The London School of Economics and Political Science

Essays on Disclosure of Holdings by Institutional Investors

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorization does not, to the best of my belief, infringe the rights of any third party.

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I confirm that Chapter 1 is co-authored with Sean Lew, and I contributed more than 50% of this work. Chapter 3 is co-authored with Sitikanda Parida and I contributed less than 50% of this work.

Abstract

This thesis contains three essays on disclosure of holdings by institutional investors. Chapter 1 presents a theoretical model that examines the impact of confidential treatment requests made by institutional investors to the Securities and Exchange Commission (SEC) to delay disclosure of their holdings. Chapter 2 presents another theoretical model that analyses how an informed trader trades strategically in the presence of copycats who track his disclosed trades. Chapter 3 is an empirical study that examines the impact of more frequent portfolio disclosure on mutual funds' performance.

Thesis Introduction

This thesis contributes to the theoretical and empirical market microstructure literature by studying the impact of mandatory disclosure of holdings by institutional investors. Institutional investors like mutual funds and hedge funds face mandatory disclosure requirements by the Securities and Exchange Commission (SEC). In particular, Section 13(f) of the Securities Exchange Act of 1934 requires investment managers (who manage more than US$100 million in assets) to publicly disclose their portfolio holdings within 45 days after the end of every quarter. Mandatory disclosure allows fund investors to monitor the performance and holdings of the funds. This helps them in their asset allocation and diversification decision, and also enables them to see whether the fund manager is complying with its stated investment objective. However, frequent mandatory disclosure may result in the fund to be targeted by front-runners and copycats. A common theme that is analysed in all three chapters is how mandatory disclosure affects the strategic behavior and performance of institutional investors. Besides the impact on institutional investors, mandatory disclosure has other market-wide effects on price informativeness and liquidity.

Mandatory disclosure could potentially have a negative impact on the trading strategy of a fund manager that seeks to accumulate a huge position of an asset. To reduce the market impact of such a huge trade, the fund manager would prefer to spread his acquisition program over a longer period, e.g. over two or more quarters. However, the fund manager also has to take into account the possible market impact that the disclosure of holdings after the first quarter would have on the asset price. To protect the interests of the fund manager and its fund investors, the SEC gives the fund manager the option to apply for confidential treatment. This aspect of market microstructure is the focus of the Chapter 1. Chapter 1 presents a theoretical model that examines the trading strategy and expected profits of an informed fund manager that applies for confidential treatment. This model is closely related to Kyle (1985) and Huddart, Hughes and Levine (2001). In a two-period Kyle (1985) model, an informed agent trades strategically over two periods, while in a two-period Huddart et al. (2001) model, the informed agent is required to disclose his first trade before trading commences in the second period. The market-maker adjusts the price of the asset upon the disclosure of the first trade. If the probability of obtaining SEC approval for confidential treatment is zero, Chapter 1's model is equivalent to a two-period Huddart et al. (2001). On the other hand, if the probability of obtaining approval is one, the model is equivalent to a two-period Kyle (1985). The SEC requires the manager to present a coherent on-going trading program in his request for confidential treatment. If his request is granted, he is restricted to trade in a manner consistent with his reported forecast in the subsequent period. The model predicts that the price impact of a disclosed trade due to a confidential treatment request denial is greater than that of a disclosed trade where there is no request.

Chapter 2 presents a theoretical model that analyses the impact of copycats that track the trades of an informed fund manager. This model also uses a framework similar to Kyle (1985) and Huddart et. al (2001). The key difference is that the copycats are able to identify the disclosed trades of the informed fund manager while the market-maker is not able to. The number of copycats can be interpreted as a measure of media exposure of the fund manager. As the number of copycats approaches infinity, the model is equivalent to a two-period Huddart et al. (2001).

An important part of the first 2 Chapters is devoted to the analysis of the expected profits of the institutional investor that faces mandatory disclosure. In Chapter 3, an empirical study is conducted to see how more frequent portfolio disclosure impacts mutual funds' performance. In 2004, SEC increased the frequency of mandatory disclosure to quarterly from semi-annual previously. This chapter uses this change in regulation as a natural experiment to see whether the performance of the mutual funds is negatively affected by more frequent disclosure. Prior to the policy change, semi-annual funds with high abnormal returns in the past year outperform the corresponding quarterly funds. This difference in performance disappears after 2004. The reduction in performance is higher for semi-annual funds holding illiquid assets. These results support the hypothesis that funds with more disclosure suffers more from activities such as front-running.

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Chapter 1

Confidential Treatment Requests

1.1 Introduction

Regular mandatory disclosure of holdings by institutional investors allows fund investors to better evaluate the performance of the funds and help them in their asset allocation and diversification decision. However, it also has its drawbacks[1]. Specifically, other market participants may copy the trades of the investment managers and thus free-ride on the latter's research expertise. Frank, Poterba, Shackelford and Shoven (2004), and Wang and Verbeek (2010) use the term copycat funds to describe these investors[2]. The mimicking trades of these copycats would make it more expensive for the investment managers if they decide to acquire more shares in subsequent quarters. This may have negative consequences on informational efficiency of markets

[1]See Wermers (2001) on a discussion of how more frequent mandatory disclosure of mutual funds could potentially reduce their profits.

[2]Frank et al. (2004) provide empirical evidence that after expenses, copycat funds earned statistically indistinguishable and possibly higher returns. They argue that if investors buy actively managed funds to obtain high net-of-expenses returns, then copycat funds could potentially erode their market share by offering comparable returns net of expenses. Wang and Verbeek (2010) show that the relative success of copycat funds have improved after 2004, when the SEC increased the mandatory disclosure frequency to quarterly from semi-annual previously.

if mandatory disclosure reduces the information acquisition efforts of institutional investors. To balance the competing interests, a provision in Section 13(f) allows them to seek confidential treatment for some of their holdings. If approved by the SEC, these holdings will be disclosed at a later date, usually up to one year.

We show that confidential treatment requests impacts the trading strategy and expected profits of institutional investors and the price informativeness of disclosed trades. In this model, we examine the trading strategy of an informed investment manager when he applies for confidential treatment. We assume that the manager seeks confidential treatment on his initial trade to better exploit his private information on the asset over two trading periods[3]. The manager trades in the first period and applies for confidential treatment on this trade. The SEC decides whether to approve this request before the manager trades in the second period. The model most similar to ours is Huddart, Hughes and Levine (2001). Their model is an extension of Kyle (1985) with mandatory disclosure of trades. A perfectly informed risk-neutral insider's trades include a random noise component to disguise the information-based component of the trades when they are publicly disclosed. This diminishes the market maker's ability to draw inferences on the insider's information from his disclosed trades. The insider therefore does not surrender his entire informational advantage after his first trade is disclosed. The authors term this trading strategy dissimulation. Other theoretical papers with variations of this dissimulation strategy include Zhang (2004, 2008), Huang (2008) and Buffa (2010).

In our model, it follows that the manager cannot report the true fair value to the SEC and use Huddart et al. (2001)'s dissimulation strategy at the same time. According to current SEC regulatory guidelines on confidential treatment requests,

[3]There are other possible motives for confidential treatment requests, which are beyond the scope of this paper. They include manipulation (see Fishman and Hagerty (1995), and John and Narayanan (1997)) and window-dressing (see Musto (1997, 1999), and Meier and Schaumburg (2006)).

the fund manager needs to detail a specific on-going investment program in his application. The trade that he wants to delay disclosure therefore needs to be coherent with the investment objective he reports to the SEC. For example, suppose the initial price of the asset before he made his first trade is 10 and he reports the true fair value of 30 to the SEC, his first trade needs to be a buy for the investment program to be coherent. Adding a dissimulation noise term in the first trade may result in a sell instead of a buy. This would result in the SEC rejecting the application.

We find that the equilibrium strategy of the manager is to dissimulate his reported estimate of the fair value to the SEC. Back to the above example, it means that he reports to the SEC a noisy signal that is a sum of the true fair value and a random normally distributed noise term. This random noise term is proportional to the unconditional variance of the fair value. Given this reported noisy signal, the manager has an estimate of the fair value, using the projection theorem of normal random variables. In the event that confidential treatment is denied, the random noise term prevents the market-maker from perfectly inferring the true fair value. Similar to Huddart et al. (2001), no invertible trading strategy can be part of a Nash equilibrium if the manager does not add noise to the true fair value. Suppose the manager reports the true fair value to the SEC. The market-maker will set a perfectly elastic price in the event that the application is rejected and the manager's trade is disclosed. The manager thus would have an incentive to deviate from reporting the true fair value, and make infinite trading profits in the second period if his application is rejected.

Besides the initial trade, we also assume that the manager's subsequent trade is coherent with the reported estimate of the fair value of the asset, in the event confidential treatment is granted. Let us suppose that the manager knows that the true fair value is 20, the estimate he reported to the SEC is 30 and the price in the first round of trading is 25. The manager is committed to buy in the second period if he is granted confidential treatment, even though he is expected to make a loss if he does so. We assume that non-compliance of the reported investment program would result in punitive costs in the form of rejections in future applications by the SEC. We believe that this assumption is reasonable as the second trade is also observable by the SEC. In addition, Agarwal, Jiang, Tang and Yang (2011) provide empirical evidence that past confidential treatment denial rates is the single most important predictor of future denial rates. Therefore it is important for managers to have a good filing track record as it would affect the probability of success in future applications.

