Finance Research Letters 31 (2019) 363–368

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

# Haze, investor attention and China's stock markets: Evidence from internet stock forum

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ARTICLE INFO

*Keywords:*
Investor attention
Haze
China's stock market
Internet stock forum

*Subject classification codes:*
G12
G14
Q53

ABSTRACT

This paper investigates the impact of haze on China's stock markets and the intermediary role of investor attention. We propose that haze attracts investor attention through direct physical and psychological experiences of haze, haze-related news and government regulations, and thereby affects stock markets through investor attention. Using novel data collected from a leading Internet stock forum in China, our empirical analysis reveals that: (1) the aggravation of haze, increase in the amount of haze-related news, and reinforcement of regulations lead investors to pay more attention to haze-related issues; (2) the increased investor attention on haze decreases stock market returns.

## 1. Introduction

Existing research has revealed the influence of environmental factors on stock markets (Saunders 1993; Hirshleifer and Shumway 2003; Kamstra et al., 2003; Chang et al., 2008; Levy and Yagil, 2011, 2013; to name just a few). In the context of China, haze has become the mostly concerned environmental issue and the synonym of air pollution. Li and Peng (2016); Zhang et al. (2017) and An et al. (2018) point out that haze has impact on China's stock markets. However, related research mainly focuses on the intermediary role of investor sentiment. Given the importance of investor attention in asset pricing and its close relation with investor sentiment, investor attention plays a non-negligible role in connecting haze with stock markets.

In this paper, we attempt to establish that haze influences investor attention and thereby impacts stock markets. The main difficulty remaining in studying investor attention is the problem of measurement. The proxy for investor attention generally contain irrelevant information and cannot directly reflect investor behavior and the content of attention. An et al. (2018) collect data from a Chinese stock forum (Xueqiu) and identify haze-related posts. However, the goal of this paper further proposes the challenge to identify the location of stock forum users because of the geographical limitation of haze's direct effect. We overcome the above limitations by collecting the data of haze-related posts from Eastmoney (China's dominant stock forum) to measure investor attention. Eastmoney allows forum users to send posts anonymously with their IP address, making it possible to identify the posts and thereby investor attention from a specific region.

Our contributions are threefold. First, we fill the gap in related literature by emphasizing the intermediary role of investor attention. Secondly, employing novel data collected from Internet stock forum, this paper constructs proxy for investor attention that

Yihao Zhang acknowledges the funding support from the National Natural Science Foundation of China (grant number 71672079).
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https://doi.org/10.1016/j.frl.2018.12.001
Received 28 March 2018; Accepted 5 December 2018
Available online 06 December 2018
1544-6123/ 

is able to reflect the content and geographical information of investor attention without irrelevant information. Last but not least, we suggest a new way to measure haze using visibility, the most easily perceived indicator of haze pollution.

## 2. Theoretical framework and hypothesis

### 2.1. Theoretical framework

The first channel through which haze influences investor attention is investor's direct physical and psychological experience. Medical research states that exposure to haze reduce people's desire for risk (Tomei et al., 2003; Rosati et al., 2011) and affects the ability of making rational choices (Coates and Herbert 2008). The growing national concern over haze may further cause psychological pressure and results in more attention over haze.

The second channel is through media reports. The Agenda Setting Theory in Communication proposes that media can guide public attention (McCombs and Shaw 1972). Considering that people in the Internet era are more easily exposed to news, frequent haze-related news is likely to drive people, including investors, to pay more attention to haze.

The third channel is government regulation. Policies and regulations may lead to resource reallocation, and the prospect of related industries and firms are influenced (Mulatu et al., 2010). It is noteworthy that China's stock market is recognized as policy-guided and investors are sensitive to policies. Therefore, policy and regulation drive investors to pay attention to related issues.

As for the influence of investor attention on stock markets, theoretical and empirical research has revealed the non-negligible role of investor attention on investor's behavior and asset prices (Peng and Xiong, 2006; Barber and Odean, 2008; Hirshleifer et al., 2008; Huddart et al., 2009; Yuan, 2015; just a few to name). This motivates us to fill the gap in related research.

