

# Game model on the information competition in the environmental system

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**Abstract**—The paper presents a game model of informational competition between an activist and a listed company in the environmental system, and proposes that in an equilibrium, the listed company discloses favorable information and hides unfavorable information, whereas the activist exposes what the company hide after filtering the collected information, and the media reports what they have found after an investigation with the bias toward regulation. It supports the spirit of the actual legislation and provides insights about several formal channels for the NGO to participate in the regulation for the environmental system.

**Keywords**—Information disclosure, Activist's filter, Media report, Environmental system, Regulation

## I. INTRODUCTION

Environmental information disclosure made by governments, listed companies, and other non-government organizations (NGO), such as activists and media, has been put into practice in China. Thousands of journalists have joined the Chinese Millennium Environmental Walk, published more than 100, 000 pamphlets, and facilitated the solutions to various environmental problems since 1993. Since 1997, the listed company has been required to explain concern towards the environmental risks and regulation policies by the China Securities Regulatory Commission. There have been nearly 2000 non-governmental environmental protection organizations (activists) in China by 2000. Environmental information disclosure through the media has become more and more popular and has helped to motivate the environmental activist to put pressure on governmental decision-making. At present, the activist's access to environmental information has been implemented under the Environmental Impact Assessment Law, the Administrative Regulations on Disclosure of Government Affairs of the Competent Departments of Environmental Protection Administration, and Public Notices on Environmental Information [1]. Therefore, the disclosure of the listed company's environmental information and the filtration of the environmental activist play an important role in the solution of the environmental problems through the media.

Plenty of the research concerning the environmental problem, at the aspects of the system sciences, focused on the design for the specific environmental system. An integrated knowledge-based system for the hilly and sandy grassland ecosystems, planting species and optimal coverage of plants, was designed to manage land use [2, 3]. Besides, a systematic approach based on integrated information systems for

agricultural ecosystem management was proposed [4, 5]. This approach helps in generating managerial/policy alternatives to consultation with agricultural and ecological specialists for the agriculture and ecosystems management. Along with this, some others have developed an industrial network flow information integration model for supply chain management and intelligent transportation [6], an environmental health information system for public health service[7] and a flood decision support system[8].

However, little contributions have stressed the impacts of the competition between listed companies and activists on the media reports with the determination of regulatory constraints. In equilibrium, listed companies voluntarily disclose three types of information: to-be-processed complementary information preprocessed complementary information and substitute information [9]. A model of informational competition between an activist and a listed company was presented, where both the interest groups seek to influence consumer private consumption and public choices by advocating their positions through the media. The media can conduct investigative journalism to obtain its own information, then, based on the information received from its sources (the activist and the listed company), provide a news report for the public. In equilibrium, for the bias toward regulation, the media mitigates the market failure by decreasing the consumer's demand, while it mitigates the government failure by shifting the consumer's votes in favor of regulation. In the meanwhile, the activist has an incentive to hide information unfavorable to its interests, whereas the listed company reveals all information [10]. The impact of the informed third-parties including independent experts and environmental activists on the regulatory process also is analyzed. Under the asymmetry information, the "third-parties filter" provides information to the administrators before the company discloses it, while the "third-parties checker" provides information to the administrators after the company discloses its information [11]. During many process, the media bias increases the expected stringency of regulation [12]. We distinguish two points from these literatures: the listed company just discloses the "to-be-processed complementary information" and the activist just filters the information about the listed company before being accepted by the media, to enhance the consumer's surplus.

The research is motivated by the desire for advancing the understanding of the mechanism of information processing. It emphasizes that activists' filter and media exposure can

enhance regulation. Our purpose is to examine which information strategy is more important in the determination of regulation strategies, and provides insight into the effectiveness of the policy allowing NGO's participation in the government regulation. Section 2 describes the basic model. The equilibrium analysis is presented in Section 3. Section 4 draws some conclusions and makes certain recommendations.

## II. MODEL

### A. Assumptions of the model

First, the paper assumes that the whole continuous economy is defined as a unit which composed of a row of agents (such as listed companies, activists, regulators and media). Each agent has a limited ability to acquire, disclose and hide some information under the cost-benefit constraints, which is confidential information. With their own heterogeneous prior beliefs, they compete with each another. This competition between activists and listed companies through the media aims at influencing the decision-making of regulators.