Although the granting of confidential treatment prevents the market-maker from inferring the manager's signal from his trade, the commitment to the reported investment program to the SEC reduces his expected profits. This is because the manager would not be able to fully exploit his knowledge of the true fair value in the event his application for confidential treatment is granted. We find that if the probability of application success is below a certain threshold, the expected profits of the manager is lower than in a scenario where he always discloses his trades, as in Huddart et al. (2001).

To our knowledge, this is the first theoretical paper that examines the impact of confidential treatment requests on the trading strategies by informed traders. The empirical literature is also relatively new as databases of institutional holdings like Thomson Reuters Ownership Data generally do not include data on confidential holdings. Agarwal et al. (2011), and Aragon, Hertzel and Shi (2011) are two empirical studies that examine confidential treatment filings. Compared to other investment managers, hedge funds are the most aggressive applicants for confidential treatment of their trades. Both papers document that confidential holdings exhibit superior performance. The first paper also finds a significant positive market reaction after the involuntary disclosure of hedge funds' holdings due to quick rejections of confidential treatment requests by the SEC. The authors conclude that the rejections force the revelation of information that has not been reflected in the stock prices, and this may disrupt the funds' stock acquisition strategies. Their findings support the assumption in our model that confidential treatment applications are primarily for protecting private information. This is in contrast to Cao (2011) who finds evidence that investment firms with poor past trading performance use confidential treatment to hide the liquidation of stocks in their portfolio that have performed poorly. Our model assumes that the manager does not have such window-dressing motives.

The rest of this chapter is structured as follows. Section 1.2 discusses the SEC regulatory guidelines on confidential treatment requests. Section 1.3 describes the model under 2 different scenarios. In the first scenario, the SEC restricts the manager's second period trade such that it is consistent with his reported forecast, in the event confidential treatment is granted. We believe that this scenario is the best depiction of current SEC regulations. We also examine the case where there is no restriction on the manager's second period trade. Comparative statics is discussed in Section 1.4, where we compare the model against a two-period Huddart et al. (2001) and a two-period Kyle (1985) model. Section 1.5 concludes.

1.2 SEC Regulatory Guidelines on Confidential Treatment Requests

Section 13(f) of the Securities Exchange Act of 1934 requires investment managers (who manage more than US$100 million in assets) to publicly disclose their portfolio holdings within 45 days after the end of every quarter. Section 13(f) was enacted by Congress in 1975 to allow the public to have access to the information regarding the purchase, sale and holdings of securities by institutional investors. However, the mandatory disclosure of holdings before an ongoing investment program is complete would be detrimental to the interests of the institutional investor and its fund investors. To balance these competing interests, the SEC allows institutional investors to apply for confidential treatment.

Generally, confidential treatment requests are granted if the investment manager can demonstrate that confidential treatment is in the public interest or for the protection of the investors. According to the SEC[4], there are several key criteria that the manager needs to fulfill for his confidential treatment request to be successful. Firstly, the manager needs to detail a specific investment program. He needs to provide the SEC information regarding the program's ultimate objective and describe the measures taken during that quarter toward effectuating the program. He also needs to provide information on the trades that are made in that quarter to support the existence of the program. Secondly, the investment program must be an on-going one that continues through the date of the filing. Thirdly, the manager must show that the disclosure of the fund's holdings would reveal the investment strategy to the public. Lastly, he must demonstrate that failure to grant confidential treatment to the

[4] See http://www.sec.gov/divisions/investment/guidance/13fpt2.htm for a description of the application process for confidential treatment. These rules were introduced in 1998 to prevent investment managers to use confidential treatment requests as a tool to manipulate the market.

holdings would harm the fund's performance. This would include lost profit opportunities due to mimicking strategies of other copycat investors as well as front-running activities by other market participants. If the manager's application is unsuccessful, he is required to disclose the holdings within 6 business days.

We attempt to explicitly model the above guidelines. We assume that an informed investment manager details a "a specific investment program" by submitting to the SEC his signal of the fair value of the asset. This signal can be interpreted as a target price for the manager. The manager also needs to submit a trade that he has already made in the previous quarter which is consistent with the target price. In the event he is granted confidential treatment, he has to continue trading in the subsequent period in a manner that is consistent with the original target price. This is because the investment program is an "on-going" one.

The SEC application guidelines for confidential treatment requests imply that the trades are typically large trades[5] that have huge price impact and are done over more than one quarter. The SEC receives about 60 such requests every quarter. A recent example is Berkshire Hathaway's (Warren Buffett's investment holding company) purchase of a 5.5% stake in IBM worth US$10 billion in 2011[6]. The SEC allowed the company to defer disclosure of the IBM trades by a quarter. Without confidential treatment being granted, it is likely that the purchase would be more costly.

It is noted that the granting of confidential treatment by the SEC is not a guaranteed event. In their sample of confidential treatment requests from 1999 to 2007, Agarwal et al (2001), report that 17.4% were denied by the SEC. Even applications by well-known investors like Warren Buffett's Berkshire Hathaway have previously

[5]In Agarwal et al.(2011)'s sample, the average confidential holding represents 1.25% of all the shares outstanding by the issuer compared to the average of 0.68% for disclosed holdings.

[6]http://dealbook.nytimes.com/2011/11/14/one-secret-buffett-gets-to-keep/

been rejected[7], with a 72.3% rejection rate from 65 applications. The distribution of rejection rates shows considerable variation across managers.

1.3 Model

1.3.1 Set-up

This Kyle (1985)-type model employs a setting similar to the two-period model in Huddart et al. (2001). There are two trading periods indexed by $n \in \{1, 2\}$. The discount rate is normalised to zero for simplicity. There is one risky asset in the market with a liquidation value of v, where $v \sim N(P_0, \Sigma_0)$. v is realised after the second trading period. There are liquidity traders who summit exogenously generated orders u_n in each trading period, where $u_n \sim N(0, \sigma_u^2)$. We assume that u_1, u_2 and v are all mutually independent.

A risk-neutral informed investment manager observes v perfectly before trading commences. He decides to apply for confidential treatment for his first period trade before making the trade. He trades x_1 in the first period and declares to the SEC that he has a signal θ of the asset value. Let D denote the event in which the first period trade is disclosed (application is unsuccessful) and N denote the event in which the trade is not disclosed (application is successful)[8]. The application for confidential treatment is successful with a probability of α. The manager trades x_2^N (x_2^D) in the second period if the application is successful (unsuccessful).

There exists a competitive risk neutral market maker who sets prices. He cannot

[7] See http://www.bloomberg.com/apps/news?pid=newsarchive&sid=aNd_pTpcmBwA&refer=news_index

[8] Similar to Huddart et al. (2001), since trading occurs only once for every reporting period, the disclosure of holdings is equivalent to the disclosure of trades.

distinguish the trades of the manager from the other uninformed orders of the liquidity traders. He only observes the aggregate order flow y_n in each period and sets the price to be equal to the posterior expectation of v. The price is therefore semi-strong efficient and the market-maker makes zero expected profits due to Bertrand competition with potential rival market-makers. In the event that the manager's first period trade is disclosed, the market-maker updates his expectation of v to P_1^* from the first period price P_1 before trading commences in the second period. Conversely, if there is no disclosure, the market-maker infers that confidential treatment has been granted.

If the manager decides to apply for confidential treatment, we show that an equilibrium exists where he declares to the SEC that he has a signal θ, where $\theta = v + \eta$, $\eta \sim N\left(0, \sigma_\eta^2\right)$, and η is distributed independently of v and u_n. η is the noise term that the manager adds to v when he applies for confidential treatment. Given θ, his reported forecast of v is v'. According to the projection theorem of normal random variables,

$$v' = P_0 + \frac{\Sigma_0}{\Sigma_0 + \sigma_\eta^2}\left(\theta - P_0\right) \tag{1.1}$$

As mentioned earlier, to stand any chance of getting SEC approval for confidential treatment, the manager needs to report a coherent on-going trading program. This means that his first period trade x_1 must be consistent with v'. If his application is successful, his second period trade also needs to be consistent with v' and not v. Using backward induction, this means that the manager chooses x_2^N to maximise his expected second period profits $E\left(\pi_2\right)$ as if his signal is v' instead of v. His maximisation problem is

$$x_2^N \in \arg\max_{x_2^N} E\left(\pi_2|v'\right) \tag{1.2}$$

Referring to the numerical example described in the introduction, we have $P_0 = 10$, $P_1 = 25$, $v = 20$ and $v' = 30$. The manager is committed to buy in the second period (since $v' > P_1$) even though he would make an expected loss in this trade (since $v < P_1$). If the application is rejected, the informed trader is forced to disclose his first period trade before trading commences in the second period. However, the informed trader is now free to make use of his knowledge of v in his second period trade x_2^D as his trading strategy is now not bounded by the confidential treatment request. In contrast to (1.2), the maximisation problem is now

$$x_2^D \in \arg\max_{x_2^D} E\left(\pi_2|v\right) \tag{1.3}$$

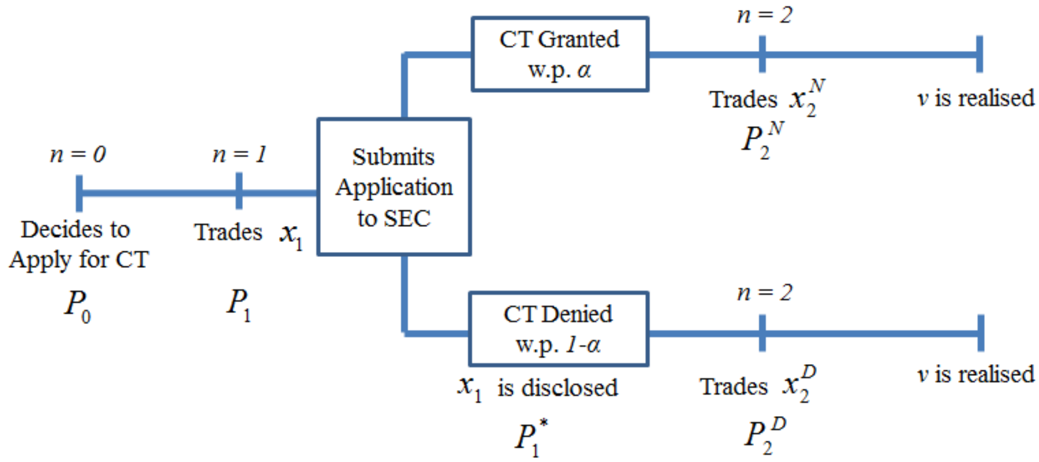
We define Σ_1^N and Σ_1^D as the amount of private information that the manager can exploit in the second period of trading, in the event that confidential treatment is granted and not granted respectively

$$\Sigma_1^N = var\left(v'|y_1\right) = var\left(v' - P_1\right) \tag{1.4}$$

$$\Sigma_1^D = var\left(v|x_1\right) = var\left(v - v'\right) \tag{1.5}$$

Fig 1.1 shows the timeline of the model.

