Online Appendix

Does Securities Regulation Matter? Mandatory Disclosure, Excess Stock Volatility and the U.S. 1934 Securities Exchange Act

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We use a simple extension of Allen and Gale (1992) (henceforth AG) to explain why enhanced disclosure helps reduce excess volatility. The main idea is outlined below, the technical details are provided in section OA.2 and OA.3, and a numerical example is presented in section OA.4.

OA.1 A Brief Summary of the Main Results

The setup is as follows. In a sequential game, there are three players: an informed trader, who knows ahead of others that a stock announcement is forthcoming; a manipulator, who attempts to disguise himself as the informed trader even when no announcement is expected; and a continuum of general investors who trade with either the informed trader or the manipulator, without knowing the identity of their trading counterpart. The informed trader and the manipulator are large traders who are assumed to be risk-neutral, while the general investors are assumed to be risk-averse. In AG's paper, an informed trader could be anyone who obtains information earlier than others. In the real world, this role is naturally filled by "directors, officers, and principal stockholders", the target groups mentioned in Section 16 of the Act of 1934. Manipulation is profitable because the manipulator can mimic the insider's trading activity, making it impossible for an ordinary investor to distinguish between the manipulator and the insider when either enters the market.[1]

We modify AG's setup by introducing a requirement for insiders to disclose either their knowledge of the future announcement and/or their holdings. In practice, such an announcement, which will impact the intrinsic value of a stock in the future, can be understood as the announcement of the success or failure of a specific investment project by a company. And the insider's information can be regarded as the company's decision to initiate the project. The Act requires companies

[1] AG classify manipulations into three categories: action-based, information-based, and trade-based. Action-based manipulation involves actions, often collective, that alter the value of assets, such as cornering the market. Information-based manipulation relies on releasing false information or spreading rumors. Trade-based manipulation involves buying and selling activities "without taking any publicly observable actions to alter the value of the firm or releasing false information to change the price." The theme of AG is to demonstrate that trade-based manipulation can be profitable under certain conditions. The term "trade-based" is somewhat misleading, as this type, like the other two, relies on the information asymmetry between large traders and general investors. In the simplest setting, AG assume that the manipulator does not know the incoming announcement but is aware of the informed trader's position. Since the informed trader acts whenever an announcement is imminent, the manipulator essentially gains the same knowledge. Thus, the informed trader and the manipulator can be seen as a single player who occasionally cheats general investors through insider trading, a form of information-based manipulation. This assumption can be relaxed so that the manipulator does not know the insider's trading position either, as discussed in AG's original paper. However, the key to successful manipulation remains the information asymmetry between general investors and large traders. For the sake of simplicity, we adhere to the simplest setting in our discussion.

to disclose significant value-affecting information of this kind in Form 8-K, with related financial details reflected in Forms 10-Q and 10-K. Furthermore, the Act mandates disclosure of insiders' holdings in Forms 3–5, as specified in Section 16. These mandatory disclosure requirements effectively exclude manipulators because the timely disclosure prevents manipulators from deceiving outside investors by simulating insider trading and fabricating non-existent changes in fundamental information. We provide a proof that the volatility caused by manipulators, which is unrelated to fundamental information, is larger than the normal volatility of stocks in other situations. We summarize the result in the following proposition, expanding on AG's original:

Proposition. *(AG's proposition) As long as the general investors are sufficiently risk-averse and the probability of manipulation is sufficiently small, there exists a pooling equilibrium in which the manipulator achieves strictly positive profits.*

(Extension) However, when the informed trader's knowledge or holdings is disclosed, the manipulator is unable to manipulate and chooses not to trade. Moreover, the volatility of the manipulated stock exceeds that of the stock when the informed trader discloses.

It is worth noting that the applicability of the model is not restricted by the simple setup. In AG's model the insider is truthfully utilizing the information to trade and the manipulator is faking his identity by mimicking the insider. The model can readily be applied to a scenario where the insider mimics the manipulator by engaging in occasional trades even in the absence of news. After all, the insider and the manipulator need not be two separate players.

