give investors information overload. Also, a large proportion of online discussions may have repetitive content or even "noise"; as a result, investors bear high costs of information processing on online message boards (Gu et al. 2007).

One way to eliminate noise of online postings is through users' collective reporting. Gu et al. (2007, p. 74) examined virtual investing-related communities (VICs):

One approach VIC providers use to improve posting quality is to actively monitor and filter low-quality postings... allowing users to report abusive postings, which are then investigated manually by VIC providers.

Another way to eliminate abusive postings is to have companies select and present relevant news articles in the "investor relations" section on corporate websites (Geerings et al. 2003). These approaches are controlled by VICs or companies, however, so information aggregation may be subject to their selection bias. For instance, companies behind some online communities may choose not to engage in noise filtering (Gu et al. 2007).

In Appendix B, we summarize these mechanisms as documented in previous research. In the next section, we explain how information aggregation on Wikipedia, the focus of our research, differs from these previous mechanisms.

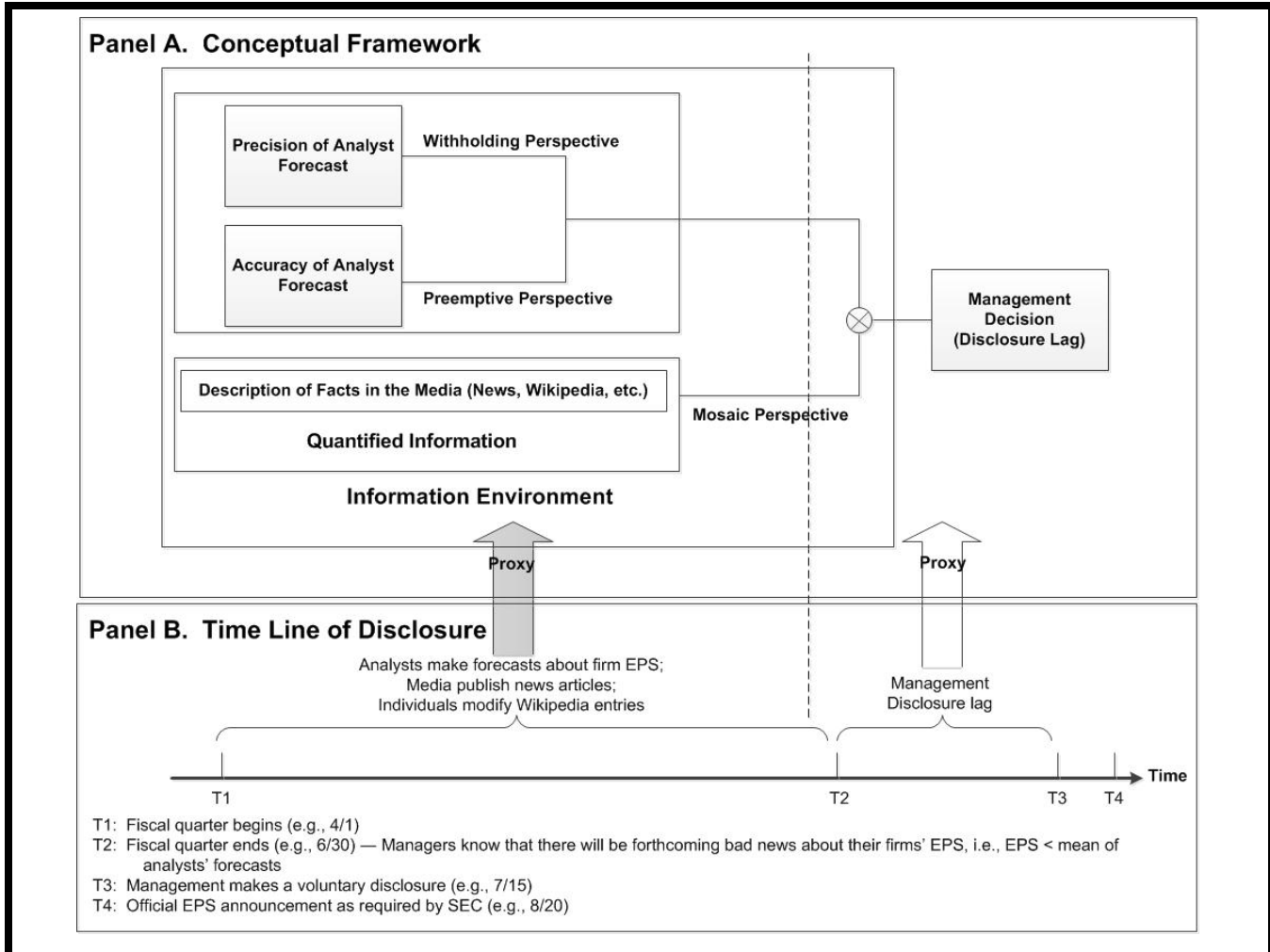
## Research Framework and Hypotheses

We develop a research framework for Wikipedia's information aggregation and managers' voluntary disclosure (Figure 1). The framework closely follows the premise of the disclosure literature that managers' decisions of voluntary disclosure are based on investors' information environment. This study moves one step forward by analyzing the additional value of Wikipedia's information aggregation in investors' information set.

### Timing of Voluntary Disclosure

The dependent variable of our framework (Figure 1) is the timing of voluntary disclosure. Disclosure timing is determined by the tension between withholding information and releasing it in a timely manner. Following the literature, we

1  
2



3 **Figure 1. Research Design**

4 restrict our attention to the disclosure of earnings performance  
 5 (among others, Anilowski et al. 2007; Baginski et al. 1994;  
 6 Cohen et al. 2007; Kasznki and Lev 1995; Miller 2002;  
 7 Skinner 1994, 1997). We focus on voluntary disclosure and  
 8 exclude mandatory disclosure, because the latter type is  
 9 required by the SEC and thus may not be attributable to fea-  
 10 tures of the information environment. Following the litera-  
 11 ture, we examine disclosure timing of bad news, that is, when  
 12 forthcoming earnings are below market expectations (e.g.,  
 13 Baginski et al. 1994; Dye 2001; Healy and Palepu 2001;  
 14 Skinner 1994, 1997; Wasley and Wu 2006). Disclosure  
 15 timing of bad news can be leveraged because of the following  
 16 considerations. First, managers generally have an incentive  
 17 to withhold unfavorable information (Dye 1985, 2001).  
 18 Second, according to the preemption perspective, it is a firm's  
 19 poor rather than good earnings performance that may result in  
 20 management turnover and damage the firm's relationship with

the professional investment community (Kasznki and Lev  
 1995; Skinner 1994, 1997). In particular, litigation risks are  
 attributable to bad rather than good news. Based on a review  
 of prior studies on litigation cases, Skinner (1994) sum-  
 marizes that more than 95 percent of firms that are targets of  
 earnings-related shareholder lawsuits can be classified as  
 having bad news on official earnings-announcement dates.<sup>14</sup>  
 Therefore, managers face a crucial decision of whether to

<sup>14</sup>Skinner (1994, p. 42) explains that "The legal reasons for this asymmetry [i.e., the dominant fraction of lawsuits related to bad news] appear to relate to proof of damages and the need to show a sufficient causal connection between the plaintiff's injury and the wrongful conduct. If an investor purchases a stock whose price subsequently declines, it is relatively easy to show both an out-of-pocket loss and (if the decline is accompanied by the release of information) causation. Conversely, a plaintiff who sells before good news is revealed suffers an opportunity loss and must show that he or she would not have sold had the information been available."

1 release unfavorable news promptly prior to the mandatory  
2 earnings announcement.

3  
4 Following this line of studies, the dependent variable in our  
5 framework (Figure 1) is *disclosure lag*, defined as the number  
6 of days between the end of a fiscal quarter and the date when  
7 managers voluntarily disclose bad news about earnings  
8 performance. The shorter the disclosure lag, the more timely  
9 is the voluntary disclosure of adverse information.

## 10 **Quantified Information**

11  
12 Prior studies on investors' information environment use two  
13 variables to characterize analysts' quantified forecasts for firm  
14 earnings: dispersion and bias (Francis et al. 1997; Karamanou  
15 and Vafeas 2005; Lang and Lundholm 1996; Roulstone  
16 2003).

17  
18 The literature uses *analyst dispersion* to proxy for information  
19 asymmetry in the information environment (Abarbanell et al.  
20 1995; Roulstone 2003). Analyst dispersion refers to the  
21 degree to which analysts' opinions are in disagreement. The  
22 withholding perspective suggests that when analysts cannot  
23 agree with each other, investors, who obtain information from  
24 analysts, are unsure about firm operations and performance.  
25 This gives managers an information advantage; that is,  
26 managers can keep silent (about their firm's bad earnings  
27 performance) for a longer time if the market is more uncertain  
28 about the information that they have. Prior studies in the  
29 disclosure literature suggest that when there is greater infor-  
30 mation asymmetry in the market, managers can delay their  
31 voluntary disclosure for a longer time, waiting for investors  
32 to acquire information and achieve a consensus about firm  
33 performance (Francis et al. 2008; Miller 2002; Wasley and  
34 Wu 2006). Greater information asymmetry generally gives  
35 managers more time to adjust accounting information to  
36 suppress bad news (Matsumoto 2002; Richardson et al. 2004).  
37 In sum, the withholding perspective suggests that *disclosure*  
38 *lag is positively related to analyst dispersion*.

39  
40 The literature uses *analyst bias* to measure the difference  
41 between true firm performance and the quantified information  
42 accessible to investors (Jacob et al. 1999; Karamanou and  
43 Vafeas 2005). According to the preemption perspective, the  
44 greater the analyst bias, the larger is the negative earnings  
45 surprise on the official earnings announcement date (Kaszni-  
46 k and Lev 1995). The negative earnings surprise exposes  
47 managers to risks of job changes, reputation damage, and  
48 stockholder lawsuits, as reviewed above. Early disclosure is  
49 probably the best strategy to reduce these risks for three  
50 reasons (Skinner 1994): (1) only investors who bought or

sold the firm's stock *before* management disclosure can sue,  
simply because investors who conduct transactions after the  
disclosure are already aware of the bad news; (2) early  
disclosure undercuts plaintiffs' argument that managers failed  
to disclose promptly, because managers made a relatively  
timely disclosure; and (3) early disclosure helps spread out  
(negative) market reactions over a longer time, which helps  
prevent the stock price from plummeting and thus helps  
mitigate the risk of management changes because of poor  
stock performance (Kaszni- and Lev 1995). In sum, the pre-  
emption perspective suggests that disclosure lag is negatively  
related to analyst bias.