Figure 1.1: Timeline of Events of Confidential Treatment Request



1.3.2 SEC restricts the manager's second period trade after confidential treatment is granted

Proposition 1.1 *If the investment manager applies for confidential treatment and the SEC restricts his second period trade in the event confidential treatment is granted, a subgame perfect linear equilibrium exists in which*

1. *The manager submits his noisy signal θ to the SEC whereby*

$$\theta = v + \eta, \eta \sim N\left(0, \sigma_\eta^2\right) \qquad \sigma_\eta^2 = h\Sigma_0$$

where $0 \leq h \leq 1$ is the only real positive root of the following equation, such that $\lambda_1 > 0$, $\lambda_2^D > 0$, $\lambda_2^N > 0$

$$\left((1-\alpha)^2 - h\right)\sqrt{(1-\alpha)^2 + h} - \alpha(1-\alpha)^2\sqrt{h} = 0$$

2. *The manager's trading strategies and expected profits are of the linear form*

$$x_1 = \beta_1 \left(v' - P_0\right)$$

$$\beta_1 = \frac{\sigma_u}{\sqrt{\Sigma_0}} \frac{\sqrt{h(1+h)}}{(1-\alpha)} \qquad \lambda_1 = \frac{\sqrt{\Sigma_0}}{\sigma_u} \frac{(1-\alpha)}{\left((1-\alpha)^2+h\right)} \sqrt{\frac{h}{1+h}}$$

$$x_2^D = \beta_2^D \left(v - v'\right) \qquad \Sigma_1^D = \frac{h}{1+h} \Sigma_0$$

$$x_2^N = \beta_2^N \left(v' - P_1\right) \qquad \Sigma_1^N = \frac{(1-\alpha)^2}{(1+h)\left((1-\alpha)^2+h\right)} \Sigma_0$$

$$\beta_2^D = \frac{\sigma_u}{\sqrt{\Sigma_1^D}} \qquad \lambda_2^D = \frac{\sqrt{\Sigma_1^D}}{2\sigma_u}$$

$$\beta_2^N = \frac{\sigma_u}{\sqrt{\Sigma_1^N}} \qquad \lambda_2^N = \frac{\sqrt{\Sigma_1^N}}{2\sigma_u}$$

$$E\left(\pi_1\right) = \frac{\beta_1 (1-\lambda_1 \beta_1) \Sigma_0}{1+h}$$

$$E\left(\pi_2^N\right) = \frac{\sigma_u \sqrt{\Sigma_1^N}}{2} \qquad E\left(\pi_2^D\right) = \frac{\sigma_u \sqrt{\Sigma_1^D}}{2}$$

3. The market-maker's pricing rule is of the linear form

$$P_1 = P_0 + \lambda_1 y_1$$

$$P_1^* = v'$$

$$P_2^D = v' + \lambda_2^D y_2^D$$

$$P_2^N = P_1 + \lambda_2^N y_2^N$$

Proof: See Appendix 1.7.1

The main intuition of the proof is as follows. After computing x_2^N and x_2^D, by backward induction, we derive the total expected profits in both periods and then take the first order condition with respect to x_1. The first order condition equation will be in terms of $v - P_0$ and x_1. Following from Huddart et al. (2001), for the mixed strategy $\theta = v + \eta$, $\eta \sim N\left(0, \sigma_\eta^2\right)$ to hold in equilibrium, the manager must be different across all values of x_1, as x_1 is a function of θ. The coefficients of $v - P_0$ and x_1 must therefore be zero, resulting in two simultaneous equations. The other parameters can then be solved.

The variance of the noise σ_η^2 that the manager adds to the forecast he submits to the SEC is directly proportional to the unconditional variance of the fair value Σ_0. In the event that confidential treatment is granted, the second period trade $x_2^N = \beta_2^N (v' - P_1)$ is a linear function of v', in spite of the manager knowing that the true fair value is v. On the other hand, if the confidential treatment request is denied, the manager's second period trade is $x_2^D = \beta_2^D (v - v')$ as the manager is now free to make use of his knowledge of v.

The market-maker is able to infer v' perfectly from x_1 because x_1 is a linear function of $v' - P_0$. He updates his expectation of v to $P_1^* = v'$ from P_1 before trading commences in the second period.

1.3.3 SEC does not restrict the manager's second period trade

In the next proposition, we will examine the manager's equilibrium trading strategy if the SEC does not restrict his second period trade when confidential treatment is granted. The manager is free to use his knowledge of v in his second period trade. We add an upper hat to the endogenous parameters in this equilibrium to distinguish them from those in Proposition 1.1. Therefore in contrast to (1.2), the manager's maximisation problem in the second period when confidential treatment is granted is

$$\widehat{x}_2^N \in \arg\max_{\widehat{x}_2^N} E\left(\widehat{\pi}_2 | v\right) \tag{1.6}$$

Proposition 1.2 *If the investment manager applies for confidential treatment and the SEC does not restrict his second period trade, a subgame perfect linear equilibrium exists in which*

1. The manager submits his noisy forecast $\widehat{\theta}$ to the SEC whereby

$$\widehat{\theta} = v + \widehat{\eta}, \widehat{\eta} \sim N\left(0, \widehat{\sigma}_\eta^2\right) \qquad \widehat{\sigma}_\eta^2 = g\Sigma_0$$

where $0 \leq g \leq 1$ is the only real positive root of the following equation, such that $\widehat{\lambda}_1 > 0$, $\widehat{\lambda}_2^D > 0$, $\widehat{\lambda}_2^N > 0$

$$\alpha\sqrt{\frac{g}{g+1}} - (1-\alpha)\left(g^{2/3}(1-\alpha)^{-4/3} - 1\right)\sqrt{\frac{\frac{g^{2/3}}{1+g}(1-\alpha)^{2/3}+1}{g^{-1/3}(1-\alpha)^{2/3}+1}} = 0$$

2. The manager's trading strategies and expected profits are of the linear form

$$\widehat{x}_1 = \widehat{\beta}_1\left(\widehat{v}' - P_0\right)$$

$$\widehat{\beta}_1 = \frac{\sigma_u}{\sqrt{\Sigma_0}}\left(\frac{1-\alpha}{\sqrt{g}}\right)^{1/3}\sqrt{1+g} \qquad \widehat{\lambda}_1 = \frac{\sqrt{\Sigma_0}(1-\alpha)}{\sigma_u\left(\frac{1-\alpha}{\sqrt{g}}\right)^{1/3}\left(g^{1/3}(1-\alpha)^{1/3}+1-\alpha\right)\sqrt{1+g}}$$

$$\widehat{x}_2^D = \widehat{\beta}_2^D\left(v - \widehat{v}'\right) \qquad \widehat{\Sigma}_1^D = \frac{g}{1+g}\Sigma_0$$

$$\widehat{x}_2^N = \widehat{\beta}_2^N\left(v - \widehat{P}_1\right) \qquad \widehat{\Sigma}_1^N = \frac{\frac{g}{1+g}\left(\frac{1-\alpha}{\sqrt{g}}\right)^{2/3}+1}{\left(\frac{1-\alpha}{\sqrt{g}}\right)^{2/3}+1}\Sigma_0$$

$$\widehat{\beta}_2^D = \frac{\sigma_u}{\sqrt{\widehat{\Sigma}_1^D}} \qquad \widehat{\lambda}_2^D = \frac{\sqrt{\widehat{\Sigma}_1^D}}{2\sigma_u}$$

$$\widehat{\beta}_2^N = \frac{\sigma_u}{\sqrt{\widehat{\Sigma}_1^N}} \qquad \widehat{\lambda}_2^N = \frac{\sqrt{\widehat{\Sigma}_1^N}}{2\sigma_u}$$

$$E\left(\widehat{\pi}_1\right) = \frac{\widehat{\beta}_1\left(1-\widehat{\lambda}_1\widehat{\beta}_1\right)\Sigma_0}{1+g}$$

$$E\left(\widehat{\pi}_2^N\right) = \frac{\sigma_u\sqrt{\widehat{\Sigma}_1^N}}{2} \qquad E\left(\widehat{\pi}_2^D\right) = \frac{\sigma_u\sqrt{\widehat{\Sigma}_1^D}}{2}$$

3. The market-maker's pricing rule is of the linear form

$$\widehat{P}_1 = P_0 + \widehat{\lambda}_1\widehat{y}_1$$

$$\widehat{P}_1^* = \widehat{v}'$$

$$\widehat{P}_2^D = \widehat{v}' + \widehat{\lambda}_2^D\widehat{y}_2^D$$

$$\widehat{P}_2^N = \widehat{P}_1 + \widehat{\lambda}_2^N\widehat{y}_2^N$$

Proof: See Appendix 1.7.2

Since the manager is free to use his knowledge of v, his second period trade given confidential treatment is $\widehat{x}_2^N = \widehat{\beta}_2^N \left(v - \widehat{P}_1 \right)$ instead of $\widehat{\beta}_2^N \left(v' - \widehat{P}_1 \right)$. Similar to the result in Proposition 1.1, the variance of the noise $\widehat{\sigma}_\eta^2$ that the manager adds to the forecast he submits to the SEC is also directly proportional to the unconditional variance of the fair value Σ_0.