### 2.2. Hypothesis

Based on foregoing analysis, we propose following hypothesis to empirically examine the relation between haze and investor attention:

**H1.** : Haze pollution has influence on investor attention.

**H1a.** : The aggravation of haze in certain region leads the local investors to pay more attention to haze.

**H1b.** : The increase in the amount of haze-related news reports leads investors to pay more attention to haze.

**H1c.** : The reinforcement of haze-related regulations leads investors to pay more attention to haze.

Existing research find that stock market returns and air pollution level are negatively correlated (Levy and Yagil 2011, 2013; Li and Peng 2016; Zhang et al., 2017). Following the literature, we hypothesize that:

**H2.** : Haze-related investor attention is negatively correlated with stock market returns.

## 3. Data and methodology

### 3.1. Data and sample

The sample starts from January 1st, 2013 to December 31st, 2015. Haze-related issues have not become a national concern until January 2013 when a severe haze pollution hit China. Because of the nation-wide ignorance of haze, it is biased to measure haze-related investor attention before 2013. Finally, due to the limited availability of visibility data, we choose the sample from January 1st, 2013 to December 31st, 2015.

Considering the geographic limitation of haze's direct influence, we select Beijing investors as our main research subjects when investigating the influence of haze on investor attention. Beijing is one of the most developed cities in China with a large amount of investors and enjoys the most extensive media and political resources. The weather condition also makes it appropriate to use visibility as the proxy for haze.

#### 3.1.1. Investor attention

Eastmoney is the leading Internet stock forum in China in terms of both the amount of users and effective browsing time. Based on Eastmoney, we use the daily total amount of posts containing “haze” in titles to measure investor attention. In particular, we identify the location of users by IP address and therefore are able to differentiate posts from Beijing investors.

#### 3.1.2. Haze

We use the daily visibility to measure haze pollution in Beijing. The most direct way for people to perceive haze is through visual experience so that visibility can characterize the physical and psychological experience of investors better than other proxies. Data are from the National Oceanic and Atmospheric Administration (NOAA).

*3.1.3. Media report*

Baidu is the dominant search engine in China. We use the daily Baidu Media Index of the keyword "haze" to measure media reports.

*3.1.4. Government regulation*

We use dummy variable to measure regulation. On September 10th, 2013, the state council of China enacted the Action Plan of Preventing and Controlling Air Pollution. The plan is considered as the most stringent haze-related regulation. We set the value of the dummy as 1 if the date is later than September 10th, 2013 and 0 otherwise.

*3.1.5. Returns*

The return on a stock index is $Ret_t = 100*\ln(\frac{Index_t}{Index_{t-1}})$, where $Index_t$ is the close price of stock index of day t. Stock index data are from Wind database.

*3.2. Empirical methodology*

Due to the geographical limitation of haze's direct influence, we firstly examine the influence of haze on investor attention in Beijing. Then we use nation-wide data to study the overall influence of investor attention on stock market returns.

*3.2.1. The influence of haze on investor attention*

Firstly, we use Beijing data to examine haze's influence on investor attention and specific channels with following linear regression model:

$$\begin{aligned}\text{BJ\_Attention}_t &= \alpha + \beta_1 + \text{BJ\_Visibility}_t + \beta_2\text{News}_t + \beta_3\text{Policy}_t \\ &+ \beta_4\text{BJ\_Attention}_{t-1} + \beta_5\text{Y2014} + \beta_6\text{Y2015} + \varepsilon_t. \end{aligned} \quad (1)$$

Considering the possible persistence of investor attention, we introduce its lag as control variable together with year dummies. As hypothesized, $\beta_1$ is expected to be negative while $\beta_2$ and $\beta_3$ are expected to be positive.