OA.2 The Model

This section provides the technical details of how disclosure impacts stock volatility. We begin by summarizing Allen and Gale (1992) (AG)'s benchmark result, then modify the model to incorporate mandatory disclosure of insider's knowledge. Following this, we prove the proposition in Section OA.1 and provide a numerical example to compare volatilities across different scenarios.

OA.2.1 Benchmark: The Allen-Gale Model of Market Manipulation

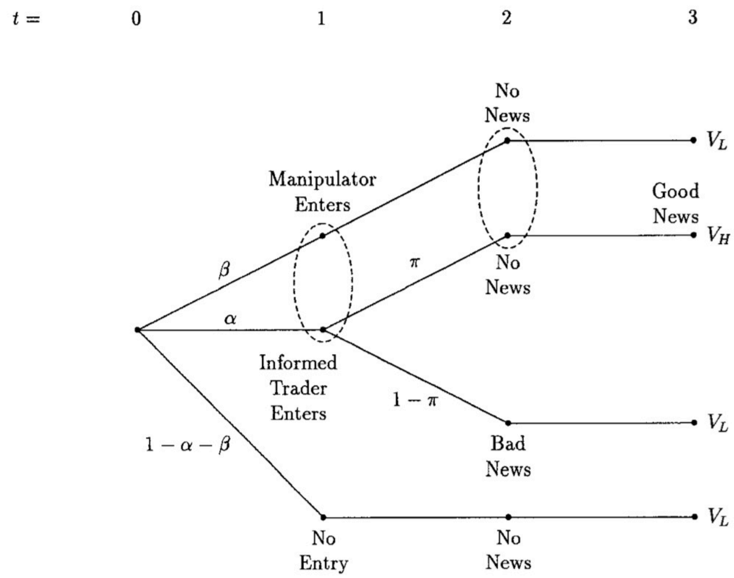
We summarize the settings of the original Allen-Gale model below. Some of the assumptions could be relaxed at the expense of more model complexity, and are discussed in the original paper. For our purpose, we follow the simplest setting Allen and Gale presented. The game tree is presented in Figure 1.

Setup

Time: There are four discrete dates, indexed by $t = 0, 1, 2, 3$.

Assets: There are two assets: cash and stock. Cash serves as the numeraire. The stock pays a single dividend at the end of the last period. The dividend could be either high, V_H, or low, V_L. Cash is riskless and has zero yield, i.e. there is no time value for cash.

Figure 1: The Original Allen-Gale Game Tree



Traders: There are three types of traders: a continuum of identical investors and two large traders: An informed trader (or insider) and a manipulator. The investors are risk averse, and the two large traders are risk neutral. It is reasonable to view the two large traders as institutional traders whose portfolios are well diversified, and the small investors as passive, long-term stockholders.

Information: With probability α, an announcement concerning the value of the stock is made. The insider knows when an announcement is forthcoming, but the general investors and the manipulator do not. With probability π the announcement is good news and the value is V_H. The value could be V_L so that the announcement is bad news with probability $1-\pi$. If it is good news, it will be announced at date 3. If it is bad news, it will be announced at date 2.

Entry and exit: At date 0, only investors are in the market. At date 1, a large trader may enter. The informed trader enters when he knows there will be an announcement. Therefore, an informed trader enters with probability α. The manipulator enters only when he knows that the informed trader did not enter. In other words, the manipulator knows the position of the informed trader and hence he actually knows that there will be an announcement or not. This assumption is not essential, as Allen and Gale discussed, but will simplify the discussion. The unconditional probability that the manipulator enters is β. With probability $1-\alpha-\beta$, no large trader enters. If at date 1 there is a large trader in the market, the investor does not know his counterparty's identity. The large trader, whether it be the insider or the manipulator, liquidates his holdings of stocks at date 2. At date 3, only the investors remain in the market.