Corollary 1.3 *Under both scenarios in Propositions 1.1 and 1.2, a) if $\alpha = 0$, the equilibrium is equivalent to a two-period Huddart et al. (2001) model; b) if $\alpha = 1$, the equilibrium is equivalent to a two-period Kyle (1985) model.*

If $\alpha = 0$, the manager has no chance of getting confidential treatment. Therefore he always discloses his first period trade and this is equivalent to a two-period Huddart et. al (2001) model. The manager adds η to v when he reports his signal to the SEC, where $\sigma_\eta^2 = \Sigma_0$. The manager's first period of trade has the same amount of dissimulation as in a two-period Huddart et. al (2001) model[9]. Similarly, if $\alpha = 1$, the manager is always successful in getting confidential treatment. His first period trade is $x_1 = \beta_1 (v - P_0)$ and he reports $\theta = v$ to the SEC. His second period is $x_2 = \beta_2^N (v - P_1)$ as this is consistent with his reported signal v to the SEC. This scenario is thus equivalent to a two-period Kyle (1985) model.

[9]The first period trade in a two-period Huddart et al. (2001) model is $\overline{x}_1 = \overline{\beta}_1 (v - P_0) + \overline{z}_1$, where $\overline{z}_1$ is the dissimulation term that has a variance of $\frac{\sigma_u^2}{2}$. In Proposition 1.1, the first period trade can be expressed as $x_1 = \frac{\beta_1 \Sigma_0}{\Sigma_0 + \sigma_\eta^2} (v - P_0) + \frac{\beta_1 \Sigma_0}{\Sigma_0 + \sigma_\eta^2} \eta$. It follows that if $\sigma_\eta^2 = \Sigma_0$, the equilibrium in Proposition 1.1 is equivalent to Huddart et al. (2001)'s. The same applies for Proposition 1.2 too.

1.4 Comparative Statics

In this section, we will focus on analysing the parameters in Proposition 1 and 2. We first compare the total expected profits against those that the manager is expected to receive if he always discloses his initial trade.

1.4.1 Manager's Profits

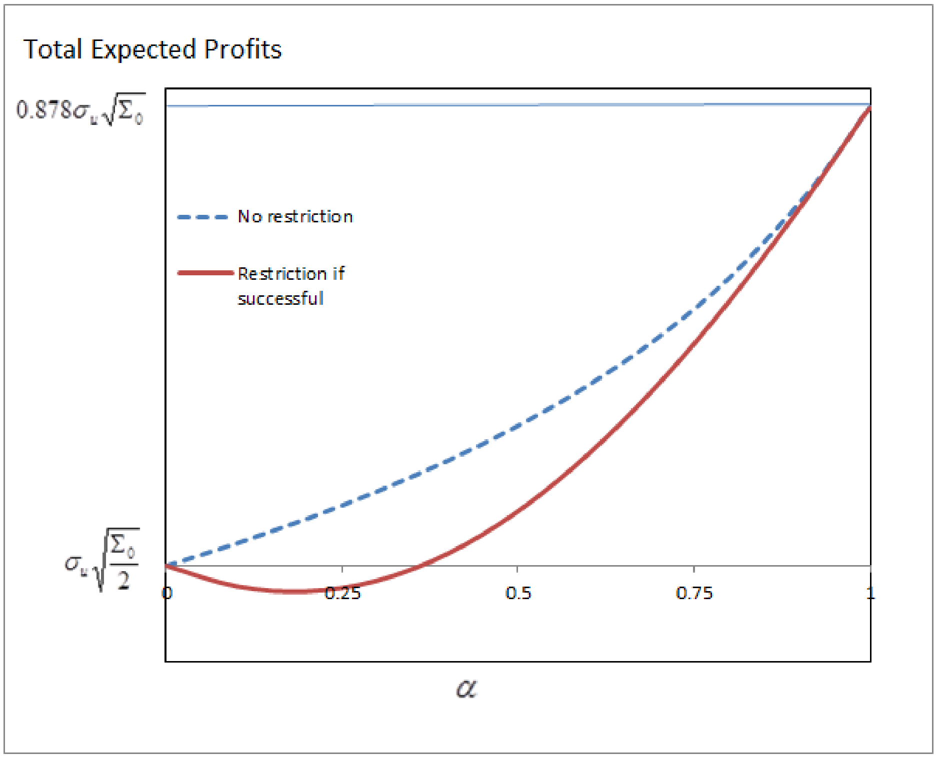
Proposition 1.4 *Compared with the expected profits where the manager always discloses his initial trade (as in Huddart et al. (2001)), a) if the SEC restricts the second period trade in the event confidential treatment is granted, the manager's expected profits will be lower if* $0 \leq \alpha \leq \alpha^*$*, where* $\alpha^* \approx 0.361$*; b) if the SEC does not restrict the second period trade, the manager's expected profits will be always higher for* $0 \leq \alpha \leq 1$

Proof: See Appendix 1.7.3

Fig 1.2 shows the total expected profits (over the two periods) of the manager when he applies for confidential treatment, under the scenarios in Propositions 1.1 and 1.2. The total expected profits under the two-period Huddart et al. (2001) equilibrium is $\sigma_u\sqrt{\frac{\Sigma_0}{2}}$, while those of a two-period Kyle (1985)[10] is approximately $0.878\sigma_u\sqrt{\Sigma_0}$. As discussed in Corollary 1.3, the equilibrium under both scenarios is equivalent to a two-period Huddart et al. (2001) model if $\alpha = 0$, and a two-period Kyle (1985) model if $\alpha = 1$. For all values of α between 0 and 1, the total expected profits in the equilibrium with no second period trade restriction is higher than $\sigma_u\sqrt{\frac{\Sigma_0}{2}}$. On

[10] See Huddart et al. (2001). The paper's Proposition 2 shows the expected profits of a two-period Huddart et al. (2001) dissimulation equilibrium, while Proposition 1 shows the expected profits in a two-period Kyle (1985) model. Note that there is a typo in Proposition 1: $E(\pi_1) = \frac{\sqrt{2K(K-1)}}{4K-1}\sigma_u\sqrt{\Sigma_0}$ instead of $E(\pi_1) = \frac{2K(K-1)}{(4K-1)^2}\sigma_u\sqrt{\Sigma_0}$.

Figure 1.2: Total Expected Profits of Manager Under the 2 Different Assumptions



the other hand, in the equilibrium with the second period trade restriction, the total expected profits are lower than $\sigma_u\sqrt{\frac{\Sigma_0}{2}}$ for $0 \leq \alpha \leq \alpha^*$.

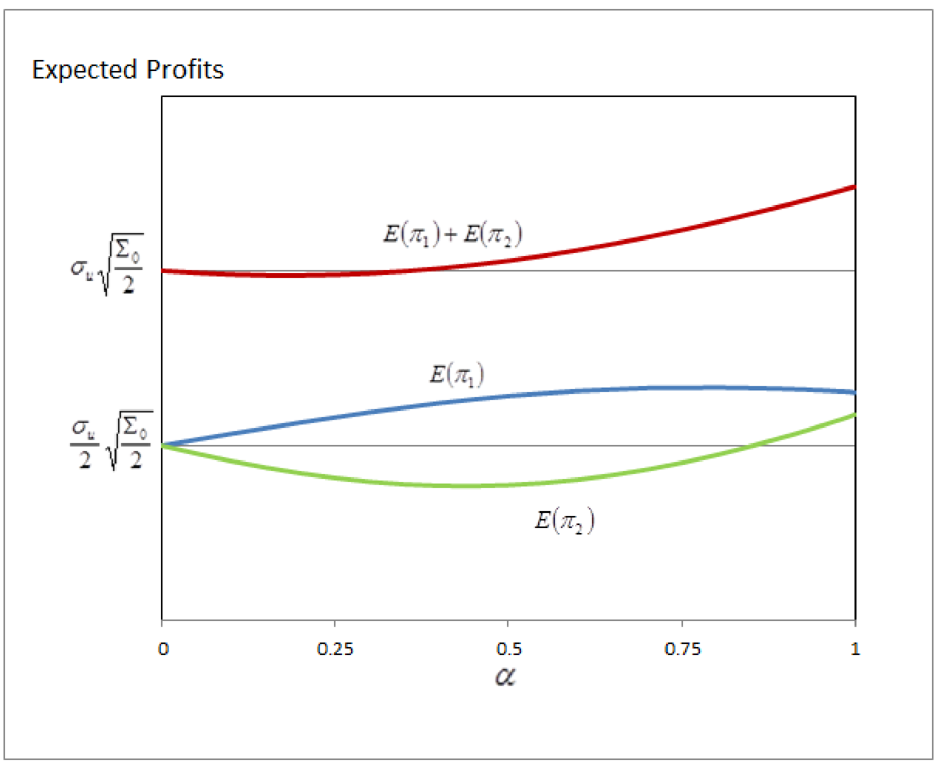
To understand why the manager might have lower expected profits if he applies for confidential treatment in the scenario in Proposition 1.1, let us examine the expected profits in both periods separately. Fig 1.3 shows the comparison of the expected profits of the manager in the scenarios of Proposition 1.1 and 1.2 against those of a