## **Qualitative Information**

Prior literature characterizes media information using the  
*number of news articles* and the amount of *newsworthy con-*  
*tent* (Antweiler and Frank 2004; Atiase 1985; Foster 1987;  
Mitchell and Mulherin 1994; Tetlock et al. 2008). We follow  
the literature and address these factors in our research. Since  
the focus of this study is the role of Wikipedia's information  
aggregation, they are posited as control variables in our  
model. We discuss their effects in detail later in the subsec-  
tion "Empirical Model for Management Disclosure."

As defined earlier, *information aggregation on Wikipedia*  
refers to a process by which individuals synthesize their  
information by contributing to Wikipedia's company entries.

## **How Does Wikipedia Aggregate Information?**

Earlier we summarized the various mechanisms of informa-  
tion aggregation as documented in prior research. Wikipedia  
differs from previous mechanisms of information aggregation  
in that it can better generate the "wisdom of crowds" (see  
Appendix B). Surowiecki (2004) suggests that a social media  
platform must satisfy four conditions for a crowd to be smart:  
diversity, independence, decentralization, and aggregation.  
Wikipedia meets these conditions.

Creating and revising any entry on Wikipedia is completely  
*decentralized*. It allows anyone to freely edit any details of  
all entries (Kane and Fichman 2009; Te'eni 2009). Wikipedia  
thus supports "democratization of contributions (e.g., leveling  
the playing field so anyone can contribute an idea)" (Majchr-  
zak 2009, p. 19; Zwass 2010). This guarantees *diversified*  
sources of contributors, in contrast to corporate websites or  
some communities that control information content (Geerings  
et al. 2003). Wikipedia ensures *independent* expression of

1 users' opinions and supports "deep profiling," allowing users  
 2 to provide detailed information to define their own personal  
 3 and social identities (Zhang and Zhu 2011). This encourages  
 4 users to identify with Wikipedia and motivates them to con-  
 5 tribute (Ma and Agarwal 2007). Contributors use the wiki  
 6 technology to edit the same pages, thus effectively *aggre-*  
 7 *gating* information (Kane and Fichman 2009) and reducing  
 8 readers' information-processing costs (Gu et al. 2007). Wiki-  
 9 pedia also provides functions to easily search and display  
 10 other users' inputs. This leads to collaborative efforts to  
 11 screen noise and eliminate abusive postings (Moon and  
 12 Sproull 2008). The difference between a wiki and a tradi-  
 13 tional discussion board is that good content is retained on a  
 14 wiki, and openness and transparency make a wiki naturally  
 15 resistant to spam (Wagner and Majchrzak 2006).

16  
 17 A relevant literature examines the editing behavior of Wiki-  
 18 pedia contributors. There is evidence that individuals' con-  
 19 tributing patterns are often determined by their personalities  
 20 and thus do not change much over time (Panciera et al. 2009).  
 21 Some prominent Wikipedians argue that a group of prolific  
 22 users is the driving force behind the success of Wikipedia  
 23 (Wales 2005), because some contributors tend to express  
 24 ownership of entries in the collaborative authoring (Thom-  
 25 Santelli et al. 2009). Recent research, however, suggests a  
 26 dramatic shift such that the collective contributions play an  
 27 increasingly bigger role (Kittur et al. 2008). Not only quality  
 28 evolves out of coordination (Kittur and Kraut 2008), but  
 29 collaborative efforts (Swarts 2009), diversity (Chen et al.  
 30 2010), and conflicts (Arazy et al. 2011; Kittur and Kraut  
 31 2010) may also determine the success of Wikipedia. Collabo-  
 32 rative authoring thus enables the aggregation of diverse, and  
 33 even conflicting, opinions from individual contributors.

### 34 **Nature of Company Information on Wikipedia**

35  
 36 Wikipedia describes firms' basic profiles. Additionally, and  
 37 importantly, Wikipedia aggregates comprehensive and timely  
 38 information about firms' up-to-date activities.

39  
 40 Wikipedia aggregates a *comprehensive array of details* about  
 41 a firm's activities, such as launching new products, changes  
 42 in top management, outsourcing, etc. This type of informa-  
 43 tion aggregation contrasts with the summative earnings fore-  
 44 casts issued by analysts (Carlson and Zmud 1999). Wikipedia  
 45 also covers detailed firm operations more broadly than any  
 46 single medium channel, because it aggregates information  
 47 from various media. On March 23, 2009, for example, a  
 48 modification on Dell's Wikipedia page suggested that Dell  
 49 sold a call center to a French outsourcing firm, Teleperfor-  
 50 mance. Only a weekly magazine, *BusinessWorld*, reported

this deal. In this case, traditional information channels may  
 leave information holes between parties with asymmetric and  
 incomplete information (Lin et al. 2005; Schultze and Leidner  
 2002), while Wikipedia helps reduce information asymmetry  
 by keeping a comprehensive record of facts.

Wikipedia aggregates information in a *timely manner*. Wiki-  
 pedia entries for Microsoft and Dell, for example, are edited  
 multiple times a day, which is more frequent than how often  
 analysts update their coverage of these companies. On  
 June 1, 2009, almost immediately after the Dow Jones'  
 announcement that Cisco was going to replace GM as a  
 component of the Dow Jones Index, the Wikipedia entry for  
 Cisco was modified to reflect it. The earliest newspaper  
 coverage, by the *Washington Post*, came as late as June 2.  
 These cases demonstrate that important information about  
 firm fundamentals becomes public on Wikipedia very  
 quickly.

Next we proceed to analyzing the impact of Wikipedia's  
 information aggregation.

### **Wikipedia and Management Disclosure**

Much prior research considers the impact of information  
 aggregation on market price and returns. Classical asset-  
 pricing models assume perfect information aggregation in the  
 financial market (Banks 1985; Radner 1979). Diamond and  
 Verrecchia's (1981) model shows that when the process of  
 information aggregation via market pricing is not perfect,  
 market outcomes can be different, and Axelson (2007) theo-  
 retically shows that managers should react (in the context of  
 securities design) to different levels of investor private infor-  
 mation. Forsythe and Lundholm (1990) and Sunder (1992)  
 examine financial information aggregation with experiments  
 and show evidence that various information aggregation  
 mechanisms affect stock prices. DellaVigna and Pollet (2009)  
 show that information aggregation eliminates the effect of  
 limited attention, thus affecting stock returns. Collectively,  
 these prior studies demonstrate the impact of information  
 aggregation on investors. An important implication for our  
 research is that information aggregation influences investors'  
 information set.

We carry this implication to the setting of information aggre-  
 gation on Wikipedia. We have offered some anecdotal evi-  
 dence (in the "Introduction") suggesting that Wikipedia can  
 benefit investors. In the same vein, Gu et al. (2007) suggest  
 that investors value high-quality linguistic descriptions about  
 firms. Butler (2001) argues that the key driver of participa-  
 tion in collaborative communities is that participants can gain



benefits from communicating and collaborating with others, and obtain information through information aggregation. Antweiler and Frank (2004) show that the aggregated sentiment of stock market discussions on Yahoo helps predict market volatility, even after controlling for news in the *Wall Street Journal*. This suggests that aggregation of linguistic descriptions informs investors. The aggregation in Antweiler and Frank, however, is based on computational methods for scholarly investigation. By contrast, Wikipedia offers a practical platform that individuals in the market use to aggregate and access qualitative information.

Our literature review motivates us to analyze how Wikipedia's information aggregation, by reshaping investors' information set, may alter management information-disclosure behaviors. Our overall logic is that, in the absence of Wikipedia, management disclosure is related to the information environment characterized by analyst dispersion and analyst bias (recall our discussions in a previous subsection, "Quantified Information"). If Wikipedia reshapes investors' information environment, then we expect different disclosure behaviors even though analyst characteristics (dispersion and bias) are the same. This expectation suggests a moderating effect of Wikipedia on the relationship between management disclosure and analyst characteristics.

According to the withholding perspective, when analyst dispersion is high, managers withhold information for a longer period (i.e., a positive relationship between disclosure lag and analyst dispersion). In this case, managers clearly have an information advantage, and their delay in disclosure indicates that they can benefit from information uncertainty in the market. Wikipedia can weaken the information advantage of managers, mainly because Wikipedia is a public platform to effectively aggregate private information possessed by individuals in the market. A high level of analyst dispersion indicates that, while managers generally have a complete set of information about their firm's economic activities, the set becomes incomplete and piecemeal when it goes to the separate information sources in the market (i.e., analysts) (Roulstone 2003). Individuals obtain their private information from analysts and, therefore, their information is a range of dispersed bits of incomplete and frequently contradictory messages. The democratization of the creation, distribution, and use of information on Wikipedia enables individuals to assemble their pieces of information into a unified whole. In doing so, information aggregation on Wikipedia would play a role in weakening managers' information advantage. If this is the case, managers would be less able to withhold unfavorable information even though there is high analyst dispersion. As such, the positive relationship between management disclosure lag and analyst dispersion would be weakened. We thus hypothesize:

**Hypothesis 1 (H1):** *Information aggregation on Wikipedia weakens the relationship between analyst dispersion and management disclosure lag.*

According to the preemption perspective, when analyst bias is high, managers' disclosure lag will be relatively shorter (i.e., a negative relationship between disclosure lag and analyst bias). This is because managers are concerned about the market's overly optimistic expectation of firm earnings. Wikipedia can help establish a more accurate expectation of firm earnings for investors in two ways. First, when investors are better informed through Wikipedia's information aggregation, they possess more comprehensive and timely information about firms' fundamentals. As a result, they can better evaluate the firm's true performance. Second, Wikipedia supports a neutral point of view (NPOV) stance (Majchrzak 2009). The NPOV policy explicitly forbids either avoiding or highlighting favorable or unfavorable facts.<sup>15</sup> Wikipedia encourages all users to comply with the NPOV policy and allows anyone to modify a firm's entry through rounds of addition, deletion, and reorganization. In such an information aggregation process, contributors are able to correct any details of an entry that violate the NPOV policy. Because this policy requires contributors to use neutral words and to only document facts, information aggregation on Wikipedia prevents one point of view from dominating. This is markedly different from analysts' recommendations, which are often biased (Jacob et al. 1999; Karamanou and Vafeas 2005). Traditional media also have a more emotional touch than Wikipedia entries, be it for ideological (Mullainathan and Shleifer 2005) or financial (Reuter and Zitzewitz 2006) reasons. When the market is replete with an overly optimistic sentiment, the NPOV policy can help investors obtain a more objective assessment of firm performance. Overall, information aggregation on Wikipedia should help alleviate managers' concerns about high analyst bias, thus weakening the negative relationship between management disclosure lag and analyst bias. Formally, we can write the following hypothesis:

**Hypothesis 2 (H2):** *Information aggregation on Wikipedia weakens the relationship between analyst bias and management disclosure lag.*

## Investor Reaction to Disclosure

Now we use the lens of investor reaction to see how Wikipedia benefits investors. The disclosure literature has long

<sup>15</sup><http://en.wikipedia.org/wiki/NPOV>.