Endowments and Preferences: The investors hold all stocks E at date 0. The informed trader and the manipulator have no stocks initially. Cash endowments of all traders can be normalized to zero without loss of generality. All traders maximize their expected utility of their final wealth. The investors are risk averse with a differentiable, strictly increasing, and strictly concave utility function U. The informed trader and the manipulator are risk averse.

Equilibrium

The game is solved by backward induction. We omit the details of finding the equilibrium price paths, as these are presented in the original paper. For later comparison, we collect the results below.

Equilibrium at date 2

1) A large trader did not enter at date 1

In this case there is no uncertainty and there is no trade at date 2. The equilibrium price equals V_L.

2) A large trader entered the market at date 1

When a large trader entered the market at date 1, he bought B shares at the price of $P_1(B)$. The manipulator and the informed trader pooled at buying the same amount, and the investor does not know their identity. The investor's belief that the large trader is informed is $Q_1(B) = \gamma = \alpha/(\alpha+\beta)$.

There are two subcases at date 2 according to whether there is an announcement of bad news or not.

(1) An announcement is made at date 2. In this case, the true value of the stock is revealed to be V_L. The investor is willing to purchase any amount at the price of $P_2 = V_L$. The informed trader's identity is revealed, and he is selling the stock at V_L.

(2) An announcement is not made. In this case the identity of the large trader is still not revealed to the general investors. The posterior probability that the large trader is informed is denoted as $\delta \equiv \gamma\pi/(\gamma\pi + 1 - \gamma)$. The manipulator and the informed trader will both propose B units of shares for sale, the equilibrium price that clears the market must satisfy the investor's first order condition:

$$P_2(B) = \frac{\delta U'\left(\left(P_1\left(B\right) - P_2\left(B\right)\right)B + EV_H\right)V_H + (1-\delta)U'\left(\left(P_1\left(B\right) - P_2\left(B\right)\right)B + EV_L\right)V_L}{\delta U'\left(\left(P_1\left(B\right) - P_2\left(B\right)\right)B + EV_H\right) + (1-\delta)U'\left(\left(P_1\left(B\right) - P_2\left(B\right)\right)B + EV_L\right)} \quad (1)$$

Equilibrium at date 1

If a large trader does not enter at date 1, the equilibrium price is V_L. If a large trader enters at date 1, the pooling strategy of the manipulator and the informed trader is an equilibrium. The large trader, whether it be the manipulator or the informed trader, buys $B > 0$ shares at the price of P_1. At date 2, the investor's final wealth will be one of the following:

(1) With probability $(1-\pi)\gamma$ the bad news is announced. The final wealth of the investor is

$$W_L(B) = (P_1 - V_L)B + EV_L$$

(2) With probability $\pi\gamma$, there is no announcement and the stock value is high. The final wealth of the investor is

$$W_H(B) = (P_1 - P_2(B))B + EV_H$$

(3) With probability $1 - \gamma$, there is no announcement and the value of the stock is low. The final wealth of the investor is

$$W_M(B) = (P_1 - P_2(B))B + EV_L$$

With these formulas, the equilibrium expected payoff to the representative investor is

$$U^*(B) = \gamma\pi U(W_H(B)) + \gamma(1-\pi)U(W_L(B)) + (1-\gamma)U(W_M(B)).$$

The market clearing price P_1 is given by

$$P_1 = \frac{\gamma\pi U'\left(W_H(B)\right)V_H + \gamma\left(1-\pi\right)U'\left(W_L(B)\right)V_L + \left(1-\gamma\right)U'\left(W_M(B)\right)V_L}{\gamma\pi U'\left(W_H(B)\right) + \gamma\left(1-\pi\right)U'\left(W_L(B)\right) + \left(1-\gamma\right)U'\left(W_M(B)\right)} \tag{2}$$

Equilibrium at date 0

At date 0, the representative investor has to decide whether to stay in the market or leave the market by selling all his shares. The utility of selling all shares is $U(P_0E)$, and the expected utility of staying in the market is

$$(1-\alpha-\beta)U(V_LE) + \alpha\pi U(W_H) + \alpha(1-\pi)U(W_L) + \beta U(W_M).$$