Figure 1.3: Comparison of Expected Profits with Two-period Huddart et al. (2001) Model

	Restriction in second period trade if confidential treatment is granted	**No restriction in second period trade**
$E(\pi_1)$	Always Higher	Always Higher
$E(\pi_2)$	Lower for $0 \leq \alpha \leq 0.854$	Always Higher
$E(\pi_2^N)$	Lower for $0 \leq \alpha \leq 0.485$	Always Higher
$E(\pi_2^D)$	Always Lower	Always Lower
$E(\pi_1)+E(\pi_2)$	Lower for $0 \leq \alpha \leq 0.361$	Always Higher

two-period Huddart et al. (2001) model, where the insider always discloses his first trade. In their model, the informed insider earns the same expected profits $\frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$ in both periods. In our model under both scenarios, the manager always earns higher expected profits in the first period, i.e. $E(\pi_1) \geq \frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$ and $E(\widehat{\pi}_1) \geq \frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$. This is because both σ_η^2 and $\widehat{\sigma}_\eta^2$ are less than Σ_0, implying that the manager is more aggressive in exploiting his information in the first period. In the second period, in the event that confidential treatment is denied, the disclosure of the first period trade results in both $E\left(\pi_2^D\right)$ and $E\left(\widehat{\pi}_2^D\right)$ to be lower than $\frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$. This is because the market-maker updates the price to reflect the information contained in the disclosed trade, reducing the information advantage that the manager can exploit in the second period.

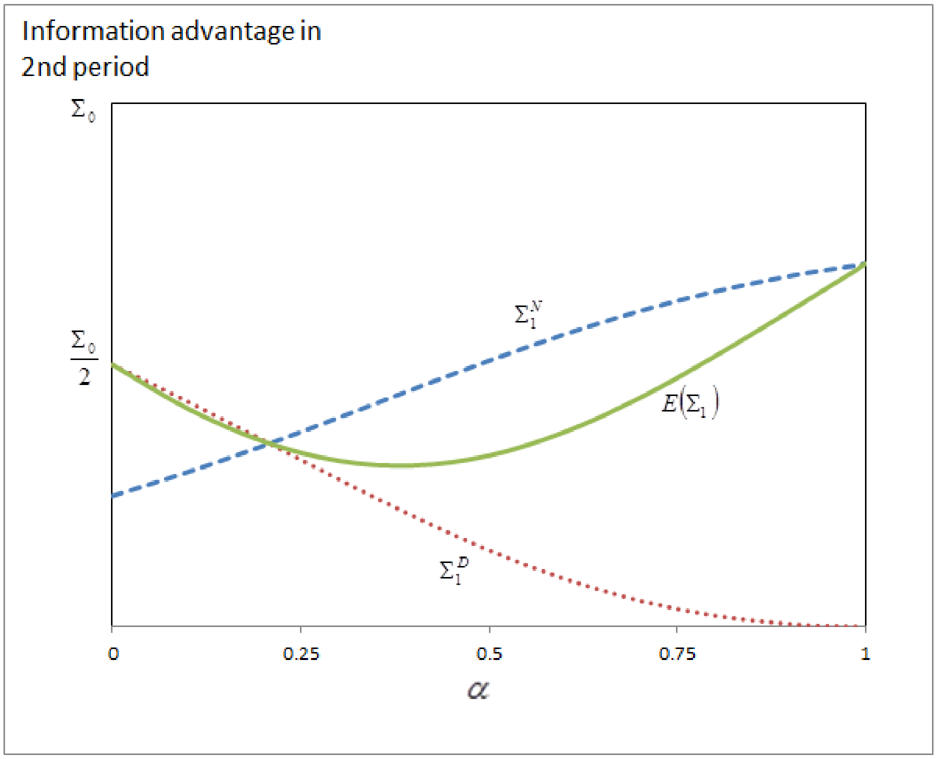
Figure 1.4: Expected Profits of Manager in the 2 Trading Periods under the Assumption that the SEC Restricts the Second Period Trade if Confidential Treatment Request is Successful



The comparison results diverge in the event that confidential treatment is granted. We find that $E\left(\widehat{\pi}_2^N\right) \geq \frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$ for all values of α between 0 and 1, while $E\left(\pi_2^N\right) \leq \frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$ for $0 \leq \alpha \leq 0.485$. Under the scenario in Proposition 1.1, the manager is only able to trade based on his knowledge of v' instead of v. His information advantage in the second period is therefore reduced with this restriction. The reduction in expected profits in $E\left(\pi_2^N\right)$ causes $E\left(\pi_2\right) \leq \frac{\sigma_u}{2}\sqrt{\frac{\Sigma_0}{2}}$ for $0 \leq \alpha \leq 0.854$. Figure 1.4 shows the breakdown in the expected profits of the manager in Proposition 1.1 graphically.

As discussed earlier, Σ_1^D and Σ_1^N measure the amount of private information that the manager can exploit in the second period of trading. These parameters are related to the second period expected profits since $E\left(\pi_2^D\right) = \frac{\sigma_u\sqrt{\Sigma_1^D}}{2}$ and $E\left(\pi_2^N\right) = \frac{\sigma_u\sqrt{\Sigma_1^N}}{2}$. It appears that Σ_1^N should always be greater than Σ_1^D since disclosing the first period trade will result in a loss in the information advantage of the manager. However, if confidential treatment is not granted, the manager can make use of his knowledge of v, while if it is granted, he can only exploit his knowledge of v'. Fig 1.5 shows the relationship between Σ_1^D, Σ_1^N and $E\left(\Sigma_1\right) = \alpha\Sigma_1^N + \left(1-\alpha\right)\Sigma_1^D$ with α. Interestingly, we find that $\Sigma_1^D > \Sigma_1^N$ for $0 \leq \alpha \leq 0.209$. In contrast, in the scenario where the SEC does not restrict the manager's second period trade, we find that $\widehat{\Sigma}_1^D < \widehat{\Sigma}_1^N$ for all values of α between 0 and 1. This is shown in Fig 1.6.

Figure 1.5: Information Advantage of Manager in the 2nd Period under the Assumption that the SEC Restricts the Second Period Trade if Confidential Treatment Request is Successful

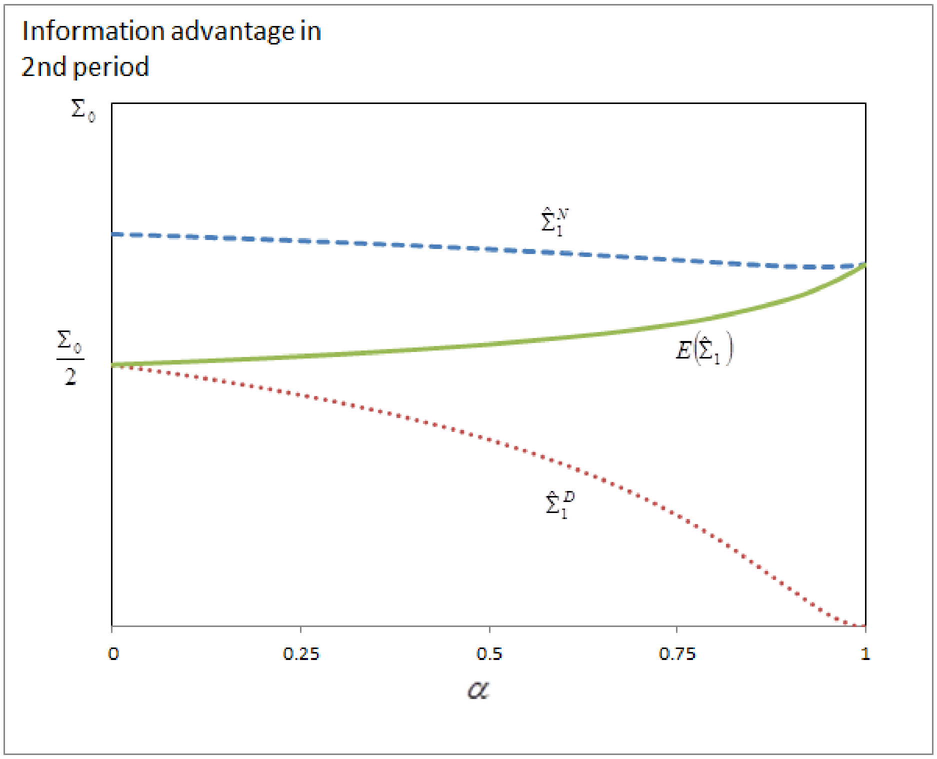


1.4.2 Noise Added to Reported Forecast to the SEC

Corollary 1.5 *a) Under both scenarios in Propositions 1.1 and 1.2, the manager adds less noise to his reported forecast to the SEC as α increases. b) The manager adds less noise in the equilibrium in Proposition 1.1 compared to that in Proposition 1.2.*