1 observed investor reaction to management disclosure of firm  
 2 earnings (Kasznik and Lev 1995; Miller 2002; Pownall and  
 3 Waymire 1989; Waymire 1984). A literature review con-  
 4 cludes that “disclosure is associated with stock price perfor-  
 5 mance” (Healy and Palepu 2001, p. 431). In this line of  
 6 research, Kasznik and Lev (1995) show a significant asso-  
 7 ciation between market reaction and unexpected earnings  
 8 surprise to investors (because of analyst bias). The higher the  
 9 bias, the more negative is the market reaction. Their study  
 10 also suggests that if investors receive warnings before  
 11 management disclosure of bad news, the disclosure is less of  
 12 a surprise to investors. In the same vein, we propose that  
 13 when investors obtain detailed and timely information about  
 14 firms’ economic reality, they adjust their firm valuation  
 15 accordingly. Later, when managers release bad news about  
 16 firm earnings, it will trigger a smaller market reaction because  
 17 of the earlier market adjustment. We, therefore, hypothesize  
 18 that information aggregation on Wikipedia, which occurs  
 19 before management disclosure (see Figure 1), would weaken  
 20 how analyst bias triggers investor reaction.<sup>16</sup>

21  
 22 **Hypothesis 3 (H3):** *Information aggregation on*  
 23 *Wikipedia weakens the relationship between analyst*  
 24 *bias and investor reaction to management*  
 25 *disclosure.*

26 **Method**

27  
 28 **Measures**

29  
 30 To develop our measures for variables in the research frame-  
 31 work (Panel A of Figure 1), we follow the disclosure  
 32 literature and present a time line of disclosures in Panel B of  
 33 Figure 1 (Skinner 1997). In a fiscal quarter (between T1 and  
 34 T2), analysts make forecasts about firm earnings-per-share  
 35 (EPS), media publish news articles, and contributors modify  
 36 firm entries on Wikipedia. The disclosure literature assumes  
 37 that managers know their own firms’ EPS at fiscal quarter end  
 38 T2, when they realize whether they are confronting forth-  
 39 coming bad news about EPS (Skinner 1997). The SEC  
 40 requires public companies to announce their EPS at T4 (the  
 41 official announcement date). During the period between T2  
 42 and T4, managers may voluntarily make disclosures about  
 43 their firms’ EPS (e.g., at T3).

44  
 45 Consistent with the literature (Kasznik and Lev 1995; Skinner  
 46 1994), we measure disclosure lag (LAG) as the number of

calendar days between fiscal quarter end (T2) and the date  
 when management voluntarily discloses bad news about EPS  
 (T3).

Analyst bias (BIAS) is the difference between the mean of  
 analyst forecasts of a firm’s EPS during a fiscal quarter  
 (between T1 and T2) and the firm’s actual EPS (Francis et al.  
 1997; Karamanou and Vafeas 2005). Analyst dispersion  
 (DISPERSION) is the standard deviation of analyst forecasts  
 of a firm’s EPS during a fiscal quarter (between T1 and T2)  
 (Abarbanell et al. 1995; Roulstone 2003).

We measure information aggregation on Wikipedia by Wiki-  
 pedia modifications (WikiMOD)—specifically, the number of  
 times modifications are made on Wikipedia about a firm in  
 one quarter (between T1 and T2). WikiMOD is a proxy for  
 information aggregation, because by modifying the same firm  
 entry on Wikipedia, individuals add their information,  
 combine different viewpoints about the firm’s operations and  
 performance, and filter out noise and biased statements, thus  
 generating synthesized information about the firm. In order  
 for WikiMOD to play a role in our analysis, a premise is that  
 managers can be informed about the magnitude of WikiMOD,  
 that is, the extent of information aggregation about their firms.  
 This premise is likely to hold. For each company’s Wikipedia  
 entry, there is a “revision history” page on Wikipedia, listing  
 information about each historical modification on that entry  
 (including the time of each modification and the content  
 modified). For example, if one wants to check the modifi-  
 cation history of IBM’s Wikipedia entry, s/he can easily see  
 the entire history (<http://en.wikipedia.org/w/index.php?title=IBM&action=history>) with no need for any special technical  
 skills. In addition, managers can use some publicly available  
 tools, like “Wikipedia Page History Statistics,” which provide  
 the number of modifications for any single Wikipedia entry in  
 the last day/week/month. As an illustration, Appendix C  
 shows the summary statistics for Apple’s Wikipedia page  
 modifications. Using such tools, it may not be too difficult  
 for managers to track and thus realize how many changes  
 were made on their company’s Wikipedia entry. Finally,  
 although our estimation uses the number of modifications as  
 a proxy for information arrivals on Wikipedia, managers do  
 not really need to know the number of modifications of their  
 Wikipedia entries in order to assess how information gets  
 leaked through Wikipedia. A quick skimming of the whole  
 page is likely to give a manager a very good idea about the  
 transparency of the information environment.

It is possible that not all modifications are related to a com-  
 pany’s financial performance (e.g., modifications related to  
 word choice, grammar mistakes, etc.). We refrain from  
 removing these unrelated modifications because that would  
 unavoidably involve subjective human judgment. These  
 modifications are likely to be orthogonal to the variables of

<sup>16</sup>We appreciate the Associate Editor’s suggestion to formally putting forth  
 this hypothesis.

1 interest. Hence, including these modifications would not  
 2 affect the direction of our estimation results, while reducing  
 3 the efficiency of the estimation. As such, the introduction of  
 4 noise would bias against our finding evidence. Another  
 5 potential concern is that WikiMOD may involve modifica-  
 6 tions in “edit wars” (i.e., back-and-forth changes due to  
 7 disagreement between contributors). As reported later in our  
 8 sensitive analysis in Appendix F, our results hold up after we  
 9 remove possible back-and-forth changes.<sup>17</sup> We also note that  
 10 if there are other social-media platforms that can achieve  
 11 information aggregation, focusing on Wikipedia is only likely  
 12 to bias our results downward. Therefore, our conclusion  
 13 regarding the effect of information aggregation would be  
 14 conservative.

15  
 16 As for investor reaction to bad news, we follow the disclosure  
 17 literature (Kasznik and Lev 1995) and develop a proxy  
 18 measure by computing the sum of market-adjusted returns in  
 19 two windows: a five-day window around voluntary disclo-  
 20 sure and a five-day window around the official EPS an-  
 21 nouncement. Market-adjusted returns (RET) in the combined  
 22 two windows represent market reaction to bad news. In  
 23 addition, we estimate cumulative abnormal returns (CAR) in  
 24 the combined two windows.<sup>18</sup> These two methods yield  
 25 highly consistent results, so the discussion below is based on  
 26 one method (CAR).

27 **Empirical Model for Management Disclosure**

28  
 29 To test H1 and H2, we use a hazard regression model,  
 30 developed in the statistics literature to assess the impact of  
 31 explanatory variables on the timing of an event. In our  
 32 research context, the event under investigation is management  
 33 transition from withholding to disclosure, and the timing of  
 34 the event refers to the disclosure lag (LAG). Because the  
 35 distribution of event timing is often far from normal, a hazard  
 36 model is usually superior to ordinary least squares regression  
 37 (Kalbfleisch and Prentice 1980). The dependent variable of  
 38 the hazard analysis is the hazard rate  $h(t)$ , which is the  
 39 probability of management transition from withholding to  
 40 disclosure at time  $t$ . Following Kauffman et al. (2000), we  
 41 specify a Cox proportional-hazard model as follows:

42  
 43 
$$h(t) = h_0(t) \exp(-\beta X) \quad (0)$$

where  $X$  is a vector of explanatory variables,  $\beta$  is a row vector of coefficients to be estimated, and  $h_0(t)$  is a hazard function with  $X = 0$ . It is worth noting that we specify  $\exp(-\beta X)$  rather than  $\exp(\beta X)$ , because with this specification, the coefficient  $\beta$  tells how the explanatory variables  $X$  affect the disclosure lag as follows: if an explanatory variable has a **positive** coefficient, it reduces the hazard rate  $h(t)$  and thus **increases** LAG; conversely, a **negative** coefficient indicates an effect to **decrease** LAG. In the literature, Kauffman et al. use a similar approach for exposition reasons.

Because H1 and H2 are about whether WikiMOD moderates how LAG relates to analyst characteristics (DISPERSION and BIAS), the explanatory variables  $X$  in model (0) include DISPERSION, BIAS, WikiMOD, WikiMOD\*DISPERSION, and WikiMOD\*BIA. We have the following hazard model for testing H1 and H2:

$$h(t) = h_0(t) \exp[-(\theta_1 \text{DISPERSION} + \theta_2 \text{BIAS} + \delta_1 \text{WikiMOD} + \delta_2 \text{WikiMOD} * \text{DISPERSION} + \delta_3 \text{WikiMOD} * \text{BIAS} + \zeta \text{controls})] \quad (1)$$

We need two sets of control variables. First, we need to include controls identified by the disclosure literature as directly affecting management disclosure:

- We control for firm risk, measured as earnings variability (VAR)—that is, the standard deviation of earnings across the eight previous fiscal quarters (Kothari et al. 2002). To compensate for high risk resulting from high earnings variability, investors tend to demand high returns that increase the firm’s costs of capital. Voluntary disclosure may help reduce costs of capital by providing more information to investors (Francis et al. 2008). As such, high earnings variability may motivate firms to disclose earlier.
- The literature suggests the need to control for firm size (MV), measured as firm market value at the beginning of a fiscal quarter, because larger firms are more exposed to litigation risks (Kasznik and Lev 1995).
- The literature suggests the need to control for two specific industry sectors: high tech (HIGHTECH) and regulated industry (REG). High-tech firms are likely to be exposed to a larger-than-average risk of shareholder lawsuits and thus may be motivated to disclose to deter investors’ litigation (Kasznik and Lev 1995).<sup>19</sup> Yet,

<sup>17</sup>We thank an anonymous reviewer for suggesting this important check.