*3.2.2. The influence of investor attention on stock market*

To further study the influence of investor attention on stock market, we use the following model:

$$\begin{aligned}\text{Ret}_t &= \alpha + \beta_1 \sum \text{Attention}_t + \beta_2\text{SAD}_{t+}\beta_3\text{Ret}_{t-1} + \beta_4\text{Vol}_{t-1} \\ &+ \beta_6 \sum \text{Day} + \beta_7 \sum \text{Month} + \beta_8 \sum \text{Year} + \varepsilon_t \end{aligned} \quad (2)$$

At this stage, we measure investor attention based on nation-wide data. We are going to examine the influence of haze-related investor attention on the stock returns of China's three main stock markets, namely the Shanghai Exchange Index, Shenzhen Exchange Index, and ChiNext Index. We use AIC and BIC to determine the lag of $\text{Attention}_t$ considering its possible persistence. If $\beta_1$ is significantly negative, then H2 is verified.

Other control variables include dummies for day and month due to calendar effect and the lag of returns and detrended trading volume (Gervais et al., 2001; Llorente et al., 2002). Year dummies are also included. Kamstra et al. (2003) propose that seasonal affective disorder (SAD) has effect on stock market. Zhang et al. (2017) verify the influence of SAD on China's stock market. In fact, SAD is calculated based on latitude. We introduce SADs of Beijing and Shanghai as control variables in that they are the two most developed cities in China with largest amount of investors. Besides, Beijing and Shanghai are the representative of northern and southern China respectively.

## 4. Empirical results

The data of investor attention are standardized, by subtracting off its mean and then divided by its standard deviation, for convenience of interpretation. So are visibility and news reports. All variables are stationary according to ADF test. Tables 1 and 2

**Table 1**
Description of variables.

| Variable | Description |
|---|---|
| $\text{Attention}_t$ | National investor attention |
| $_{\text{BJ\_Attentiont}}$ | Beijing investor attention |
| $\text{BJ\_Visibility}_t$ | Beijing visibility |
| $\text{News}_t$ | Baidu Media Index |
| $\text{Policy}_t$ | The dummy variable for regulation |
| $\text{Ret}_t$ | The return of stock index |
| $V_t$ | Detrended trading volume |
| $\text{SAD\_BJ}_t$ | The seasonal affective disorder of Beijing |
| $\text{SAD\_SH}_t$ | The seasonal affective disorder of Shanghai |

**Table 2**
Descriptive statistics.

| Variable | Mean | Median | Max | Min | Std |
|---|---|---|---|---|---|
| $Attention_t$ | 22.10 | 6 | 983 | 0 | 58.05 |
| $BJ\_Attention_t$ | 0.78 | 0 | 20 | 0 | 1.95 |
| $BJ\_Visibility_t$ | 3.87 | 3.70 | 11.70 | 0.50 | 1.71 |
| $News_t$ | 428.55 | 122 | 26,159 | 0 | 1208.37 |

### 4.1. The influence of haze on investor attention

Primarily, we want to examine whether haze has effect on investor attention and the specific channels. At this stage, we only use Beijing data. Table 3 gives the results.

We first do the baseline regression by only introducing Beijing visibility and control variables to test the existence of haze's impact on investor attention. Column (1) shows that the coefficient of Beijing visibility is significantly negative. Beijing investor attention increases by 0.19 standard deviations if Beijing visibility drops by 1 standard deviation. It shows that worse haze pollution in Beijing leads Beijing investors to pay more attention to haze-related topics. To show that the result is robust, we employ the wind speed of Beijing as the instrument variable for Beijing visibility and the 2SLS result is given in column (2). Furthermore, following Zhang et al. (2017), we substitute the key variable visibility with the daily average PM2.5 of Beijing. Results in column (2) and (3) show that our result is robust.

We theorize that the direct physical and psychological experience, haze-related news and environmental regulations altogether influence investors. To verify the specific channels, we regress model (1).

Column (4) shows the OLS result on standardized variables. After introducing news reports and the dummy of regulation, we can see that both of them have significantly positive influence on investor attention as expected. The increase of haze-related news reports and the reinforcement of regulations lead investors to pay more attention to haze. It supports that H1b and H1c hold. In addition, the coefficient of Beijing visibility is still significantly negative. Comparing the coefficients, we can see that the indirect channels, especially regulations, play the more important role in shaping investor attention than the direct physical and psychological experience of investor. It is consistent with the policy-guided characteristic of China's stock market. Government policies have great impact on stock market and investors therefore tend to be more sensitive to policy.