Second, both the listed company and the activist as a risk neutral man might make true or false disclosures. To maximize the individual interests, the former has an incentive to hide the adverse information and to oppose regulation. However, the latter seeks to supervise companies' hiding and to support regulation in order to maximize the public interest. The activist obtains a certain reputation income if it exposes the company's hiding, while the listed company losses its reputation because of hiding information. As the main sources of the media, both of them enjoy relative advantage of information, selectively convey their favorable information to the media and hide the unfavorable.

Third, the media with a risk preference tends to expose others' hidings to the public. In the pursuit of maximizing their overall profits, the performance of journalists and the public interests, the media has an incentive to cater the public and support the government's regulation. Based on the information from the sources as well as its own investigation, media provides some reports for regulators. If the sources are intended to hide information, the media will investigate the listed company and the activist because of asymmetric information. As one of social services, the media achieves an income generated from the gained reputation by exposing the hiding of the listed company and the activist.

Fourth, as a risk aversion man, the regulator with a purpose of maximizing the public interest has an opportunism tendency to maintain the status quo. Although regulatory agencies realize that the goals and bias vary from the media to listing companies and activists, they still are strongly dependent on the media reports to save the cost. This means that reinforcing regulation happens when the media reports that much important information is hidden. In contrast, deregulation happens in the regulatory decision-making when less information is hidden.

### B. Model setting

It is well known that a natural state has only two extreme values  $\theta \in \{\theta_L, \theta_H\}$ ,  $\theta_L < \theta_H$ .  $\theta_H$  stands for the serious environmental pollution, with a priori probability defined

by  $p = \Pr(\theta = \theta_H)$ ,  $p \in [0, 1]$ .  $\theta_H$  enables the activist to maximize consumers' welfare and regulate pollution.  $\theta_L$  is favorable to the listed company with the priori probability  $1 - p$ .  $s$  indicates regulation and  $1 - s$  no regulation. The listed company (referred to as I) is in the pursuit of the profit-maximization with the belief of deregulation, that is  $pr_I(s) < pr_I(1 - s)$ , and has an incentive to acquire information and to hide the adverse information. The activist (referred to as A) and the media (referred to as M), with good professional skills and a certain degree of authority and independence, seek to maximize the public interests with the belief of strengthening regulation, that is,  $pr_A(s) > pr_A(1 - s)$ ,  $pr_M(s) > pr_M(1 - s)$  and have an incentive to expose the hidden information. The regulator (referred to as R) makes no regulatory decisions without considering the media report (referred to as r), that is,  $pr(s) = pr(r) \in [0, 1]$ . The regulation is dependent on the media reports.

The environmental information disclosure consists of three stages. First, the activist and the listed company search for information, and send messages to the media; second, the media decide whether to conduct investigative journalism or not, and then provide a news report on the basis of the available information. Third, regulators decide whether to regulate the pollution according to the media reports. Figure 1 identifies the sequence of actions in the game.

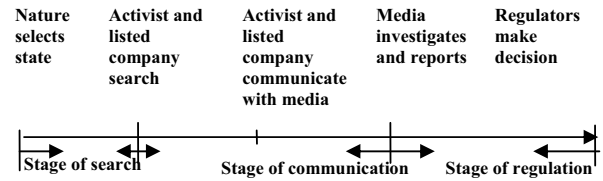


Figure 1 Timeline

In the stage of search, the activist and the listed company simultaneously search and obtain a signal  $\sigma_i, i = A, I$  with the probability  $q_i \in [0, 1]$ , which means that they acquire the hard information on the natural states, while the failure means that they obtain nothing. Therefore, there is  $\sigma \in \{\theta_L, \theta_H, \phi\}$ , in which  $\phi$  is a zero set. In the stage of communication, the information  $m_i \in M, i = A, I$  is sent to the media by the listed company with an incentive to hide their illegal operation. With an incentive to expose the listed companies' violations, the activists advocate their benefits by exposing their favorable information and hiding the unfavorable ones to the media. Therefore, the information obtained by the media relies mainly on the different incentives of the two sources in the disclosure of information. If  $\theta = \theta_H$ , the listed company would have a dominant strategy of sending  $m_I = \theta_L$  to the media with the probability  $1 - \rho_I \in [0, 1]$ . However, the activist has a dominant strategy of sending  $m_A = \theta_H$  to the media with the