<sup>18</sup>We estimate an equation  $R_t = a + b * R_{mt}$ , where  $R_t$  is a firm’s actual return on day  $t$  and  $R_{mt}$  is the market return. The difference between  $R_t$  and the predicted value based on the equation is the firm’s abnormal returns on day  $t$ .

<sup>19</sup>Kasznik and Lev (1995, p. 124) argue “high technology (‘high tech’) firms appear to be exposed to a larger-than-average risk of shareholder lawsuits, particularly at the early stage of operations. Among the reasons for the

among the reasons for shareholder lawsuits are high-tech firms' aggressive accounting techniques (e.g., excessive capitalization of software development costs). Disclosing poor EPS may not help fend off such lawsuits (Kasznik and Lev 1995). In regulated industries, firms may be obliged to release information about their operations, in addition to quarterly financial reports. But firms in regulated industries may be perceived as having low risk (Dewan et al. 2007), which may reduce firms' incentive to disclose. We thus include the two industry dummies (HIGHTECH and REG) but do not predict their signs.

- We also control for fiscal quarters. Managers are more likely to withhold bad news in the fourth quarter than in earlier quarters (Baginski et al. 1994), as releasing bad news in the last fiscal quarter affects firm performance for the entire fiscal year.

Second, we need to control for news coverage, because modifications on Wikipedia and news coverage may be triggered by common events. If news coverage also informs investors, we need to address their moderation effects in model (1) as well. This helps rule out alternative explanations for the moderating role of Wikipedia modifications.

- The recent literature on media impact suggests that readers are sensitive to newsworthy content, which can be measured with the amount of positive words (POSITIVE) and negative words (NEGATIVE) in news articles (Tetlock et al. 2008). Given the same level of dispersion and uncertainty, an increased level of positive news affords managers the possibility to take advantage of it, causing further delay in disclosure.<sup>20</sup> We therefore expect a positive interaction effect between POSITIVE and DISPERSION on disclosure lag; conversely, we expect a negative interaction effect between NEGATIVE and DISPERSION. Regarding the moderation on BIAS, because a positive media bias means that EPS is already below expectation, negative news may further hasten

managers to disclose bad news to minimize damage. We therefore expect a negative interaction effect between NEGATIVE and BIAS on disclosure lag; conversely, we expect a positive interaction effect between POSITIVE and BIAS.

- We count the number of news articles (NEWS) in the business press about a firm in one quarter (Antweiler and Frank 2004; Frankel and Li 2004). We expect the role of NEWS is similar to that of NEGATIVE, because prior research finds that readers are generally more affected by negative than positive words (Tetlock et al. 2008).

### Empirical Model for Investor Reaction

To test H3, our analysis builds on the management disclosure literature (Kasznik and Lev 1995), which has established a regression model relating analyst bias (BIAS) to investor reaction (i.e., cumulative abnormal returns—CAR—as defined above). We extend the model by adding the moderating effect of WikiMOD, and have an ordinary least squares (OLS) model as follows:

$$CAR = \alpha + \eta BIAS + \delta_1 WikiMOD + \delta_2 WikiMOD * BIAS + \zeta \text{ controls} + \varepsilon \quad (2)$$

Regarding controls in the above model, we follow prior research and include firm size, which moderates the effect of BIAS, in that investors are more tolerant of analyst bias for large firms than for small firms (Kasznik and Lev 1995). The reason is that poor performance in one quarter may have less impact on large firms' long-term economic viability as compared with that of small firms (Kasznik and Lev 1995). We also include news articles and newsworthy content, for the abovementioned reasons. If negative news content can inform investors about forthcoming bad news, it can mitigate investor reaction to bad news, while positive news content may play an opposite role. Regarding the number of news articles, we expect that its role is similar to that of negative news (Tetlock et al. 2008).

### Data and Sample

We collect data from several sources: (1) management disclosure data from the First Call Historical Database (FCHD), (2) editing history data from Wikipedia, (3) firm data from Compustat and Center for Research in Security Prices (CRSP), and (4) news-coverage data from Lexis-Nexis. Table 1 summarizes the measures and data sources of all variables, which are described in detail below.

prevalence of shareholder lawsuits against high tech firms is their relatively high risk, resulting in large price fluctuations and potential losses to investors. The aggressive accounting techniques sometimes used by such firms (e.g., front loading of gains from long-term contracts, excessive capitalization of software development costs) may also contribute to litigation exposure." Along the same line, Chen et al. (2002, p. 232) argue "high-tech firms also operate in rapidly changing environments that make their future operations, and hence future earnings, relatively more uncertain."

<sup>20</sup>We thank an anonymous reviewer for providing insights into how newsworthy content may interact with analyst dispersion and analyst bias in affecting management disclosure lag.

Table 1. Variable Definitions		
Variable	Computation	Source
<b>Theoretical Variables</b>		
<b>LAG</b> (disclosure lag)	The number of calendar days between fiscal quarter end and the date when management voluntarily discloses bad news about EPS (i.e., between T2 and T3 in Figure 1)	First Call
<b>DISPERSION</b> (analyst dispersion)	The standard deviation of analyst forecasts about a firm's EPS in a fiscal quarter (i.e., between T1 and T2 in Figure 1), scaled by the mean EPS forecast	First Call
<b>BIAS</b> (analyst bias)	The absolute value of the difference between firm EPS in a quarter and the mean EPS forecast made by analysts in the quarter (i.e., between T1 and T2 in Figure 1), scaled by the mean EPS forecast	First Call
<b>WikiMOD</b> (Wikipedia modifications— a proxy for information aggregation on Wikipedia)	Natural logarithm of one plus the number of Wikipedia modifications for a company in a fiscal quarter (between T1 and T2 in Figure 1)	Wikipedia
<b>CAR</b> (cumulative abnormal returns)	Sum of abnormal returns in a combined window including 5 days around voluntary disclosure (i.e., T3 in Figure 1) and 5 days around the official earnings announcement (i.e., T4 in Figure 1)	CRSP
<b>RET</b> (market adjusted returns)	Sum of market adjusted returns (i.e., less market average returns) in a combined window including 5 days around voluntary disclosure (i.e., T3 in Figure 1) and 5 days around the official earnings announcement (i.e., T4 in Figure 1)	CRSP
<b>Control Variables</b>		
<b>NEWS</b> (number of news articles )	Natural logarithm of one plus the number of news articles about a company in a fiscal quarter (between T1 and T2 in Figure 1), as documented in Lexis-Nexis	Lexis-Nexis
<b>POSITIVE</b> (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, $POSITIVE = (POS\% - Mean\_POS) / Sd\_POS$ .	Lexis-Nexis
<b>NEGATIVE</b> (negative news)	<i>NEGATIVE</i> is calculated similar to <i>POSITIVE</i> , with the proportion of negative words.	Lexis-Nexis
<b>VAR</b> (earnings variability)	The standard deviation of quarterly earnings across eight fiscal quarters before the quarter under examination (i.e., prior to T1 in Figure 1)	Compustat
<b>MV</b> (market value)	Natural logarithm of firm market value at the beginning of the fiscal quarter (i.e., at T1 in Figure 1)	Compustat
<b>HIGHTECH</b> (high-tech industries)	<i>HIGHTECH</i> 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	Compustat
<b>REG</b> (regulated industries)	<i>REG</i> 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	Compustat

1 We obtain access to FCHD from Wharton Research Data  
 2 Services (WRDS). FCHD reports the history of analysts’  
 3 estimates of companies’ EPS, based on which we compute  
 4 analyst bias (BIAS) and dispersion (DISPERSION). FCHD  
 5 also records company-issued guidelines about forthcoming  
 6 EPS and labels whether the guidelines are bad news.<sup>21</sup> We  
 7 use this information to identify bad news and calculate  
 8 disclosure lag (LAG).

9  
 10 FCHD contains quarterly earnings information for 8,500 U.S.  
 11 securities; we limit our attention to common stocks. For each  
 12 stock, we obtain firm identity (provided by FCHD) and then  
 13 search on Wikipedia for the corresponding entry. A PERL  
 14 program is used to search our list of companies on Wikipedia.  
 15 After obtaining the URLs of these entries, we manually go  
 16 over all of these Wikipedia pages to ensure that the entries are  
 17 correctly matched to the companies. This practice yields 375  
 18 Wikipedia entries of public companies. To obtain Wikipedia  
 19 revision information, we use a software robot program to  
 20 collect the complete “revision history” of all these entries.<sup>22</sup>  
 21 After comparing each revision with the previous revision, we  
 22 calculate the number of words added or deleted and record the  
 23 number of modifications (WikiMOD) in each fiscal quarter  
 24 for each firm. Overall, for the period between March 21,  
 25 2001, and May 19, 2006, 8,789 registered users and 5,450  
 26 unregistered users contributed a total of 77,921 modifications  
 27 on these Wikipedia firm entries.<sup>23</sup>

28  
 29 We manually search the Lexis-Nexis database for news  
 30 articles about each of the 375 companies in our final sample.  
 31 For Lexis-Nexis’s HTML output, we develop a program to  
 32 parse the result pages and record the newspaper name, date,  
 33 and content of each piece of news. These are our raw data for  
 34 quantifying news coverage (NEWS) and analyzing news

<sup>21</sup>When companies make voluntary earnings disclosures in press releases and interviews, the disclosures can be a number (e.g., \$2.35), a range of numbers (e.g., from \$2.35 to \$2.68), or a simple text item (e.g., the earnings will be above/below analysts’ expectations). FCHD reports the form of each specific disclosure and uses a field to describe the disclosure and indicate whether it is a positive or negative surprise. Please refer to FCHD Technical Guide for further details.