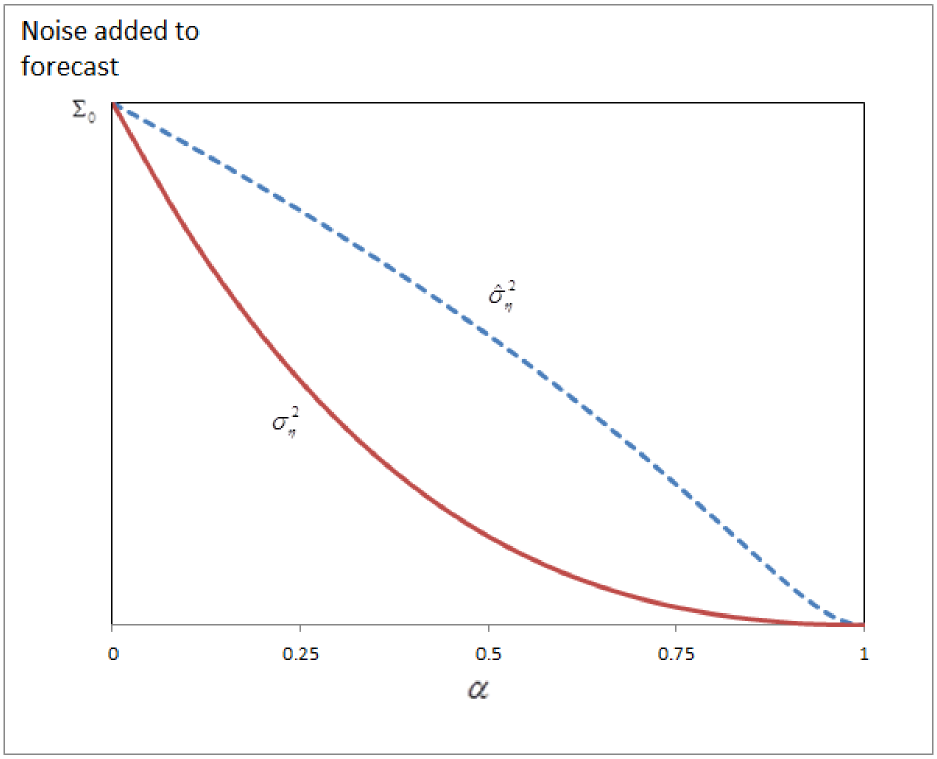
Fig 1.7 shows the relationship between α and the noise that the manager adds to the forecast that he submits to the SEC. As α increases, the manager adds less noise to the forecast, i.e. both $\frac{d\sigma_\eta^2}{d\alpha}$ and $\frac{d\widehat{\sigma}_\eta^2}{d\alpha}$ are negative. This is because adding more noise in the forecast would be more beneficial to the manager ex-post, in the event that his application is rejected. If $\alpha = 1$, the equilibrium is a two-period Kyle (1985) model where there is no noise (the manager reports the true fair value of v to the

Figure 1.6: Information Advantage of Manager in the 2nd Period under the Assumption that the SEC does not Restrict the Second Period Trade



SEC), while if $\alpha = 0$, the equilibrium is a two-period Huddart et al. (2001) model where the noise term is Σ_0. In addition, we note that $\sigma_\eta^2 \leq \widehat{\sigma}_\eta^2$ for all values of α between 0 and 1. Adding more noise to the forecast would result in a v' that varies more from the true fair value v. If the SEC forces the manager to trade based on the reported v' in the event that confidential treatment is granted, the manager would forgo substantial trading profits if he adds too much noise in his application in the first period. The restriction on the second period trade therefore forces the manager to be more truthful in the forecast that he submits to the SEC.

Figure 1.7: Noise Added to the Forecast by Manager in his Confidential Treatment Request under the 2 Different Assumptions



1.4.3 Price Impact of Disclosed Trade

Upon facing a rejection of the confidential treatment request, the manager needs to disclose his first period trade. The market-maker updates the price from P_1 to $P_1^* = v'$ before trading commences in the second period. The price impact of the disclosed trade is

$$E\left(\frac{v' - P_1}{x_1}\right) = \frac{1}{\beta_1} - \lambda_1 \tag{1.7}$$

The first period trade x_1 thus has a price impact of λ_1 on P_1 and another price impact of $\frac{1}{\beta_1} - \lambda_1$ when it is disclosed. Following from Proposition 2 in Huddart et al. (2001), if the manager does not apply for confidential treatment, the corresponding price impact of the disclosed trade is $\frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{2}}$.

Figure 1.8: Price Impact if Manager's Trade is Disclosed due to Unsuccessful Confidential Treatment Request under the 2 Different Assumptions

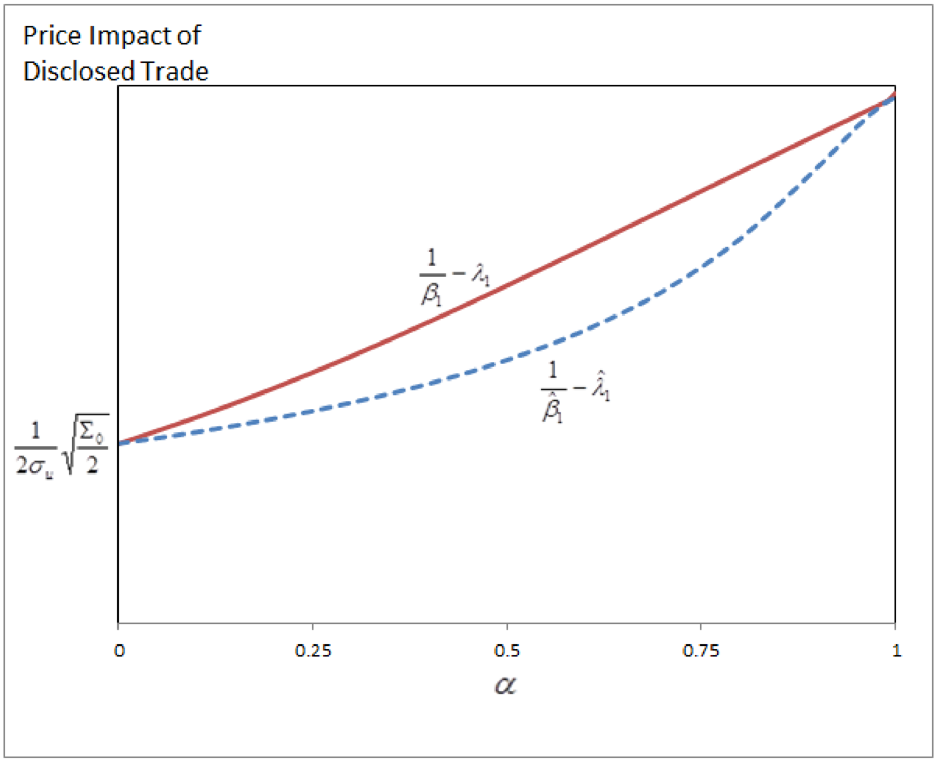


Fig 1.8 depicts the positive relationship between the price impact of the disclosed trade and α. The price impact due to a confidential treatment request denial is greater than that of a voluntarily disclosed trade (where $\alpha = 0$). If managers with a better market reputation of uncovering the fair value of stocks like Warren Buffett are assigned a higher α, then it follows that their disclosed trades due to confidential treatment denials will result in a larger price impact. In addition, we note that the price impact under the scenario where the SEC restricts the second period trade is greater than the price impact under the scenario where there are no restrictions, i.e. $\frac{1}{\beta_1} - \lambda_1 \geq \frac{1}{\beta_1} - \widehat{\lambda}_1$. This follows from Fig 1.7, as the manager adds less noise under the first scenario and therefore the disclosed trade is more informative.

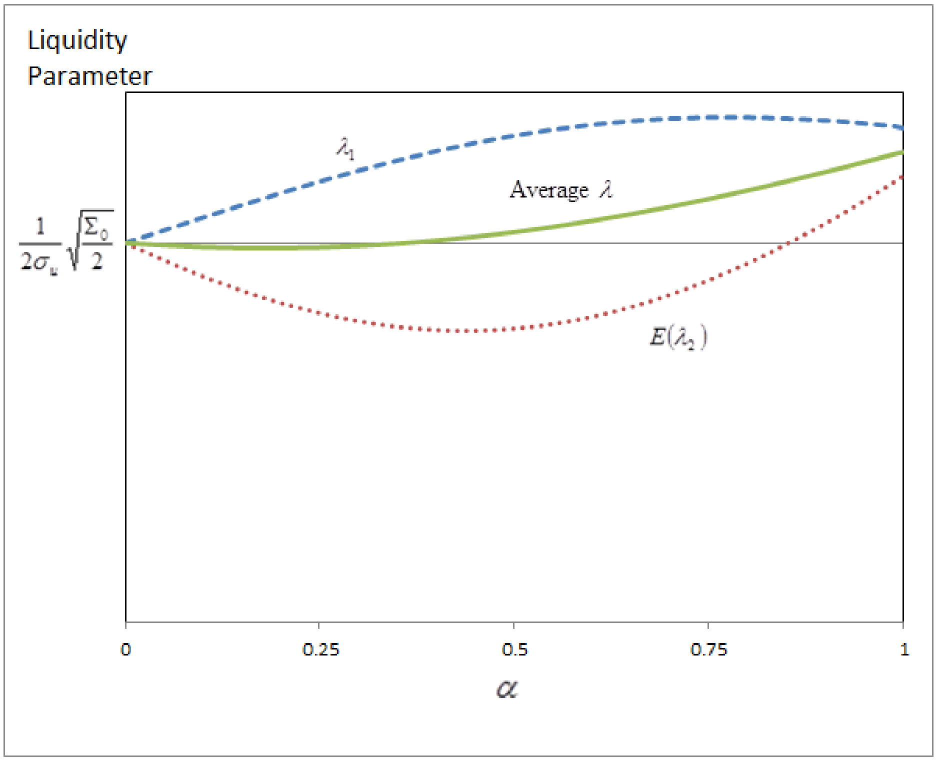
Agarwal et al. (2011) document a significant positive market reaction associated with involuntary disclosure of positions due to relatively quick confidential treatment denials[11] by the SEC. The authors attribute the market reaction as evidence supporting the private information motive of confidential treatment requests. The results of our model imply that the market reaction would be greater for managers with higher α.