probability  $1 - \rho_A$ , which means the activists' exposure. Provided that  $\theta = \theta_L$ , both of them have a dominant strategy of hiding information, by sending  $m_A = m_I = \phi$  with the probability  $\rho_A \in [0,1]$  and  $\rho_I$ , respectively. If messages of  $m_A = m_I = \phi$  or  $m_A = \theta_H, m_I = \theta_L$  are received, the media can investigate with the probability  $\xi \in [0,1]$  and the probability of successful investigation  $q_M$ . Thus, with probability  $q_M$ , the media observes  $\sigma_M = \theta_H$  and reports  $r = \theta_H$ ; while with probability  $1 - q_M$ , the observed would be  $\sigma_M = \phi$  and reported would remain  $r = \theta_H$ . During the investigation, if no messages or conflicting messages are received, the media would believe that the listed company hides with probability  $\rho_I$ , and the activist hides with the posterior probability  $\rho_A$ , they are given as follows:

$$\rho_I = \Pr(\sigma_I = \theta_L | m_A = m_I = \phi \text{ or } m_A = \theta_L, \sigma_M = \theta_H) = \frac{q_I \rho_I}{q_I \rho_I + 1 - q_I} \quad (1)$$

$$\rho_A = \Pr(\sigma_A = \theta_L | m_A = m_I = \phi \text{ or } m_A = \theta_L, \sigma_M = \theta_H) = \frac{q_A \rho_A}{q_A \rho_A + 1 - q_A} \quad (2)$$

In the stage of regulation, the government investigates if the media reports are  $r = \theta_H$  with probability  $\alpha \in [0,1]$ . In case of  $r = \theta_H$ , the government observes  $\sigma_M = \theta_H$  and decides to regulate the pollution ( $s = s^+$ ) with probability  $q_R$ .

### III. EQUILIBRIUM ANALYSIS

The remainder of this paper studies the case of  $\alpha = q_R = 1$ . The government can regulate the disclosure of information when  $r = \theta_H$ . To determine the outcome of the regulator's responses to the environmental disclosure, we worked backwards in game, starting with the decision of the media.

#### A. The Equilibrium Strategy of the Media

According to Baron (2005), the utility  $U_M$  of the media is specified as:

$$U_M = \pi_M + \xi(-c_M + \chi W_{\xi=1} + \delta J) + (1 - \xi)\chi W_{\xi=0} \quad (3)$$

Where  $\pi_M$  is the total profit except for the investigation,  $c_M$  is the cost of the media's investigation,  $\chi \in (0,1)$  is the weight given by the media to the aggregation of the public welfare, and  $W_{\xi=1}$  and  $W_{\xi=0}$  are the aggregate welfare with and without the media's investigations, respectively.  $\delta \in (0,1)$  is the influencing weight attached to the journalistic performance which includes the income of reputation gained by the media's exposing of the hidings of the listed company and the activist. If the reputation of the media is  $b_i^M, i = A, I$ , its income of

reputation is  $\rho_I b_I^M$  and the media's reputation income gained from the exposure of what the activists have done is  $\rho_A b_A^M$ , therefore,  $J = \rho_A b_A^M + \rho_I b_I^M$ . The media's investigation brings about two possibilities: to obtain the reputation for its successful investigation, or to fail to obtain the effective information, thus gaining no reputation. However, both of them have to afford some costs. Therefore, the expected utility of the media as a function of its acquisition and investigation is as follows:

$$EU_M(\xi, q_M) = \pi_M + \xi q_M (\delta J - c_M + \chi W_{\xi=1}) + (1 - \xi) \chi W_{\xi=0} \quad (4)$$

According to the derivative of the media function, the conditions met by the optimal strategies,  $\xi^*, q_M^*$  of the media's successful acquisition information and investigation are as follows:

$$\xi^* = \begin{cases} \in (0,1] & \text{if } c_M \leq c_M^* \\ = 0 & \text{if } c_M > c_M^* \end{cases}, q_M^* = \begin{cases} \in (0,1] & \text{if } b_i^M \geq 0, b_A^M \geq 0 \\ = 0 & \text{if } b_i^M < 0, b_A^M < 0 \end{cases} \quad (5)$$