<sup>22</sup>A detailed explanation of Wikipedia’s revision history can be found at [http://en.wikipedia.org/wiki/Help:Page\\_history](http://en.wikipedia.org/wiki/Help:Page_history).

<sup>23</sup>Wikipedia attributes modifications to users’ registered names if contributors log into the system. Anonymous contributors who do not log in are identified only by their IP addresses. We exclude all modifications contributed by anonymous users in our subsequent analysis because, given the low cost of anonymous editing, spammers and abusers often contaminate entries and because knowledge contribution on social media is found to be strongly associated with identity verification (Ma and Agarwal 2007; Wasko and Faraj 2005; Zhang and Zhu 2011).

content. We follow prior research to conduct a content analysis to quantify the language used in news stories. We compute the proportions of positive words (POSITIVE) and negative words (NEGATIVE) in all news stories related to a firm in one quarter (between T1 and T2).<sup>24</sup> The algorithm of our computation comes directly from the literature on stock-market responses to news content (Das and Chen 2007; Tetlock 2007; Tetlock et al. 2008).<sup>25</sup>

We obtain stock-return data from CRSP and use the data to calculate market-adjusted returns (RET) and cumulative abnormal returns (CAR), as defined above. We use firm data from Compustat for earnings variability (VAR), market value (MV), a high-tech industry dummy (HIGHTECH), and a regulated industry dummy (REG).

Our research context adds two necessary restrictions to our sample. First, a firm’s EPS in a quarter should be below the mean EPS forecast made by analysts during the same quarter. This implies a situation in which managers faced forthcoming bad news. Second, the firm should voluntarily disclose bad news about EPS (between T2 and T4 in Figure 1). These two restrictions reduce our sample to a set of 161 warnings (i.e., voluntary disclosures of bad news about EPS) released by 96 public companies during the observation period when the Wikipedia modification history is available to us. These 161 warnings form our final sample used in the subsequent analysis.

## Summary Statistics

Table 2 reports summary statistics. In the final sample, the mean disclosure lag is 14.11 days, and the maximum is 43

<sup>24</sup>NEGATIVE is a standardized measure of the proportion of negative words in all news stories related to a firm (Tetlock et al. 2008). Specifically, we calculate the 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 the same quarter. We then calculate the mean ( $\mu_{NEG}$ ) and the standard deviation ( $\sigma_{NEG}$ ) of the proportion of negative words for the prior calendar year, and define  $NEGATIVE = (NEG\% - \mu_{NEG}) / \sigma_{NEG}$ . Similarly, we compute  $POSITIVE = (POS\% - \mu_{POS}) / \sigma_{POS}$ . To categorize the words as positive or negative, we follow Tetlock (2007) and Tetlock et al. (2008) and use the Harvard-IV-4 psychosocial dictionary.

<sup>25</sup>Das and Chen (2007) propose an algorithm to identify investor sentiments from stock message boards. Tetlock (2007) examines the relation between media content, specifically *The Wall Street Journal*’s “Abreast of the Market” column, and daily stock-market activity. He finds evidence to support that the media directly influence investors’ sentiments toward securities. Tetlock et al. (2008) find that a quantitative measure of language used in *The Wall Street Journal* and Dow Jones News Service stories can be used to predict individual firms’ accounting earnings and stock returns.

**Table 2. Summary Statistics (Variable Definitions Are in Table 1)**

	LAG	DISPERSION	BIAS	NEWS	WikiMOD	POSITIVE	NEGATIVE	VAR	MV	HIGH TECH	REG	CAR	RET
Mean	2.2667	0.3246	1.0083	2.0316	1.5947	-1.0366	0.0491	0.4418	18.1280	0.3625	0.0188	-0.0484	-0.0684
Std. Dev.	0.8765	0.8691	3.0376	1.3455	1.0907	1.6965	1.3778	1.4266	1.2513	0.4822	0.1361	0.1112	0.1126
Bivariate Correlations (p-values shown in parentheses)													
LAG	1												
DISPERSION	0.151 (0.056)	1											
BIAS	0.068 (0.391)	0.499 (0.000)	1										
NEWS	-0.231 (0.003)	-0.155 (0.051)	-0.008 (0.924)	1									
WikiMOD	-0.158 (0.046)	-0.132 (0.096)	-0.051 (0.519)	0.332 (0.000)	1								
POSITIVE	-0.136 (0.087)	0.054 (0.497)	0.056 (0.482)	-0.027 (0.736)	-0.019 (0.816)	1							
NEGATIVE	-0.018 (0.825)	0.086 (0.282)	-0.002 (0.984)	-0.021 (0.796)	-0.061 (0.440)	-0.108 (0.175)	1						
VAR	-0.122 (0.124)	0.220 (0.005)	0.418 (0.000)	0.066 (0.406)	-0.140 (0.077)	0.091 (0.250)	0.030 (0.708)	1					
MV	-0.260 (0.001)	-0.246 (0.002)	-0.303 (0.000)	0.445 (0.000)	0.354 (0.000)	-0.056 (0.484)	-0.128 (0.105)	-0.227 (0.004)	1				
HIGHTECH	0.121 (0.129)	0.272 (0.000)	0.203 (0.010)	-0.267 (0.001)	-0.184 (0.020)	0.045 (0.570)	-0.082 (0.304)	0.224 (0.004)	-0.234 (0.003)	1			
REG	0.026 (0.748)	-0.050 (0.529)	-0.046 (0.563)	0.009 (0.910)	-0.144 (0.069)	0.038 (0.635)	0.007 (0.932)	-0.037 (0.639)	0.016 (0.842)	-0.104 (0.190)	1		
CAR	-0.080 (0.316)	-0.226 (0.004)	-0.250 (0.001)	0.074 (0.351)	0.007 (0.926)	-0.054 (0.501)	-0.056 (0.485)	-0.195 (0.013)	0.215 (0.006)	-0.254 (0.001)	0.004 (0.965)	1	
RET	-0.113 (0.156)	-0.221 (0.005)	-0.259 (0.001)	0.086 (0.278)	0.020 (0.798)	-0.071 (0.373)	-0.053 (0.506)	-0.198 (0.012)	0.225 (0.004)	-0.247 (0.002)	0.007 (0.934)	0.993 (0.000)	1

days. The mean number of modifications for a sample company on Wikipedia is 8.19 in one quarter, and the maximum number is 129. The mean number of news articles about a sample company in one quarter is 15.28, and the maximum is 75. We log-transform these variables because they are skewed.

Both Wikipedia modifications (WikiMOD) and news coverage (NEWS) are positively correlated with firm size (MV), suggesting that larger firms receive more media coverage. Firm size is negatively correlated with earnings variability (VAR) and analyst dispersion (DISPERSION), suggesting that larger firms have less uncertainty in earnings and may release more information to analysts (Kothari et al. 2002; Lang and Lundholm 1996). These correlations together may explain why WikiMOD is negatively correlated with VAR and DISPERSION.

Disclosure lag is negatively correlated with WikiMOD and NEWS, suggesting that information arrivals may result in

earlier disclosure. Given the positive correlation between WikiMOD and NEWS, however, this univariate analysis cannot tell us whether LAG is attributable to information aggregation or news arrivals per se, or both. LAG is also negatively correlated with firm size, because large firms are more exposed to litigation risks than small firms (Kaszniak and Lev 1995). Hence, large firms are more likely to disclose earlier to immunize themselves from litigation. LAG is positively correlated with analyst dispersion, suggesting that announcements occur later, in the presence of higher information uncertainty in the market.

Regarding analyst forecasts, both analyst bias and analyst dispersion are negatively correlated with firm size and positively correlated with earnings variability and the high-tech dummy. It could be the case that more information is available for larger firms, making analysts' forecasting relatively easier (Lang and Lundholm 1996). In addition, high-tech firms feature greater earnings variability, which may make it more difficult for analysts to predict future EPS (Dewan et al.

2007). The correlation between BIAS and DISPERSION is positive, suggesting that analysts' forecasts are more accurate when they agree more with each other. Overall, the correlations are consistent with observations in previous research.

## Results

### Results about Management Disclosure

To test H1 and H2, Table 3 reports regression results for model (1). The software package used is R and the function is `coxph`. From columns (1) through (5), Table 3 presents results when explanatory variables are added step by step. The purpose is to compare different model specifications to check the robustness of the results. We mean-center variables involved in interactions to ease the interpretation of results.

We discuss the results in turn below.

#### Analyst Forecasts (DISPERSION and BIAS)

We first examine the impact of analyst dispersion and bias. In column (1) of Table 3, the coefficients on DISPERSION and BIAS represent their *average* (or *constant*) effects across all values of moderators (Aiken and West 1991). In columns (2) through (5), as we add moderators, the coefficients on DISPERSION and BIAS change in magnitude and significance. This is not surprising because in columns (2) through (5), the coefficients on DISPERSION and BIAS represent their impact *conditioned* on the mean values of the moderators (Aiken and West 1991).

As show in column (1) of Table 3, the positive sign of DISPERSION indicates that its average effect is to increase disclosure lag. This confirms the notion that when the external information environment regarding firm EPS is highly dispersed, managers tend to delay disclosure. The negative sign of BIAS indicates that its average effect is to decrease disclosure lag. This supports the notion that managers are more likely to disclose unfavorable information when analysts are far off in estimating firm earnings.

#### Information Aggregation on Wikipedia (WikiMOD)

Regression results in Table 3 support our hypotheses about information aggregation on Wikipedia (H1 and H2). As seen in Table 3, the results for WikiMOD are consistent across columns (2) through (5). Below we use column (2) to present the results.

**H1, supported:** The average effect of DISPERSION in column (1) suggests that managers tend to withhold adverse information if they enjoy an information advantage. The interaction with Wikipedia modification ( $-0.1321$ ,  $p < 0.05$ , column (2) of Table 3), however, moderates the effect. The interaction's negative sign suggests that, in the presence of more Wikipedia modifications, the extent to which managers leverage their information advantage is weakened. This supports our hypothesis that WikiMOD may mitigate the impact of DISPERSION on disclosure lag, such that the positive relationship between DISPERSION and disclosure lag is less conspicuous in the presence of higher WikiMOD.