The equilibrium price P_0 will be set at the level that selling all shares and staying in the market would be the same for the investor:

$$P_0(B) = \frac{(1-\alpha-\beta)U'(V_LE)V_L + \alpha\pi U'(W_H(B))V_H}{U'(P_0E)} + \frac{\alpha(1-\pi)U'(W_L(B))V_L + \beta U'(W_M(B))V_L}{U'(P_0E)} \tag{3}$$

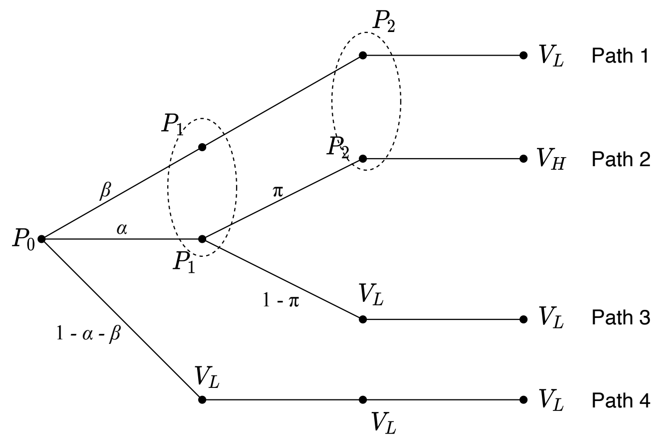
Summary

In sum, there are four price paths in the original model:

$$\begin{cases} \text{path 1: } P_0 \to P_1 \to P_2 \to V_L, & \text{if the stock is manipulated;} \\ \text{path 2: } P_0 \to P_1 \to P_2 \to V_H, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 3: } P_0 \to P_1 \to V_L \to V_L, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 4: } P_0 \to V_L \to V_L \to V_L, & \text{if no large trader enters.} \end{cases} \tag{4}$$

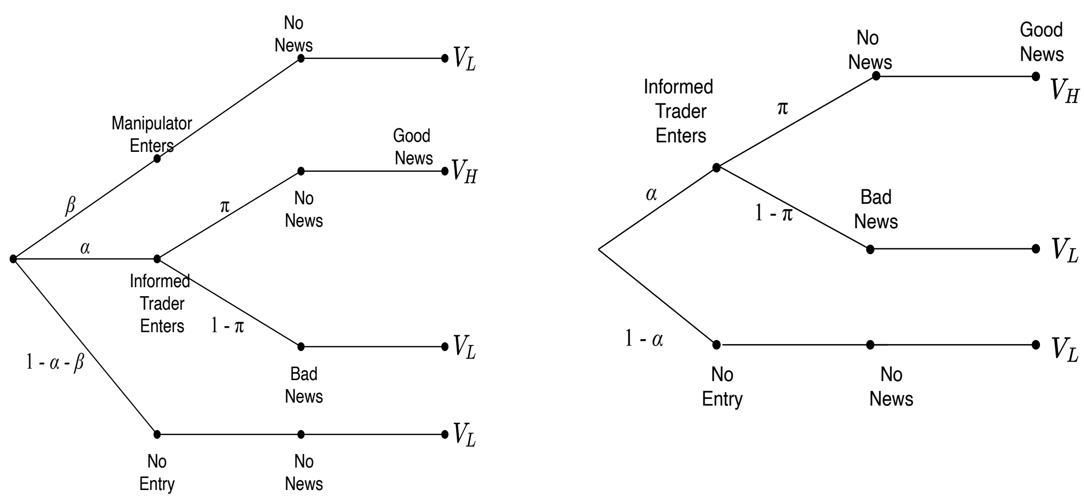
These price paths are labeled in Figure 2.