Column (5) and (6) aims to demonstrate that our result is robust. Considering that the values of a considerable fraction of investor attention are zero, we construct dummy variable based on original data and conduct Logit regression. The value of the dummy is 1 if there is at least one haze-related post from Beijing and 0 otherwise. In column (6) we again replace the key variable Beijing visibility with Beijing PM2.5 level. The results show that H1a, H1b and H1c still hold.

Based on above analysis, we conclude that hypothesis H1 holds.

### 4.2. The influence of investor attention on the stock market

At this stage, we use nation-wide data to measure investor attention. The results of model (2) are given in table 4. According to AIC and BIC, the lag of investor attention has no significant influence on stock markets.

As shown in table 4, we can see that investor attention has significantly negative effect on stock markets as expected, supporting hypothesis H2. A standard-deviation increase of haze-related investor attention leads Shanghai, Shenzhen, and ChiNext index returns to drop by 0.034%, 0.072%, and 0.053% respectively. Attention is a kind of scarce resource Kahneman, 1973). Reallocating attention affects investor's behavior. Moreover, exposure to haze pollution may reduces people's desire for risk and affects the ability of making rational choices. Attention to haze can augment these effects. However, we can find that investor attention has comparatively smaller impact on Shanghai stock exchange index in terms of both the value of coefficient and statistical significance compared with the results in column ((2) and (3). In fact, stocks listed in Shanghai Stock Exchange are mainly large-cap and state-owned enterprise

**Table 3**
The influence of haze on investor attention.

| | (1) OLS | (2) 2SLS | (3) OLS | (4) OLS | (5) Logit | (6) OLS |
|---|---|---|---|---|---|---|
| $BJ\_Visibility_t$ | −0.19 (0.046)*** | −1.70 (0.321)*** | | −0.15 (0.045)*** | −0.35 (0.119)*** | |
| $BJ\_PM2.5_t$ | | | 0.01 (0.002)*** | | | 0.01 (0.002)*** |
| $News_t$ | | | | 0.20 (0.075)*** | 3.64 (0.365)*** | 0.30 (0.011)*** |
| $Policy_t$ | | | | 0.43 (0.166)** | 0.97 (0.329)*** | 0.75 (0.238)*** |
| $BJ\_Attention_{t-1}$ | 0.56 (0.084)*** | 0.40 (0.078)*** | 0.48 (0.051)*** | 0.47 (0.092)*** | 0.23 (0.138)* | 0.41 (0.118)*** |
| Y2014 | −0.14 (0.078)* | −0.92 (0.378)** | −0.10 (0.125) | −0.40 (0.166)** | −0.56 (0.306)* | −0.54 (0.239)** |
| Y2015 | −0.11 (0.074) | −0.49 (0.383) | −0.10 (0.132) | −0.41 (0.167)** | −1.16 (0.325)*** | −0.58 (0.24) |
| C | 0.11 (0.06)* | 7.53 (1.359)*** | −0.10 (0.172) | −0.04 (0.055) | −0.98 (0.205)*** | −0.38 (0.15)** |
| $R^2$ | 0.31 | N/A | 0.34 | 0.35 | 0.34 | 0.38 |

Notes: Newey-West standard errors are reported in parenthesis. *, ** and *** denote significance level at 10%, 5% and 1% respectively.

**Table 4**
The influence of investor attention on stock market.

| | (1) Shanghai | (2) Shenzhen | (3) ChiNext |
|---|---|---|---|
| $Attention_t$ | −0.034 (0.02)* | −0.072 (0.022)*** | −0.053 (0.022)** |
| $SAD\_BJ_t$ | −1.14 (2.889) | −1.22 (2.82) | 2.167 (2.912) |
| $SAD\_SH_t$ | 1.27 (4.14) | 1.43 (4.051) | −2.985 (4.136) |
| $Ret_{t-1}$ | 0.105 (0.061)* | 0.109 (0.057)* | 0.092 (0.05)* |
| $V_{t-1}$ | 0.031 (0.036) | −0.004 (0.055) | −0.06 (0.048) |
| Day/Month/Year | Fixed | Fixed | Fixed |
| C | 0.54 (0.412) | 0.44 (0.43) | 0.137 (0.42) |
| $R^2$ | 0.04 | 0.04 | 0.04 |

Notes: Newey-West standard errors are reported in parenthesis. *, ** and *** denote significance level at 10%, 5% and 1% respectively.