**H2, supported:** The average effect of BIAS in column (1) suggests that when analysts are too optimistic in estimating earnings, managers typically shorten the lag to offer information more promptly. The significant interaction between WikiMOD and BIAS ( $0.0623$ ,  $p < 0.05$ , column (2) of Table 3), however, moderates the effect. If the reason behind an earlier release of bad news is managers' concern about large stock-price declines on official announcement dates, then Wikipedia modifications may play the role of releasing information to the public earlier, thereby alleviating that concern. As such, when there are more Wikipedia modifications, managers are not as worried as before. The positive sign on WikiMOD\*BIAS supports our hypothesis that WikiMOD may mitigate the impact of BIAS on disclosure lag, such that the negative relationship between BIAS and disclosure lag is less severe in the presence of higher WikiMOD.

#### Number of News Articles and News Content

As shown in Table 3, the coefficients on NEGATIVE are negative, suggesting that when there are more negative words about a company, managers tend to disclose earlier. This is consistent with our expectation and suggests a plausible "backfire" effect associated with NEGATIVE. Managers in our research context face forthcoming bad news given an upward market bias introduced by analysts. If investors follow analysts first and realize analyst bias later (on the official announcement date), then the inconsistency between market expectation and NEGATIVE would lead investors to suspect that managers had withheld unfavorable information. The inconsistency would backfire, exposing managers to risks resulting from negative earnings surprises.

The interaction between NEGATIVE and BIAS is negative as expected, although the significance level is weak. The interaction between NEGATIVE and DISPERSION is significant and positive, different than our expectation. The positive interaction suggests that NEGATIVE's effect of shortening disclosure lag would be salient when DISPERSION is low.



**Table 3. Wikipedia and Management Disclosure (H1 and H2) (Regression specification is based on model (1) in text. Variable definitions are in Table 1.)**

	Analysts	Aggregation via Wikipedia	Number of News Articles	Content of News (Positive & Negative Words)	
	(1)	(2)	(3)	(4)	(5)
<b>Theoretical Variables</b>					
Wikipedia Modifications ( <i>WikiMOD</i> )		-0.1350** (0.0747)	-0.1048* (0.0744)	-0.1255** (0.0731)	-0.1206* (0.0737)
<b><i>WikiMOD*DISPERSION</i></b>		<b>-0.1321** (0.0621)</b>	<b>-0.1495*** (0.0580)</b>	<b>-0.3480*** (0.1005)</b>	<b>-0.3473*** (0.1308)</b>
<b><i>WikiMOD*BIAS</i></b>		<b>0.0623** (0.0148)</b>	<b>0.0672*** (0.0128)</b>	<b>0.1036*** (0.0227)</b>	<b>0.0990*** (0.0408)</b>
Analyst Dispersion ( <i>DISPERSION</i> )	0.1732** (0.1009)	0.1395** (0.0464)	0.1711** (0.0827)	-0.0724 (0.1416)	-0.0508 (0.1890)
Analyst Bias ( <i>BIAS</i> )	-0.0349* (0.0261)	-0.0378** (0.0157)	-0.0322** (0.0168)	0.0121 (0.0285)	0.0091 (0.0460)
<b>Control Variables</b>					
Number of News Articles ( <i>NEWS</i> )			-0.0995* (0.0675)	-0.0987* (0.0689)	-0.0947* (0.0702)
<i>NEWS*DISPERSION</i>			0.0656 (0.0620)	0.2613** (0.1513)	0.2476 (0.1960)
<i>NEWS*BIAS</i>			-0.0113 (0.0134)	-0.0562** (0.0302)	-0.0531 (0.0469)
Negative Words ( <i>NEGATIVE</i> )				-0.0804** (0.0487)	-0.0929* (0.0650)
<i>NEGATIVE*DISPERSION</i>				0.2862*** (0.1109)	0.2661* (0.1748)
<i>NEGATIVE*BIAS</i>				-0.0667* (0.0480)	-0.0519 (0.0800)
Positive Words ( <i>POSITIVE</i> )					-0.0571 (0.0545)
<i>POSITIVE*DISPERSION</i>					-0.0201 (0.1730)
<i>POSITIVE*BIAS</i>					-0.0052 (0.0779)
Earnings Variability ( <i>VAR</i> )	-0.1413*** (0.0278)	-0.1240*** (0.0271)	-0.1099*** (0.0295)	-0.0920*** (0.0329)	-0.0922*** (0.0316)
Market Value ( <i>MV</i> )	-0.2973*** (0.0828)	-0.2536*** (0.0860)	-0.2325*** (0.0878)	-0.2295*** (0.0843)	-0.2489*** (0.0913)
High-tech ( <i>HIGHTECH</i> )	0.2423 (0.1735)	0.2129 (0.1654)	0.1387 (0.1780)	0.1785 (0.1746)	0.1664 (0.1935)
Regulation ( <i>REG</i> )	0.0420 (0.2075)	-0.1332 (0.2308)	-0.0930 (0.2625)	-0.1137 (0.2699)	-0.0957 (0.2587)
Quarter 1 Dummy ( <i>Q1</i> )	-0.4517*** (0.1814)	-0.5662*** (0.2111)	-0.5431*** (0.2101)	-0.4925** (0.2140)	-0.4338** (0.2211)
Quarter 2 Dummy ( <i>Q2</i> )	-0.0826 (0.1958)	-0.1424 (0.2007)	-0.1405 (0.2071)	-0.0869 (0.2116)	-0.1051 (0.2069)
Quarter 3 Dummy ( <i>Q3</i> )	-0.4644** (0.2132)	-0.5340*** (0.2064)	-0.5413*** (0.2054)	-0.5587*** (0.2048)	-0.4858** (0.2251)
Observations	161	161	161	161	161
Likelihood Ratio Test	p = 0.001	p < 0.001	p < 0.001	p = 0.001	p = 0.003
Pseudo R-Squared	0.158	0.203	0.215	0.230	0.235

**Note:** Robust estimates of standard errors are reported in parentheses. Significance levels are one-tailed for directional predictions and two-tailed otherwise. \*p < 0.10; \*\*p < 0.05; \*\*\*p < 0.01. The pseudo R<sup>2</sup> refers to Nagelkerke's (1991) R<sup>2</sup>.

1 This implies that managers may perceive the risk associated  
 2 with negative media content (i.e., the threat of backfire as  
 3 mentioned above) to increase as DISPERSION decreases.  
 4 When analysts are consistent with each other (i.e., low  
 5 DISPERSION), their forecasts may become more convincing  
 6 to investors. This would expose managers to a greater threat  
 7 of backfire; consequently, managers may disclose earlier to  
 8 minimize damage.

9  
 10 The impacts of NEWS are similar to those of NEGATIVE.  
 11 The impacts of POSITIVE are not significant. These findings  
 12 are consistent with prior research suggesting that readers are  
 13 more affected by negative than positive news content (Tetlock  
 14 et al. 2008).

15  
 16 Overall, our results seem to indicate that, unlike the salient  
 17 role played by WikiMOD, some variables capturing media  
 18 coverage turn out to be not significant. Similar to our result,  
 19 Frankel and Li (2004) find that media coverage does not seem  
 20 to improve investors' information environment. A possible  
 21 explanation offered by the literature is media bias. The litera-  
 22 ture on media bias suggests that media are often biased for  
 23 both demand- and supply-side reasons (Knight and Chiang  
 24 2008). On the demand side, consumers may prefer to con-  
 25 sume information that confirms their prior beliefs; profit-  
 26 maximizing publishers thus have incentives to bias their  
 27 reports (Gentzkow and Shapiro 2006; Mullainathan and  
 28 Shleifer 2005). On the supply side, individual journalists and  
 29 financial analysts may also bias reports to reflect their own  
 30 views or achieve their own financial objectives (Baron 2006;  
 31 Reuter and Zitzewitz 2006). As a result, financial reports in  
 32 the media often slant information through "selective omission,  
 33 choice of words, and varying credibility ascribed to the  
 34 primary source" (Gentzkow and Shapiro 2006, p. 281). Wiki-  
 35 pedia, owing to its NPOV policy and because contributions on  
 36 Wikipedia follow a democratic and collaborative model, is  
 37 less susceptible to media bias. Prior studies establish that this  
 38 kind of "wisdom-of-crowds" production model tends to gen-  
 39 erate facts (Kittur and Kraut 2008; Swarts 2009). If this is the  
 40 case, one may expect that Wikipedia, instead of media, plays  
 41 a salient role in improving the market's information environ-  
 42 ment. Our results offer supportive evidence, although we  
 43 cannot completely rule out the possibility of the existence of  
 44 bias on Wikipedia.

### 45 **Results about Investor Reaction**

46  
 47 To test H3, Table 4 presents the regression results for model  
 48 (2). Columns (1) and (2) report regressions using CAR over  
 49 a five-day time window to measure investors' reaction;  
 50 columns (3) and (4) examine CAR over a three-day time win-

dow, for a robustness check; and columns (5) through (8)  
 examine market-adjusted returns (RET) based on a five-day  
 time window and a three-day time window. These columns  
 show highly consistent results. Below, we use columns (1)  
 and (2) to discuss our findings.

Column (1) of Table 4 establishes the baseline result. Since  
 our sample includes only bad news, the market reaction  
 should be negative. As expected, the more optimistic the  
 analysts, the more disappointed are the investors (i.e., a  
 negative coefficient on BIAS).

**H3, supported:** In column (2), WikiMOD\*BIAS has a posi-  
 tive sign, suggesting that WikiMOD moderates investor reac-  
 tion to bad news. Had there existed a medium that disclosed  
 information to the public, this medium would have offset the  
 surprise caused by BIAS. Our results suggest that WikiMOD  
 seems to play such a role, in support of H3.

Regarding controls, firm size plays a positive moderating role  
 as expected. NEWS and NEGATIVE play a negative moderat-  
 ing role. These results suggest that (1) more news coverage  
 exacerbates the problem of overly optimistic analyst esti-  
 mates, and (2) when there is an upward analyst bias, investors  
 are more disappointed if traditional media used many negative  
 words to describe that firm. The first effect seems to suggest  
 that more news coverage may merely magnify the effect of  
 analyst bias. Or, investors are generally affected by negative  
 instead of positive words, so NEWS and NEGATIVE play  
 similar roles. Judging from the sign, we can at least argue  
 that more news coverage does not offer more information to  
 reduce the impact of analyst bias or improve the information  
 environment (Frankel and Li 2004). The second effect is  
 consistent with the backfire story discussed above. Given the  
 negative coefficient on BIAS, and the nonsignificant coeffi-  
 cient on NEGATIVE, it is plausible to argue that investors  
 tend to "trust" analysts more than newspapers. That is, inves-  
 tors seem to follow analysts' upward-biased recommendation,  
 even when newspapers use many negative words to describe  
 a company. When analysts are wrong, the inconsistency  
 between news and analysts' optimistic estimates would back-  
 fire. This may help explain why the interaction between  
 NEGATIVE and BIAS is significantly negative.