Where the cost threshold of the media  $c_M^*$  and the reputation income threshold of the media  $b_i^M, b_A^M$  can be deducted from

$$\frac{dEU_M}{d\xi} = 0 \text{ and } \frac{dEU_M(\xi)}{dq_M} = 0, \text{ respectively.}$$

Result 1: When the listed company is independent on the activist and others controlled, the regulator makes no decision without consulting the media report. If and only if  $c_M \leq c_M^*$ ,  $\xi \in (0,1]$ , the media would investigate. But, if and only if  $b_i^M \geq 0, b_A^M \geq 0, q_M^* \in (0,1]$ , the media would successfully acquire the information. When  $\xi \in [\xi^*, 1]$  and  $q_M \in [q_M^*, 1]$ , the expected utility of the media increases with the increase in the probability of its acquisition and investigation.

#### B. The Equilibrium Strategy of the Activist

In the model proposed by [9], an independent activist is considered as a "third-party filter". According to [11], the activist identifies and filters the relevant information about listed companies to explore what has been hidden. As a supervisor, the activist must decide whether or not to expose its findings to the media. The activist can gain a reputation income for exposing it; on contrast the activist will loss reputation for hiding these findings, once being found by the regulator. With regard to the close relationship among the profit from exposing the listed company's hiding, the activist's social impact and its investigation cost, the activist's utility function can be credited as follows:

$$U_A = \pi_A + q_A(-c_A + \nu W_{q_A=1} + \Gamma \rho_I b_I^A) + (1 - q_A)\nu W_{q_A=0} \quad (6)$$

Where  $\pi_A$  is the total profits except for the profits of investigation,  $c_A$  is the investigation cost,  $\nu \in (0,1)$  is the influencing weight attributed to the social welfare of the activist,  $q_A$  is the probability of the activist's successful

acquisition of information.  $W_{q_A=1}$  and  $W_{q_A=0}$  indicate the welfare gained respectively by successful and unsuccessful acquisition.  $\Gamma \in (0,1)$  is the weight of the activist's personal achievement,  $b_i^A$  is the reputation income that the activist exposes what the listed company is intended to hide. The expected utility of the activist can be seen as the function of the probability of hiding and successful acquisition:

$$U_A(\rho_A, q_A) = \pi_A + q_A[\rho_A(-c_A + \mathcal{W}_{q_A=1}) + (1-\rho_A)(-c_A + \mathcal{W}_{q_A=0} + \Gamma \rho_A b_i^A)] + (1-q_A)\mathcal{W}_{q_A=0} \quad (7)$$

If the activist obtains some information on the listed company and finds nothing or it intentionally hides its violation, which is found and reported by the media after its investigation, the reputation of the activist would be damaged. The media's investigation produces two possibilities: Firstly, the media finds the activist's hiding after a successful investigation, which results in the activist's reputation loss; Secondly, both the media and the activist fail to obtain what the listed company has hidden and thus the activist will not suffer from reputation loss. Therefore, the expected utility function of the activist is as follows:

$$EU_A(q_A, q_M) = (q_A + (1-q_A)\xi^* q_M)U_A(\rho_A, q_A) - \rho_A H_A + (1-q_A)(1-\xi^* q_M)U_A(0, q_A) \quad (8)$$

Where  $U_A(0, q_A)$  and  $U_A(\rho_A, q_A)$  respectively indicate the utility of the activist with hiding and without hiding when the media has reported the serious pollution ( $r = \theta_H$ ). Provided that  $m_A = \theta_H$  and  $r = \theta_H$ ,  $q_A$  is the probability of the activist's successful acquisition;  $(1-q_A)\xi^* q_M$  is the probability that the activist fails to obtain information on the listed company, but the media successfully investigates and makes negative reports about the listed company;  $(1-q_A)(1-\xi^* q_M)$  is the probability that both the activist and the media fail to obtain information on the listed company, but the latter still makes negative reports on the listed company;  $H_A$  is the activist's reputation loss. As a result, the expected utility function of the activist, considering the impact of the media, is as follows:

$$EU_A(\rho_A, q_A; q_M) = \rho_A EU_A(q_A, q_M) + (1-\rho_A)U_A(0, q_A) \quad (9)$$