Figure 2: The Price Paths of the Original Allen-Gale Model



OA.2.2 Extension: When the Insider Discloses

Figure 3: The Allen-Gale Game Tree when the Informed Trader Discloses



When the insider's knowledge about the project, or their holdings is disclosed to the public, there is no uncertainty about the identity of the counterparty, as is shown in the left panel of Figure 3. When the manipulator enters at date 1, the investors know for sure that there is no news in the future and thus they have no incentive to trade. The share price remains at V_L at date 1, date 2, and date 3. Anticipating this, the manipulator would not enter the market at date 1. Would an insider choose not to trade because of disclosure? It can be demonstrated that the insider's expected return remains nonnegative as long as outside investors are risk-averse (see inequalities (6) and (7) below). Consequently, the risk-neutral insider is incentivized to trade. Therefore, the game reduces to the one presented in the right panel of Figure 3.

Following the original model, we focus on the equilibrium in which at date 2 the informed trader sells all shares purchased at date 1. No further analysis is needed at date 3, as all values of shares simply reveal. We begin with date 2.

Equilibrium at date 2

1) The informed trader did not enter at date 1

No trade occurs at date 1, and consequently no trade occurs at date 2 either. The stock's value remains at V_L.

2) The informed trader entered at date 1

When the informed trader entered at date 1, investors know the identity of their counterparty. If there is no announcement at date 2, the investors know for sure there will be good news at date 3. In this case, the equilibrium price $P_2^D = V_H$. We add an superscript D to distinguish variables in the "Disclosed" model from those in the original one. If there is an announcement of bad news at date 2, the equilibrium price is $P_2^D = V_L$.

Equilibrium at date 1

As discussed above, when the informed trader chooses not to enter, the price stays at V_L and there is no need for further analysis. When the informed trader enters at date 1, the representative investor confronts two possible scenarios at date 2:

(a) With probability π, there will be no announcement, which is equivalent to good news at date 3. The final wealth of the investor will be:

$$W_H^D(B) \equiv EV_H + (P_1^D - P_2^D)B = EV_H + (P_1^D - V_H)B$$

(b) With probability $1 - \pi$, there will be an announcement of bad news and the final wealth of the investor will be:

$$W_L^D(B) \equiv EV_L + (P_1^D - P_2^D)B = EV_L + (P_1^D - V_L)B$$

The equilibrium payoff to the representative investor if B units of stock are purchased is given by

$$U^*(B) = \pi U(W_H^D(B)) + (1 - \pi)U(W_L^D(B)).$$

The equilibrium price P_1^D satisfies the investors' first-order condition, and is given by

$$P_1^D(B) = \frac{\pi U'\left(W_H^D(B)\right) V_H + (1-\pi) U'\left(W_L^D(B)\right) V_L}{\pi U'\left(W_H^D(B)\right) + (1-\pi) U'\left(W_L^D(B)\right)}. \tag{5}$$

Similar to the setup in the original model, B is the equilibrium choice of shares traded. It would be beneficial for the informed trader to trade if the payoff is nonnegative:

$$-P_1^D(B)B + \pi V_H B + (1-\pi)V_L B \geq 0. \tag{6}$$

This is equivalent to

$$U'(W_L^D(B))(V_H - V_L) \geq U'(W_H^D(B))(V_H - V_L). \tag{7}$$

As long as the investors are risk averse, this inequality is satisfied.

Equilibrium at date 0

At date 0, the representative investor has to decide whether to stay in the market or leave the market by selling all his shares. The utility of selling all shares is $U(P_0^D E)$, and the expected utility of staying in the market is

$$(1-\alpha)U(V_L E) + \alpha\pi U(W_H^D) + \alpha(1-\pi)U(W_L^D).$$

In equilibrium selling all shares or staying in the market would be no different to the investor, and thus

$$P_0^D(B) = \frac{(1-\alpha)U'(V_L E)V_L + \alpha\pi U'(W_H^D(B))V_H + \alpha(1-\pi)U'(W_L^D(B))V_L}{U'(P_0^D E)} \tag{8}$$