### **Additional Analysis**

**Possible Endogeneity of WikiMOD:** As with other empirical  
 studies, we cannot control for *all* possible information sources  
 to completely rule out the existence of alternative channels  
 through which managers and investors get informed. Endo-  
 geneity concerns are legitimate in this context for two rea ons.

**Table 4. Investor Reaction to Disclosure (H3) (Regression specification is based on model (2) in text. Variable definitions are in Table 1.)**

	Cumulative Abnormal Returns: [-2,2] Window		Cumulative Abnormal Returns: [-1,1] Window		Market-adjusted Returns: [-2,2] Window		Market-adjusted Returns: [-1,1] Window	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Theoretical Variables</b>								
Analyst Bias (BIAS)	-0.0085*** (0.0019)	-0.0827*** (0.0321)	-0.0053*** (0.0022)	-0.0557** (0.0332)	-0.0088*** (0.0019)	-0.0808** (0.0367)	-0.0055*** (0.0022)	-0.0552* (0.0357)
WikiMOD		-0.0084 (0.0099)		-0.0087 (0.0102)		-0.0074 (0.0099)		-0.0075 (0.0103)
<b>WikiMOD*BIAS</b>		<b>0.0035*** (0.0015)</b>		<b>0.0033** (0.0018)</b>		<b>0.0035** (0.0015)</b>		<b>0.0033** (0.0019)</b>
<b>Control Variables</b>								
Market Value (MV)		0.0057 (0.0096)		0.0133 (0.0099)		0.0061 (0.0099)		0.0134 (0.0100)
MV*BIAS		0.0046*** (0.0017)		0.0034** (0.0019)		0.0045*** (0.0019)		0.0035** (0.0020)
NEWS		0.0075 (0.0088)		0.0034 (0.0086)		0.0087 (0.0088)		0.0045 (0.0087)
NEWS*BIAS		-0.0039*** (0.0013)		-0.0056*** (0.0015)		-0.0042*** (0.0015)		-0.0059*** (0.0015)
NEGATIVE		0.0025 (0.0045)		0.0022 (0.0035)		0.0031 (0.0044)		0.0025 (0.0034)
NEGATIVE*BIAS		-0.0100*** (0.0042)		-0.0104** (0.0036)		-0.0109** (0.0047)		-0.0109*** (0.0038)
POSITIVE		-0.0016 (0.0036)		-0.0022 (0.0019)		-0.0029 (0.0036)		-0.0033* (0.0020)
POSITIVE*BIAS		0.0000 (0.0033)		-0.0015 (0.0034)		0.0008 (0.0037)		-0.0007 (0.0037)
Observations	161	161	161	161	161	161	161	161
R-Squared	0.0752	0.1498	0.0307	0.1323	0.0789	0.1574	0.0327	0.1383

**Note:** Robust estimates of standard errors are reported in parentheses. Significance levels are one-tailed for directional predictions and two-tailed otherwise. \*p < 0.10; \*\*p < 0.05; \*\*\*p < 0.01.

First, it is possible that managers may release information through Wikipedia themselves. If a manager decides to release information through Wikipedia, and if the decision to edit the entry correlates with the decision about disclosure lag (e.g., because of an incentive to release information to the public), then the manager’s self-editing may confound Wikipedia’s effect.

Second, if there exists an alternative information channel that influences both Wikipedia modifications and disclosure lags, then the identified effect of WikiMOD cannot be attributed to Wikipedia. More broadly, if there are some omitted factors that affect disclosure lags and are correlated with Wikipedia modifications, endogeneity is a concern. We address these endogeneity issues by conducting an instrumental variable (IV) estimation with two possible IVs. Our results suggest that these concerns are not serious. Appendix D reports the details of our IV estimation.

**An Alternative Explanation:**<sup>26</sup> We need to control for the possible impact of firm visibility. It is an alternative explanation for the impact of WikiMOD, in that firm visibility is correlated with WikiMOD and may influence management disclosure. We reviewed prior studies on firm visibility and found that they used three sets of proxy variables for firm visibility. The first set refers to fundamental firm characteristics that are associated with firm visibility, including firm size (e.g., market value), firm profitability (e.g., ROA), firm age, and advertising expenditure. Firms with a larger size and greater profitability and older firms may be associated with higher levels of visibility (Bushee and Miller 2012, Grullon et al. 2004), and advertising may also help increase firm visibility (Grullon et al. 2004). The second set refers to media coverage in that the amount of news reports tends to covary

<sup>26</sup>We thank an anonymous reviewer for suggesting this important test.

1 with firm visibility (Bushee and Miller 2012). The third set  
 2 concerns firm visibility in the capital market (Baker et al.  
 3 1999; Bushee and Miller 2012; Grullon et al. 2004) and  
 4 suggests that firm visibility may be positively related to  
 5 NYSE listing (a dummy variable indicating firms listed at  
 6 NYSE), institutional ownership (the percentage of a firm's  
 7 common stock held by institutions), and analyst following  
 8 (the number of analysts following a firm).  
 9

10 In addition to the traditional measures of firm visibility, we  
 11 seek to control for online firm visibility, given that the interest  
 12 of our research is the effect of an online information channel.  
 13 In a very recent paper, Da et al. (2011) use Google's Search  
 14 Volume Index (SVI) of company names as a proxy for inves-  
 15 tor attention. We collect Google SVI data from Google  
 16 Insights.<sup>27</sup> SVI for a search term is the number of searches for  
 17 that term scaled by its time-series average. To make search  
 18 volumes of different companies comparable, we obtain all  
 19 firm SVIs relative to the generic word "cotton," which  
 20 remains stable throughout the observation period. Figure 2  
 21 gives an example of how the relative search volume for  
 22 "Dell" is obtained. The blue (lower) line is the search volume  
 23 for "cotton." The red (upper) line is the search volume for  
 24 "Dell." Google reports relative measures of the two search  
 25 volume indices. Throughout the observation period, the  
 26 search volume for cotton is normalized to 1. Some company  
 27 names, such as Palm and Gap, may have alternative meanings  
 28 that are not directly related to the respective companies. We  
 29 manually go through our list and create an indicator for such  
 30 companies. When reporting our results, we include all such  
 31 companies to avoid a subjectivity bias. The results remain  
 32 qualitatively unchanged after removing such companies from  
 33 our sample.  
 34

35 Appendix E presents the results. For ease of comparison,  
 36 Column (1) shows the base model (i.e., Column (5) in  
 37 Table 3). Column (2) includes all of the traditional controls  
 38 for firm visibility. Column (3) further includes the control for  
 39 Google SVI. Appendix E conveys two key messages. First,  
 40 firm visibility generally plays a role in leading firms to  
 41 disclose earlier, as evident in the significant and negative  
 42 coefficients on firm size, NYSE listing, analyst following, and  
 43 firm profitability. Second, importantly, we see qualitatively  
 44 unchanged effects of WikiMOD, after incorporating the  
 45 various controls for firm visibility.

<sup>27</sup><http://www.google.com/insights/search/>. For more information about how the indices were constructed, please refer to Google's help documents: <http://support.google.com/insights/>. Similar to Da et al. (2011), we search for both the company names and their stock tickers. The results are highly consistent.

In Appendix F, we examine the economic significance of Wikipedia modifications. We show that information aggregation on Wikipedia has an economically meaningful impact on market reaction. Appendix G shows that our results are robust to alternative samples (e.g., excluding firms with very low and very high values of WikiMOD, removing modifications that are involved in edit wars), and to alternative measures (e.g., using the number of words added to proxy for information aggregation on Wikipedia).

## Concluding Remarks

### Major Findings

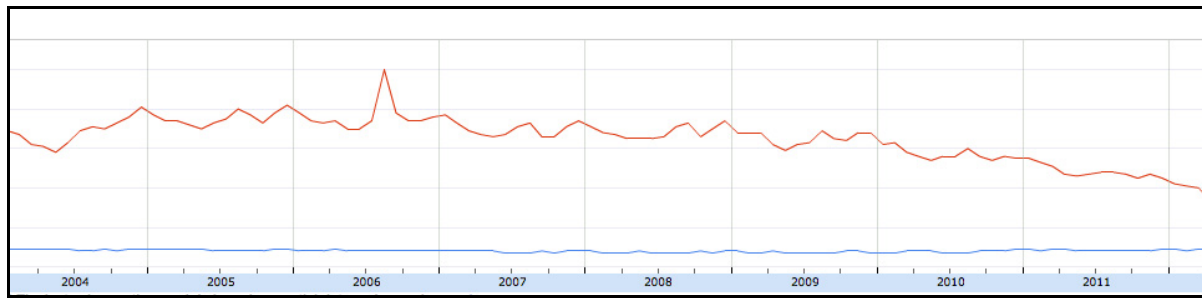
In this paper, we explore the question of whether Wikipedia improves the information environment for financial market investors, and if so, how public-firm managers change their voluntary disclosure behavior concerning bad news when there are variations in Wikipedia coverage. Our analysis is based on a unique data set collected from financial records of public firms, management-disclosure records, news articles related to these firms, and the modification history of firm entries on Wikipedia. The following new findings add to the existing literature.

First, we find that information aggregation on Wikipedia about public firms can moderate the timing of management disclosure of earnings disappointments. The timing of management disclosure is a function of the information environment, as described by the characteristics of analyst forecasts, a finding consistent with the disclosure literature. Although managers generally tend to delay disclosure of bad news when analyst forecasts are highly dispersed, the delay is shortened by Wikipedia's information aggregation, suggesting that Wikipedia weakens information asymmetry between managers and investors.

Second, although the literature points out that when facing high analyst bias, managers tend to release bad news early to avoid various risks, this study finds that information aggregation on Wikipedia helps alleviate managers' concerns, thus making management's disclosure timing less dependent on analyst bias.