According to the derivative of the activist function, the conditions met by the optimal strategies of the activist's successful acquisition and hiding are as follows:

$$q_A^* \begin{cases} \in (0,1] & \text{if } c_A \leq c_A^* \\ = 0 & \text{if } c_A > c_A^* \end{cases}, \rho_A^* \begin{cases} \in (0,1] & \text{if } H_A \leq H_A^* \\ = 0 & \text{if } H_A > H_A^* \end{cases} \quad (10)$$

where the cost threshold  $c_A^*$  and the activist's reputation income threshold  $H_A^*$  can be obtained from  $\frac{dEU_A}{dq_A} = 0$

and  $\frac{dEU_A}{d\rho_A} = 0$ , respectively.

Result 2: When the listed company is independent on the activist and others controlled, the regulator makes no decision without consulting the media report. If and only if  $c_A \leq c_A^*$ ,  $q_A^* \in (0,1]$ , the activist would success in investigation. But, If and only if  $H_A \leq H_A^*$ ,  $\rho_A^* \in (0,1]$ , the activist would hide the

truth. When  $q_A \in [q_A^*, 1]$  and  $\rho_A \in [\rho_A^*, 1]$ , the expected utility of the activist increases with the increase of the probability of its acquisition and investigation.

### C. The Equilibrium Strategy of the Listed Company

The media and the activist are preferment to the regulation exposed the hiding of the listed company that damaged the reputation of the listed company. The listed company has no incentive to hide information without more profits in equilibrium [10]. However, a large number of researches have shown that company managers have an incentive to disclose good news, but to delay or hide unfavorable information [13, 14 and 15]. Therefore, it is assumed that the listed company tends to disclose good news and to hide unfavorable information.

The listed company tends to hide information and try to influence the decisions of investors and other information users, which occurs before regulatory bureaucracies and others find it. Boot & Thakor (2001) assumed that the listed company were the stock price-makers, and set as follows:  $t \in (0,1)$  is the probability of high-quality companies  $G$  with the cash flow  $x$ ,  $1-t$  is the probability of the low-quality companies  $B$  with the cash flow  $y$ , and thus  $\sigma_i (i = G, B)$  is the information set by the companies corresponding to the cost of acquisition  $c_i$  and other costs  $C_i$ . All the companies issue stock at the cost  $x-y$  ( $0 < y < x$ ) and the quantity  $\tau$ , which is random and given exogenous,  $\Omega$  presents the increasing quantity of stock due to the companies' successful acquisition,  $P^*$  is the income made by stock sales in equilibrium, the expected revenue obtained by stock sales is denoted by  $R = y + E(P^*)$ . If the listed company acquires information successfully, it may choose whether to hide the unfavorable news or not. Therefore, the utility function for the listed company to acquire information successfully and to hide unfavorable information is as follows:

$$\begin{aligned} U_i(\rho_i, \theta_i) &= y - c_i - C_i + \rho_i P^* (\Omega + \tau) + (1-\rho_i)P^* (\tau) \\ &= y - c_i - C_i + \frac{t\rho_i(x-y) - \rho_i P^* (\Omega + \tau)}{t\rho_i + (1-t)(1-\rho_i)} \quad (9) \end{aligned} \quad (11)$$

If the listed company obtains some information successfully, and finds nothing or tends to hide any unfavorable information, which is found and reported by the media after an investigation, the reputation of the listed company would be damaged. Therefore, when  $\theta = \theta_H$ ,  $m_i = \theta_L$ , the expected utility function of the listed company is as follows:

$$EU_i(\theta_i) = (q_i + (1-q_i)\xi^* q_M^*)U_i(\rho_i, \theta_i) - \rho_i H_i + (1-q_i)(1-\xi^* q_M^*)U_i(0, \theta_i) \quad (12)$$

Where  $U_i(\rho_i, \theta_i)$  and  $U_i(0, \theta_i)$  are the utility that the listed company sends the information  $m_i = \theta_L$  to the media with or without hiding. When  $m_i = \theta_L$  and  $r = \theta_H$ ,  $q_i$  is the probability of the activist's successful acquisition;  $(1-q_i)\xi^* q_M^*$  is the probability that the listed company fails to obtain information, while the media successfully investigates and makes negative reports on the listed company;  $(1-q_i)(1-\xi^* q_M^*)$  is the probability that both the listed company and the media fail to investigate but the latter still makes negative reports on the

listed company;  $H_i$  is the loss of the listed company's reputation. As a result, the expected utility function of the listed company, considering the impact of the media, is as follows:

$$EU_i(\rho_i, q_i; q_m) = \rho_i EU_i(\theta_L) + (1 - \rho_i) U_i(0, \theta_L) \quad (13)$$