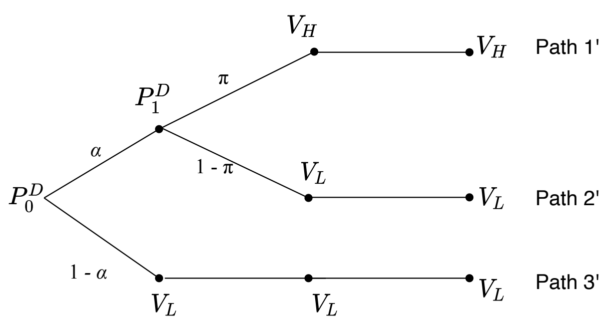
Summary

When the insider discloses, there are three possible price paths:

$$\begin{cases} \text{path 1': } P_0^D \to P_1^D \to V_H \to V_H, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 2': } P_0^D \to P_1^D \to V_L \to V_L, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 3': } P_0^D \to V_L \to V_L \to V_L, & \text{if the insider does not enter.} \end{cases} \tag{9}$$

This is visualized in Figure 4.

Figure 4: The Price Paths when the Insider Discloses



OA.3 Proof of the Proposition

The existence of the pooling equilibrium in the original game is provided by Allen and Gale (1992). When the informed trader discloses, there is no information asymmetry and the manipulator finds it non-profitable to trade and thus exits the market. It remains to demonstrate that the volatility of the manipulated stock exceeds that of the stock when not manipulated; specifically, that the price path 1 in equation (4) is greater than each of the paths 1', 2', and 3' in equation (9).

We use the logrithmic return as stock returns. The volatility of a stock is defined as the sample standard deviation of its return series, so it is enough to prove that

$$\mathrm{Var}\left(\left[\log(\frac{P_1}{P_0}), \log(\frac{V_H}{P_1}), \log(\frac{V_L}{V_H})\right]\right) > \mathrm{Var}\left(\left[\log(\frac{P_1^D}{P_0^D}), \log(\frac{V_H}{P_1^D}), \log(\frac{V_H}{V_H})\right]\right), \quad (10)$$

$$\mathrm{Var}\left(\left[\log(\frac{P_1}{P_0}), \log(\frac{V_H}{P_1}), \log(\frac{V_L}{V_H})\right]\right) > \mathrm{Var}\left(\left[\log(\frac{P_1^D}{P_0^D}), \log(\frac{V_L}{P_1^D}), \log(\frac{V_L}{V_L})\right]\right), \quad (11)$$

$$\mathrm{Var}\left(\left[\log(\frac{P_1}{P_0}), \log(\frac{V_H}{P_1}), \log(\frac{V_L}{V_H})\right]\right) > \mathrm{Var}\left(\left[\log(\frac{V_L}{P_0^D}), \log(\frac{V_L}{V_L}), \log(\frac{V_L}{V_L})\right]\right), \quad (12)$$

where $\mathrm{Var}([\cdot])$ is the sample variance of the given series. Note that when $\beta \to 0$ and the general investors' degree of relative risk aversion grows without bound, $P_2 \to V_H$, $P_1 \to \pi V_H + (1-\pi)V_L$, $P_0 \to \alpha\pi V_H + (1-\alpha\pi)V_L$, $P_1^D \to \pi V_H + (1-\pi)V_L$ and $P_0^D \to \alpha\pi V_H + (1-\alpha\pi)V_L$, as could be seen from equations (1), (2), (3), (5), and (8). It can be shown with some algebra that

$$\begin{aligned}&\mathrm{Var}\left(\left[\log(\frac{P_1}{P_0}), \log(\frac{V_H}{P_1}), \log(\frac{V_L}{V_H})\right]\right) - \mathrm{Var}\left(\left[\log(\frac{P_1^D}{P_0^D}), \log(\frac{V_H}{P_1^D}), \log(\frac{V_H}{V_H})\right]\right)\\ &= \frac{1}{3}\log\left(\frac{V_L}{V_H}\right)\left[-\log\left(\frac{\pi(V_H-V_L)+V_L}{\alpha\pi(V_H-V_L)+V_L}\right) - \log\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right) + \log\left(\frac{V_L}{V_H}\right)\right] > 0,\end{aligned}$$