1.4.4 Liquidity

We next examine the welfare implications of liquidity traders if the manager applies for confidential treatment. Compared to the case where the manager always discloses his initial trade, confidential treatment implies greater information asymmetry between the manager and the market maker. We would expect greater transaction costs for liquidity traders as market depth decreases. Fig 1.9 depicts the relationship between α and the market-maker's liquidity parameters in Proposition 1.1. In the two-period Huddart et al. (2001) model, $\overline{\lambda}_1 = \overline{\lambda}_2 = \frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{2}}$. Since the liquidity parameters in the second period λ_2^N and λ_2^D are different and liquidity traders by definition cannot choose when they can trade, we compute the expected value of the liquidity parameter in the second period: $E\left(\lambda_2\right) = \alpha\lambda_2^N + \left(1-\alpha\right)\lambda_2^D$. It can be seen that $\lambda_1 \geq \frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{2}}$ for all values of α, while that is not true for $E\left(\lambda_2\right)$. However the average liquidity parameter $\frac{\lambda_1 + E(\lambda_2)}{2}$ over the two periods is greater than $\frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{2}}$ for $\alpha \geq \alpha^*$. We therefore conclude that liquidity traders are worse off if the investment manager applies for confidential treatment. We also arrive at the same conclusion when there is no restriction in the second period trade by the SEC, as shown in Fig 1.10. In this scenario, even $E\left(\widehat{\lambda}_2\right)$ is greater than $\frac{1}{2\sigma_u}\sqrt{\frac{\Sigma_0}{2}}$.

[11] They classify these quick denials as filings that are denied within 45-180 days after the quarter-end portfolio date.

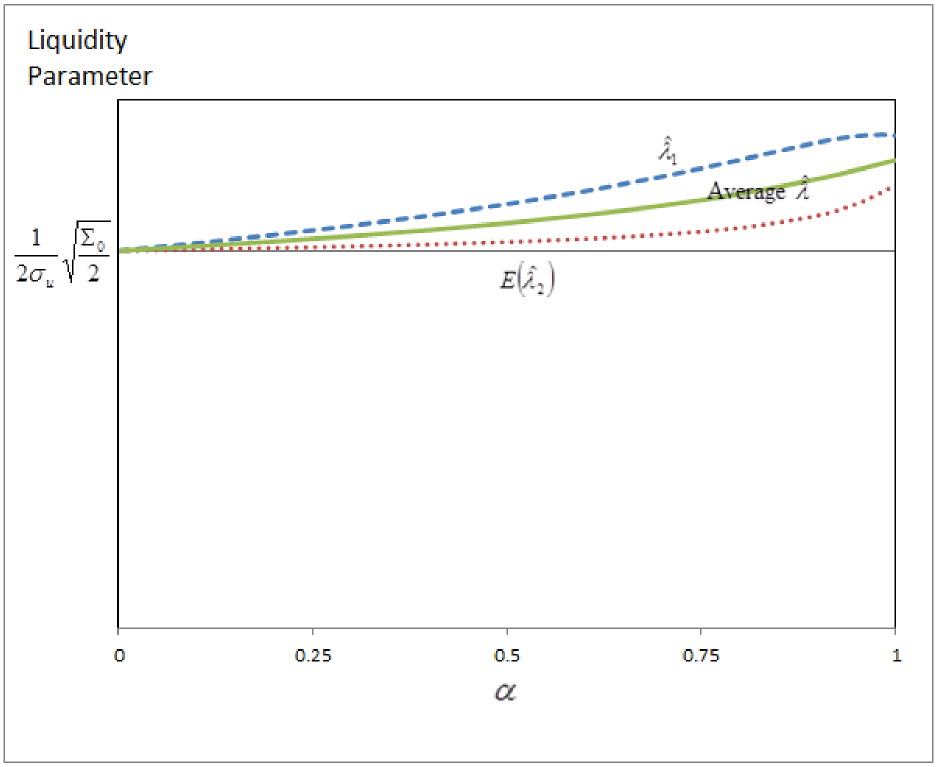
Figure 1.9: Liquidity Parameter under the Assumption that the SEC Restricts the Second Period Trade if Confidential Treatment Request is Successful



1.4.5 Potential Policy Change

Under current SEC policy, the manager needs to make the initial trade before he submits his confidential treatment request, to prove that the trade is part of an ongoing trading program. As discussed earlier, the manager faces the risk that the application is rejected and the trade is disclosed. A potential policy change that increases the manager's welfare would be for him to apply for confidential treatment and the SEC making the decision on the request before trading commences. Similar to the scenario in Proposition 1.2 where there is no restriction on the manager's second period trade, he would always apply for confidential treatment. The manager would be in a two-period Kyle (1985) equilibrium with probability α, and Huddart et. al (2001) equilibrium with probability $1-\alpha$. The manager's profit functions under both scenarios in Propositions 1.1 and 1.2 are convex in α (see Fig 1.2) for $0 \leq \alpha \leq 1$. This

Figure 1.10: Liquidity Parameter under the Assumption that the SEC does not Restrict the Second Period Trade



is because in the event of a successful application, he does not forgo any expected profits by adding noise in the initial trade, unlike the earlier scenarios. Therefore the manager would be better off with this change in policy. Correspondingly, expected liquidity falls and noise traders are worse off.

1.5 Conclusion

The primary contribution of this paper is a theoretical model which describes market microstructure with confidential treatment requests of trades by investment managers. These trades are typically large ones that have huge price impact and are done over more than one quarter. The key feature we capture is that the SEC requires the manager to present a coherent on-going trading program in his application for confidential treatment. In the event his confidential treatment request is granted, he has to trade in a manner consistent with his reported forecast in the subsequent period. We assume that failure to do so would result in future rejections by the SEC and model this as an exogenous restriction in the manager's second period trade. Analogous to Huddart et al.'s (2001) dissimulation trading strategy, in equilibrium, the manager adds noise to the forecast that he reports to the SEC.

Our model explains various stylized facts described in the empirical literature. Although all investors can apply for confidential treatment, not everybody does. Furthermore, when they do apply, they are not always successful. Our model predicts that with the SEC restriction in the second period, managers only earn higher expected profits if their probability of successful application is higher than a certain threshold. If there is no such restriction, expected profits would always be higher. This is consistent with managers having heterogeneous probabilities of success. For instance, funds that employ quantitative and statistical arbitrage trading strategies involving multiple assets may find it more difficult to convince the SEC that disclosure would reveal the trading strategy to the public and harm its performance[12]. This

[12] See http://sec.gov/rules/other/34-52134.pdf. It is a rejection letter issued by the SEC on Two Sigma Investments LLC confidential treatment request in 2005. The fund uses trading strategies based on statistical models. In another case, D.E. Shaw & Company, a large quant-oriented hedge fund manager filed for confidential treatment for its entire second quarter portfolio in 2007. Their request was rejected and they were forced to disclose their whole portfolio valued at US$79 billion.

is because the SEC will only grant confidential treatment on a position-by-position basis. In addition, Agarwal et al. (2011) report that hedge funds with higher past rejection rates are more likely to be rejected again in future applications which supports the assertion that the probability of success is a fund characteristic.

Aragon et al. (2011) and Agarwal et al. (2011) both find confidential holdings of hedge funds yield superior performance. In our model, trading after a successful application has higher expected profits whenever managers find it ex ante optimal to apply. Agarwal et al. (2011) further report a significant positive market reaction after the involuntary disclosure of hedge funds' trades following rejections of confidential treatment requests. We also find that in our model. The noise that the manager adds to the first period trade successfully obscures some of his private information which can be exploited in the second period. However, a failed application reveals this information and prices react accordingly.

Finally, we examine the impact of confidential treatment provisions on market liquidity and the welfare of liquidity traders. We find that market depth is lower when the manager applies for confidential treatment. Liquidity traders will be worse off.