The conditions that the optimal strategies of the listed company's successful acquisition and hiding must satisfy, according to the derivative of the listed company function, are as follows:

$$q_i \begin{cases} \in (0,1] & \text{if } P(\Omega+\tau) \geq P^*(\Omega+\tau) \\ = 0 & \text{if } P(\Omega+\tau) < P^*(\Omega+\tau) \end{cases}, \rho_i \begin{cases} \in (0,1] & \text{if } H_i \leq H_i^* \\ = 0 & \text{if } H_i > H_i^* \end{cases} \quad (14)$$

where the expected revenue threshold  $P^*(\Omega+\tau)$  and the listed company's reputation loss threshold  $H_i^*$  can be derived

from  $\frac{\partial EU_i}{\partial q_i} = 0$  and  $\frac{\partial EU_i}{\partial \rho_i} = 0$ , respectively.

Result 3: when the listed company is independent on the activist and others controlled, the regulator makes no decision without consulting the media report. If and only if  $P^*(\Omega+\tau) \geq P^*(\Omega+\tau)$ ,  $q_i^* \in (0,1]$ , then the listed company would success in the investigation. But, if and only if  $H_i \leq H_i^*$ ,  $\rho_i^* \in (0,1]$ , the listed company would hide the truth. When  $q_i \in [q_i^*, 1]$  and  $\rho_i \in [\rho_i^*, 1]$ , the expected utility of the listed company increases with the increase in the probability of its acquisition and investigation.

#### IV. CONCLUSIONS AND RECOMMENDATIONS

This paper presents a model of informational competition between the activist and the listed company, both of them seeks to influence the regulatory decision to strengthen their positions through the media. According to the results, the following conclusions can be drawn: when the listed company is independent on the activist and others controlled, the regulator makes no decision without consulting the media report; the optimal strategy of each party in the game of environmental disclosure depends on its expected threshold of maximizing utility. Specifically, for maximization expected utility, the media's decision to investigate and acquire information depends on the cost threshold of investigation  $c_m^*$  and the threshold of obtaining reputation  $b_i^{M^*}$ ,  $b_a^{M^*}$ , respectively; the activist decides to acquire or hide information depending on the cost threshold of investigation  $c_a^*$  and the threshold of reputation loss  $H_a^*$ , respectively; the listed company decides to acquire or hide information relies on the expected revenue threshold of stock sale  $P^*(\Omega+\tau)$  and the threshold of reputation loss  $H_i^*$ , respectively.

This conclusion is of great practical significance to the policy making in well-developed market economy with serious pollution. To enhance the capacity of media supervision, it is necessary to take more legislation to reduce the cost of the media investigation and to improve the reputation of the media gained by its investigation and supervision. It is necessary for the government to increase the reputation loss of the activist in order to reduce the cost of its investigation through legislation and other means. Reducing the activist's frauds, which leads to

decreasing the violations of the listed company, can be achieved by enhancing the reputation loss of the listed company and its revenue gained from its investigation through various means.

(13)

The paper supports the spirit of the actual legislation and provides insights about several formal channels for the NGO's participation in environmental regulation. Although there are several significant deficiencies of the environmental information disclosure [1], the NGO's participation into the environmental regulation can not be achieved without the government supports. To identify the most effective channels for NGO's participations under Chinese social and economic conditions, improving activists and media access to investigating and exposing environmental information hidden by listed company are important to the improvement of decision-making, pollution control, and the environmental performance of government and companies. Therefore, more and more general information about legislation and formal channels for the NGO's participation in environmental regulation should be provided by the government. The effectiveness of the NGO's (such as activists and media) participation remains to be improved by making laws and regulations, reducing the acquisition cost, enhancing the reputation income for acquisitions and exposures and the reputation loss for hidings, and choosing appropriate and effective disclosure methods.

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