where the inequality is established by noting that $V_H > V_L > 0$, $0 < \alpha < 1$, $0 < \pi < 1$. This proves inequality (10). To prove inequality (11), write

$$\begin{aligned}&\mathrm{Var}\left(\left[\log(\frac{P_1}{P_0}), \log(\frac{V_H}{P_1}), \log(\frac{V_L}{V_H})\right]\right) - \mathrm{Var}\left(\left[\log(\frac{P_1^D}{P_0^D}), \log(\frac{V_L}{P_1^D}), \log(\frac{V_L}{V_L})\right]\right)\\ &= \frac{1}{3}\Bigg\{\log^2\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right) - \log^2\left(\frac{V_L}{\pi(V_H-V_L)+V_L}\right) - \log\left(\frac{V_L}{V_H}\right)\log\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right)\\ &\qquad + \log^2\left(\frac{V_L}{V_H}\right)\Bigg\}.\end{aligned}$$

As $V_H > V_L > 0$ and $0 < \pi < 1$,

$$\log^2\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right) > \log^2\left(\frac{V_L}{\pi(V_H-V_L)+V_L}\right),$$

$$-\log\left(\frac{V_L}{V_H}\right)\log\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right) > 0.$$

This proves inequality (11). Finally,

$$
\begin{aligned}
&\mathrm{Var}\left(\left[\log(\frac{P_1}{P_0}),\log(\frac{V_H}{P_1}),\log(\frac{V_L}{V_H})\right]\right)-\mathrm{Var}\left(\left[\log(\frac{V_L}{P_0^D}),\log(\frac{V_L}{V_L}),\log(\frac{V_L}{V_L})\right]\right)\\
&=\frac{1}{3}\Bigg\{-\log^2\left(\frac{V_L}{\alpha\pi(V_H-V_L)+V_L}\right)+\log^2\left(\frac{\pi(V_H-V_L)+V_L}{\alpha\pi(V_H-V_L)+V_L}\right)\\
&\quad-\left[\log\left(\frac{V_L}{\pi(V_H-V_L)+V_L}\right)\right]\log\left(\frac{\pi(V_H-V_L)+V_L}{\alpha\pi(V_H-V_L)+V_L}\right)\\
&\quad+\log^2\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right)-\log\left(\frac{V_L}{V_H}\right)\log\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right)+\log^2\left(\frac{V_L}{V_H}\right)\Bigg\}.
\end{aligned}
$$

Similarly, given that $V_H > V_L > 0$, $0 < \alpha < 1$ and $0 < \pi < 1$,

$$-\log^2\left(\frac{V_L}{\alpha\pi(V_H-V_L)+V_L}\right)+\log^2\left(\frac{\pi(V_H-V_L)+V_L}{\alpha\pi(V_H-V_L)+V_L}\right)>0,$$

$$-\left[\log\left(\frac{V_L}{\pi(V_H-V_L)+V_L}\right)\right]\log\left(\frac{\pi(V_H-V_L)+V_L}{\alpha\pi(V_H-V_L)+V_L}\right)>0,$$

$$-\log\left(\frac{V_L}{V_H}\right)\log\left(\frac{V_H}{\pi(V_H-V_L)+V_L}\right)>0,$$

hence inequality (12) is valid. This completes the proof.

OA.4 A Numerical Example

For ease of comparison, we use the same parameter values as those in Allen and Gale (1992): $V_H = 12$, $V_L = 10$, $\alpha = 0.5$, $\pi = 0.5$, $E = 1$, $B = 0.45$. Relative risk aversion is set to 2, and the unconditional probability of the manipulator entering is $\beta = 0.0102$, ensuring that $1-\gamma = 0.02$ as in AG's paper. Stock return is defined as $\log(P_{t+1}/P_t)$. Volatility is defined as the standard deviation of returns in each price path.

With these values, the prices at each date can be solved. The price, return and volatility paths are presented below.