**Table 5**
Robust Test of investor attention's influence on stock market.

| | (1) Shanghai | (2) Shenzhen | (3) ChiNext |
|---|---|---|---|
| Panle A: Excluding top 5% returns | | | |
| $Attention_t$ | −0.024 (0.019) | −0.071 (0.022)*** | −0.062 (0.02)*** |
| $SAD\_BJ_t$ | −0.365 (2.874) | −1.745 (2.902) | 0.622 (2.965) |
| $SAD\_SH_t$ | 0.297 (4.113) | 2.326 (4.158) | −0.713 (4.199) |
| $Ret_{t-1}$ | 0.037 (0.037) | 0.028 (0.033) | 0.02 (0.037) |
| $V_{t-1}$ | 0.08 (0.031)*** | 0.046 (0.047) | −0.086 (0.04)** |
| Day/Month/Year | Fixed | Fixed | Fixed |
| C | 0.349 (0.39) | 0.265 (0.395) | 0.111 (0.372) |
| $R^2$ | 0.05 | 0.05 | 0.06 |
| Panle B: Excluding top 10% returns | | | |
| $Attention_t$ | −0.032 (0.016)** | −0.062 (0.016)*** | −0.054 (0.02)*** |
| $SAD\_BJ_t$ | −0.874 (2.652) | 1.06 (2.45) | 1.438 (3.089) |
| $SAD\_SH_t$ | 1.153 (3.797) | −1.403 (3.497) | −1.846 (4.351) |
| $Ret_{t-1}$ | 0.039 (0.038) | −0.005 (0.033) | −0.006 (0.034) |
| $V_{t-1}$ | 0.053 (0.023)** | 0.056 (0.031)* | −0.047 (0.034) |
| Day/Month/Year | Fixed | Fixed | Fixed |
| C | 0.091 (0.354) | −0.242 (0.33) | 0.01 (0.303) |
| $R^2$ | 0.05 | 0.06 | 0.05 |

Notes: Newey-West standard errors are reported in parenthesis. *, ** and *** denote significance level at 10%, 5% and 1% respectively.

stocks and are not easily affected. Comparatively more private-owned and small-cap stocks are traded in Shenzhen Stock Exchange and ChiNext stock market. Thus Shenzhen and ChiNext stock markets are more prone to be affected by investor attention.

Barber and Odean (2008) suggest that extreme return is indicator of investor attention. To address the possible endogeneity, we give the results after excluding top 5% and 10% returns in table 5. We can see that hypothesis H2 still holds and the comparison between Shanghai and other two stock markets is consistent.

## 5. Conclusion

We adopt the number of haze-related posts as the proxy for investor attention, and investigate the relationship between haze and stock markets in the context of China. Focusing on investor attention, we firstly use Beijing data to study the influence of haze on investor attention. We find that the aggravation of haze, increase in the amount of haze-related news and reinforcement of environmental regulations lead investors to pay more attention to haze-related issues. Furthermore, using nation-wide data, we show that the increased investor attention over haze decreases stock market returns.

We contribute to the literature by showing the non-negligible role of investor attention in connecting haze with China's stock markets. To overcome the limit that existing proxy of investor attention cannot reflect the content and geographical information of investor attention, we construct proxy of investor attention based on novel data collected from Internet stock forum that allows us to identify the content and geographical information. Last but not least, we suggest that high-quality visibility data is an appropriate way to measure haze.

In this paper, we do not explain why investor attention has negative impact on stock returns. Future research may reveal the relationship between investor attention and stock market in a more specific manner and investigate the relationship between investor attention and sentiment.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2018.12.001.

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