Finally, by examining how investors react to management disclosure of bad news, we find that investors' negative reaction to bad news is moderated by Wikipedia modifications. Although Wikipedia may not be the only means by which investors can enjoy the benefits of social media, our results suggest a market adjustment associated with information aggregation on Wikipedia before a firm announces bad news.

1



2 **Note:** The blue (lower) line is the search volume for "cotton"; it remains relatively stable over the observation period. The red (upper) line  
 3 is the search volume for "Dell." Google reports relative measures of the two search volume indices. Throughout the observation period,  
 4 the search volume for cotton is normalized to 1.

5 **Figure 2. Google Search Volume**

## 6 **Theoretical Implications**

7

8 This paper makes several theoretical contributions. Most  
 9 prior studies of Wikipedia focus on users' contribution  
 10 behavior (e.g., Greenstein and Zhu 2012a; Kittur and Kraut  
 11 2008, 2010; Thom-Santelli et al. 2009; Zhang and Zhu 2011).  
 12 In many ways, these studies have improved our understanding  
 13 of how individuals may be motivated to contribute to Wiki-  
 14 pedia. Without establishing the value of the outcomes of such  
 15 collaborations, however, research on contribution incentives  
 16 is limited. This study fills such a gap and examines how  
 17 Wikipedia makes an impact to the real world. To this end, we  
 18 document IT's capability of aggregating information (Ben-  
 19 basat and Zmud 2003) and analyze the impact of an IT artifact  
 20 (Wikipedia) directly (Orlikowski and Iacono 2001; Venkatesh  
 21 et al. 2007).

22

23 Our finding suggests that the informational impact of social  
 24 media such as Wikipedia can be derived from social inter-  
 25 actions and collaborative efforts. This study supports a shift  
 26 to conceptualizing users as social actors rather than indi-  
 27 vidualistic entities (Lamb and Kling 2003). With such a shift,  
 28 our study goes beyond the view of Wikipedia contributors as  
 29 disjointed individuals, with each following his or her own  
 30 agenda. Rather, we promote a theoretical anchor for iden-  
 31 tifying the value of information aggregation arising from  
 32 collaborative efforts.

33

34 In building the theory, this paper taps into the accounting  
 35 literature of management disclosure. This not only introduces  
 36 a new lens to the information systems literature but also  
 37 demonstrates the complementarity of information systems  
 38 research with that of other related fields. The increasing

reliance of business on IT opens a door for information sys-  
 tems research to contribute to these other business disciplines.  
 As this study shows, the analysis of the impact of Wikipedia  
 sheds light on how managers and investors obtain and use  
 information in the financial market.

## **Managerial Implications**

This study also has implications for investors, managers, and  
 policy makers in the financial market. Importantly, different  
 from news stories, which fade away quickly, Wikipedia's  
 aggregating and accumulating information keeps a good  
 record of a company's important events. This suggests that  
 Wikipedia's effects on investors, managers, and regulators  
 can be long-lasting.

Our results suggest that investors can benefit greatly from the  
 value of information aggregation offered by services such as  
 Wikipedia. This type of information aggregation stands in  
 stark contrast to traditional ways for investors to get informed.  
 In the traditional model of information acquisition, individual  
 investors suffer a significant information disadvantage. The  
 channel to obtain information is very limited and both news-  
 papers and analysts can introduce significant biases. Unlike  
 these channels, the decentralized information aggregation on  
 Wikipedia seems to be offering a new channel that is either  
 free of these biases or resistant to them. Interestingly, some  
 individual investors have already started to build an infor-  
 mation aggregation portal that utilizes the wiki technology.  
 This new service is called "Wikinvest"<sup>28</sup> On their "About Us"

<sup>28</sup>The website is <http://www.wikinvest.com>.

1 page, they write, “We’re regular, everyday investors who are  
2 sick of the level of innovation at the major finance portals.”  
3 One major difference between Wikinvest and traditional  
4 financial information websites is that Wikinvest relies heavily  
5 on user-generated content, and it extracts the value of infor-  
6 mation aggregation.

7  
8 For managers, our study suggests that their information  
9 advantage is increasingly compromised with the advent of  
10 information aggregation channels like Wikipedia. In the pre-  
11 Wikipedia era, they could utilize their private information and  
12 manipulate what and when the market could learn about their  
13 firms. With Wikipedia and other types of social-media chan-  
14 nels, it becomes increasingly difficult to maintain the same  
15 level of control over information. It may be necessary for  
16 managers to change their mindset and embrace the benefits  
17 brought about by new media. One of our findings suggests  
18 that Wikipedia can alleviate their litigation concerns when  
19 analyst bias is high. Our view is that the information asym-  
20 metry between managers and investors is not necessarily a  
21 zero-sum game. If managers can recognize the unavoidable  
22 impact of IT, and make good use of it, they will be able to  
23 better capture opportunities and resolve challenges.

24  
25 Regulators such as the SEC should welcome the improved  
26 information transparency introduced by Wikipedia and other  
27 social-media channels. To restore investors’ confidence in  
28 the market after a series of corporate scandals, the Sarbanes-  
29 Oxley Act (SOX) was enacted in 2002. SOX aims to reform  
30 public company accounting and protect investors, and one  
31 major objective is to enhance corporate transparency (Coates  
32 2007). The information transparency achieved through infor-  
33 mation aggregation on Wikipedia offers a complementary  
34 mechanism to achieve the same goals as those of regulators.  
35 This paper examines information aggregation on Wikipedia  
36 for only public companies, and thus it is important to note that  
37 many private companies also have Wikipedia pages. If Wiki-  
38 pedia can improve the information transparency of these  
39 privately held companies, given that SOX does not apply to  
40 them, then our results suggest that technology-enabled infor-  
41 mation aggregation by individuals plays a broader role than  
42 the legal mechanism in enhancing companies’ information  
43 environment.

#### 44 **Limitations and Future Research**

45  
46 This paper has several limitations that may need future work  
47 to address. First, as explained above, we focus on only  
48 Wikipedia and do not capture the full range of social-media  
49 channels (e.g., blogs, Twitter, Facebook, etc.). Although  
50 other social-media channels can also aggregate information,

the mechanisms through which these other channels affect  
management information disclosure may be different. Blogs,  
for example, are typically managed in a centralized manner,  
such that one blog can have only one or a few contributing  
bloggers (Sun and Zhu 2012). Only some frequent bloggers  
can attract the public’s attention, and their potential influence  
is limited to loyal followers of these blogs. Although it is  
easy to find some information about almost all public  
companies on Wikipedia, blogging information of these  
companies is scattered and may be difficult to find. Twitter  
is different from Wikipedia in that Twitter’s social influence  
follows a directional path. In addition, similar to traditional  
news, information about specific companies on Twitter has  
short-lived popularity. On Facebook, network ties are based  
on friends, and the tie strength is much stronger than the  
poster–reader relation on Wikipedia. As a result, the  
information-exchange mechanism is different. As a result of  
the structural differences between Wikipedia and other social  
media platforms, whether other social media channels affect  
management disclosure in a similar way needs careful  
examination before our results can be generalized. Our pre-  
diction of such effects is rather optimistic. If the unmeasured  
information aggregations were to be correlated with what we  
have incorporated in our analysis, then our estimates would  
partially reflect this broader range of information over social  
media. This is likely to be true, because information can  
diffuse across social-media channels (Watson-Manheim and  
Bélanger 2007). A future study could deepen our under-  
standing by studying other types of social-media channels.

Second, Wikipedia may play other roles in the financial  
market. This study merely touches the tip of the iceberg. We  
employ a narrow lens to examine managers’ behavior of  
information disclosure. There are other significant issues,  
such as investor sentiments, insider trading, changes in  
liquidity, and stock-price volatility associated with social-  
media coverage. These would be fruitful avenues for future  
research.

Third, this study adopts a positivist perspective to infer the  
relationship between Wikipedia and the financial market’s  
information environment. Our results could be complemented  
by case studies, surveys, or ethnographic methods. For  
instance, it remains an assumption that managers know that  
information aggregation over Wikipedia provides information  
to investors. Future research can conduct a survey to ask  
managers whether they are aware of information aggregation  
over Wikipedia and how they perceive the extent to which  
investors get informed from that. While our results present  
evidence of Wikipedia’s role in the financial market, these  
alternative methods offer important insights about why and  
how such roles take place.

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43 133-148.

## About the Authors

**Sean Xin Xu** is an associate professor at School of Economics and Management, Tsinghua University. He received his Ph.D. from the University of California, Irvine. His current research interests include IT value under different corporate governance structures, post-adoptive behaviors of IT use, social media, enterprise systems and information risk, and IT use in supply chain contexts. His papers have been published in *Management Science*, *MIS Quarterly*, *Information Systems Research*, *Journal of MIS*, *Strategic Management Journal*, *European Journal of Information Systems*, and *International Journal of Technology Management*. He serves on the editorial board of *Information Systems Research* as an associate editor, and that of *MIS Quarterly* as a guest associate editor. He was nominated for the Best Paper Award at the International Conference on Information Systems (ICIS) in 2009. He won the Vernon Zimmerman Best Paper Award at the Asian-Pacific Conference on International Accounting Issues in 2007, two Best Paper Awards at ICIS in 2002 and 2003, and a Best Paper Award (International Track) at the 2004 Americas' Conference on Information Systems.

**Xiaoquan (Michael) Zhang** is an assistant professor of Information Systems, Business Statistics, and Operations Management at the Hong Kong University of Science and Technology. He holds a Ph.D. in Management from MIT Sloan School of Management, an M.Sc. in Management, a BE in Computer Science, and a BA in English from Tsinghua University. Before joining academia, he worked as a consultant for an investment bank, and as an international marketing manager for a high-tech company. He holds a U.S. patent, and started a social-network company. Michael's research interests are on issues related to creation, dissemination, and processing of information in business and management contexts. His works study pricing of information goods, online word-of-mouth, online advertising, incentives of creation in open source and open content projects, and use of information in financial markets. His research has appeared in *American Economic Review*, *Management Science*, *Journal of Marketing*, *MIS Quarterly*, *Journal of Management Information Systems*, *Decision Support Systems*, and *Journal of Interactive Marketing*. He currently serves as an associate editor for *Information Systems Research* and as a guest associate editor for *MIS Quarterly*, and is also on the editorial boards of *Production and Operations Management* and *Electronic Commerce Research and Applications*.