(a) The Original Model

Price paths:

$$
\begin{cases}
\text{path 1: } 10.44 \to 10.87 \to 11.89 \to 10, & \text{if the stock is manipulated;}\\
\text{path 2: } 10.44 \to 10.87 \to 11.89 \to 12, & \text{if the insider enters and the news turns out to be good;}\\
\text{path 3: } 10.44 \to 10.87 \to 10 \to 10, & \text{if the insider enters and the news turns out to be bad;}\\
\text{path 4: } 10.44 \to 10 \to 10 \to 10, & \text{if no large trader enters.}
\end{cases}
$$

Return paths:

$$\begin{cases} \text{path 1: } 4.04\% \rightarrow 8.97\% \rightarrow -17.31\%, & \text{if the stock is manipulated;} \\ \text{path 2: } 4.04\% \rightarrow 8.97\% \rightarrow 0.92\%, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 3: } 4.04\% \rightarrow -8.34\% \rightarrow 0.00\%, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 4: } -4.31\% \rightarrow 0.00\% \rightarrow 0.00\%, & \text{if no large trader enters.} \end{cases}$$

Volatilities of each path:

$$\begin{cases} \text{path 1: } 13.97\%, & \text{if the stock is manipulated;} \\ \text{path 2: } 4.06\%, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 3: } 6.31\%, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 4: } 2.49\%, & \text{if no large trader enters.} \end{cases} \tag{13}$$

(b) The model when informed trader discloses:
Price paths:

$$\begin{cases} \text{path 1': } 10.44 \rightarrow 10.90 \rightarrow 12 \rightarrow 12, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 2': } 10.44 \rightarrow 10.90 \rightarrow 10 \rightarrow 10, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 3': } 10.44 \rightarrow 10 \rightarrow 10 \rightarrow 10, & \text{if the insider does not enter.} \end{cases}$$

Return paths:

$$\begin{cases} \text{path 1': } 4.31\% \rightarrow 9.61\% \rightarrow 0.00\%, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 2': } 4.31\% \rightarrow -8.62\% \rightarrow 0.00\%, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 3': } -4.31\% \rightarrow 0.00\% \rightarrow 0.00\%, & \text{if the insider does not enter.} \end{cases}$$

Volatilities of each path:

$$\begin{cases} \text{path 1': } 4.81\%, & \text{if the insider enters and the news turns out to be good;} \\ \text{path 2': } 6.58\%, & \text{if the insider enters and the news turns out to be bad;} \\ \text{path 3': } 2.49\%, & \text{if the insider does not enter.} \end{cases} \tag{14}$$

The volatility of the manipulated stock is 13.97%, while the largest possible volatility of the stock with disclosure is 6.58%. Note that when prices reflect fundamental news, the resulting volatility is naturally larger than when there is no news and no manipulation. In this scenario, the price path with the given parameters is $10.44 \rightarrow 10 \rightarrow 10 \rightarrow 10$, resulting in a volatility of 2.49%. Now when there is news, whether positive (path 2) or negative (path 3), the insider trades, leading to price fluctuations that reflect this information. In the case of good news, the price path is $10.44 \to 10.87 \to 11.89 \to 12$, while for bad news, it follows $10.44 \to 10.87 \to 10 \to 10$. The resulting volatility is 4.06% for good news and 6.31% for bad news. Clearly, these two numbers are larger than 2.49%.

Another observation concerns price efficiency. For instance, suppose there is good news in the future that drives the price to 12. When insider does not disclose, outside investors, uncertain whether they are trading against an insider or a manipulator, would see a price path of $10.87 \to 11.89 \to 12$ (starting from the second price in price path 2 of (a)). However, when the insider is required to disclose, outside investors no longer need to guess, resulting in a price path of $10.90 \to 12 \to 12$ (starting from the second price in price path 2' of (b)). Here, the trading price converges more quickly to 12, indicating greater efficiency, as outside investors no longer need to consider the possibility of the stock being manipulated without fundamental support.

References

Allen, F. and Gale, D. (1992). Stock-price manipulation. *Review of Financial Studies*, 5(3):503–529.