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1.7 Appendix

1.7.1 Proof of Proposition 1.1

If the application is not successful, his first period trade will be disclosed. The market-maker observes x_1 and is able to infer v' perfectly. The price of asset will be adjusted to v' before the second round of trading commences. Assume that

$$x_2^D = \beta_2^D \left(v - v'\right) \tag{1.8}$$

$$P_2^D = v' + \lambda_2^D y_2^D$$

If the application is successful, his first period trade will not be disclosed. Assume that

$$x_2^N = \beta_2^N \left(v' - P_1\right) \tag{1.9}$$

$$P_2^N = P_1 + \lambda_2^N y_2^N$$

The model is solved by backward induction. Let us first analyse the scenario in which the application is not successful and the informed trader is forced to disclose his first period trade. The informed trader maximises second period profits

$$E\left[\left(v - P_2^D\right) x_2^D | v\right] = E\left[\left(v - v' - \lambda_2^D x_2^D\right) x_2^D\right]$$

Taking first order condition with respect to x_2^D results in the following equations

$$x_2^D = \frac{1}{2\lambda_2^D} \left(v - v'\right)$$

$$\beta_2^D = \frac{1}{2\lambda_2^D} \tag{1.10}$$

$$E\left[\pi_2^D\left(v', v\right)\right] = \frac{1}{4\lambda_2^D}\left(v - v'\right)^2$$

In the event that the application is successful, the informed trader has to choose x_2^N that is coherent with v'. This means that x_2^N is chosen such that it maximises second period profits as if the informed trader has a signal v'.

$$E\left[\left(v - P_2^N\right) x_2^N | v'\right] = E\left[\left(v' - P_1 - \lambda_2^N x_2^N\right) x_2^N\right]$$

Taking first order condition with respect to x_2^N

$$x_2^N = \frac{1}{2\lambda_2^N}\left(v' - P_1\right)$$

$$\beta_2^N = \frac{1}{2\lambda_2^N} \tag{1.11}$$

Since the informed trader knows v instead of v', the expected profits in the second period when confidential treatment is granted is

$$E\left[\pi_2^N\left(P_1, v'\right)|v\right] = E\left[\left(v - P_2^N\right) x_2^N | v\right] = \frac{1}{2\lambda_2^N}\left(v - \frac{v'}{2} - \frac{P_1}{2}\right)\left(v' - P_1\right)$$

Stepping back to the first period, the total expected profits in both periods is

$$\begin{aligned} & E\left[\left(v - P_1\right) x_1 + \left(1 - \alpha\right)\pi_2^D\left(v', v\right) + \alpha\pi_2^N\left(P_1, v'\right)|v\right] \\ = \; & E\left[\begin{array}{c} \left(v - P_0 - \lambda_1 x_1\right) x_1 + \frac{1-\alpha}{4\lambda_2^D}\left(v - P_0 - \frac{x_1}{\beta_1}\right)^2 \\ + \frac{\alpha}{2\lambda_2^N}\left(v - P_0 - \frac{x_1}{2\beta_1} - \frac{\lambda_1 x_1}{2}\right)\left(\frac{x_1}{\beta_1} - \lambda_1 x_1\right) \end{array}\right] \end{aligned}$$

Taking first order condition with respect to x_1

$$(v - P_0)\left(1 - \frac{1-\alpha}{2\lambda_2^D \beta_1} + \frac{\alpha}{2\lambda_2^N}\left(\frac{1}{\beta_1} - \lambda_1\right)\right) + x_1\left(-2\lambda_1 + \frac{1-\alpha}{2\lambda_2^D \beta_1^2} - \frac{\alpha}{2\lambda_2^N}\left(\frac{1}{\beta_1^2} - \lambda_1^2\right)\right) = 0$$

The second-order condition is

$$-2\lambda_1 + \frac{1-\alpha}{2\lambda_2^D \beta_1^2} - \frac{\alpha}{2\lambda_2^N}\left(\frac{1}{\beta_1^2} - \lambda_1^2\right) \leq 0$$

Following from Huddart et al. (2001), for the mixed strategy $\theta = v + \eta$, $\eta \sim N\left(0, \sigma_\eta^2\right)$ to hold in equilibrium, the manager must be indifferent across all values of x_1, as x_1 is a function of θ. We seek positive values of λ_1, λ_2^D and λ_2^N such that

$$1 - \frac{1-\alpha}{2\lambda_2^D \beta_1} + \frac{\alpha}{2\lambda_2^N}\left(\frac{1}{\beta_1} - \lambda_1\right) = 0$$

and

$$-2\lambda_1 + \frac{1-\alpha}{2\lambda_2^D \beta_1^2} - \frac{\alpha}{2\lambda_2^N}\left(\frac{1}{\beta_1^2} - \lambda_1^2\right) = 0$$

Re-arranging terms,

$$\beta_1 = \frac{1}{\lambda_1} - \frac{1-\alpha}{2\lambda_2^D} \tag{1.12}$$

and

$$\beta_1 = \frac{2\lambda_2^N - \alpha\lambda_1}{\lambda_1\left(4\lambda_2^N - \alpha\lambda_1\right)} \tag{1.13}$$

Using the projection theorem of normal random variables on y_1, y_2^N and y_2^D, we obtain

$$\lambda_1 = \frac{\frac{\beta_1 \Sigma_0^2}{\Sigma_0 + \sigma_\eta^2}}{\frac{\beta_1^2 \Sigma_0^2}{\Sigma_0 + \sigma_\eta^2} + \sigma_u^2} \tag{1.14}$$

$$\Sigma_1^D = \frac{\sigma_\eta^2}{\Sigma_0 + \sigma_\eta^2}\Sigma_0 \tag{1.15}$$

$$\Sigma_1^N = \frac{\Sigma_0^2}{\Sigma_0 + \sigma_\eta^2} - \frac{\left(\frac{\beta_1 \Sigma_0^2}{\Sigma_0 + \sigma_\eta^2}\right)^2}{\frac{\beta_1^2 \Sigma_0^2}{\Sigma_0 + \sigma_\eta^2} + \sigma_u^2} \tag{1.16}$$

$$\lambda_2^D = \frac{\beta_2^D \Sigma_1^D}{\beta_2^{D^2} \Sigma_1^D + \sigma_u^2} \tag{1.17}$$

$$\lambda_2^N = \frac{\beta_2^N \Sigma_1^N}{\beta_2^{N^2} \Sigma_1^N + \sigma_u^2} \tag{1.18}$$

(1.10) and (1.17) imply

$$\beta_2^D = \frac{\sigma_u}{\sqrt{\Sigma_1^D}} \tag{1.19}$$

$$\lambda_2^D = \frac{\sqrt{\Sigma_1^D}}{2\sigma_u} \tag{1.20}$$

while (1.11) and (1.18) imply

$$\beta_2^N = \frac{\sigma_u}{\sqrt{\Sigma_1^N}} \tag{1.21}$$

$$\lambda_2^N = \frac{\sqrt{\Sigma_1^N}}{2\sigma_u} \tag{1.22}$$

Substituting (1.14), (1.15) and (1.20) into (1.12) gives us

$$\beta_1 = \frac{\sigma_u \sigma_\eta}{(1-\alpha)\,\Sigma_0}\sqrt{\frac{\Sigma_0 + \sigma_\eta^2}{\Sigma_0}} \tag{1.23}$$

$$\lambda_1 = \frac{(1-\alpha)\,\Sigma_0\sigma_\eta}{\sigma_u\left(\sigma_\eta^2 + (1-\alpha)^2\,\Sigma_0\right)}\sqrt{\frac{\Sigma_0}{\Sigma_0+\sigma_\eta^2}} \tag{1.24}$$

Substituting (1.16), (1.22), (1.23) and (1.24) into (1.13) results in the following equation for σ_η^2

$$\left((1-\alpha)^2 - h\right)\sqrt{h+(1-\alpha)^2} - \alpha\,(1-\alpha)^2\sqrt{h} = 0 \tag{1.25}$$

where $\sigma_\eta^2 = h\Sigma_0$

Expected profits in first period

$$\begin{aligned}
&E\left(\pi_1\right) = E\left[\left(v-P_1\right)x_1|v\right] \\
&= E\left[\left(v-P_0-\lambda_1\beta_1\left(v'-P_0\right)\right)\beta_1\left(v'-P_0\right)\right] \\
&= \tfrac{\beta_1(1-\lambda_1\beta_1)\Sigma_0}{1+h}
\end{aligned}$$

Expected profits in second period with successful application

$$\begin{aligned}
&E\left(\pi_2^N\right) = E\left[\left(v-P_2^N\right)x_2^N|v\right] \\
&= E\left[\left(v-v'+\tfrac{1}{2}\left(v'-P_1\right)\right)\beta_2^N\left(v'-P_1\right)\right] \\
&= \tfrac{\beta_2^N\Sigma_1^N}{2}
\end{aligned}$$

Expected profits in second period with unsuccessful application

$$\begin{aligned}
&E\left(\pi_2^D\right) = E\left[\left(v-P_2^D\right)x_2^D|v\right] \\
&= E\left[\tfrac{1}{2}\beta_2^D\left(v-v'\right)^2\right] \\
&= \tfrac{\beta_2^D\Sigma_1^D}{2}
\end{aligned}$$

1.7.2 Proof of Proposition 1.2

If the manager's second period trade is not enforced by the SEC in the event he is granted confidential treatment, he is free to use v instead of $\widehat{v}'$. Therefore we have

$$\widehat{x}_2^N = \widehat{\beta}_2^N \left(v - \widehat{P}_1\right) \tag{1.26}$$

$$E\left[\widehat{\pi}_2^N\left(\widehat{P}_1, v\right)|v\right] = E\left[\left(v - \widehat{P}_2^N\right)\widehat{x}_2^N|v\right] = \frac{1}{4\widehat{\lambda}_2^N}\left(v - \widehat{P}_1\right)^2$$

Similar to the proof in Proposition 1.1, we obtain

$$\widehat{\beta}_2^N = \frac{1}{2\widehat{\lambda}_2^N} \tag{1.27}$$

$$\widehat{x}_2^D = \widehat{\beta}_2^D \left(v - \widehat{v}'\right) \tag{1.28}$$

$$\widehat{\beta}_2^D = \frac{1}{2\widehat{\lambda}_2^D} \tag{1.29}$$

Stepping back to the first period, the total expected profits in both periods is

$$\begin{aligned} &E\left[\left(v - \widehat{P}_1\right)\widehat{x}_1 + (1-\alpha)\,\widehat{\pi}_2^D\left(\widehat{v}', v\right) + \alpha\widehat{\pi}_2^N\left(\widehat{P}_1, v\right)|v\right] \\ &= E\left[\left(v - P_0 - \widehat{\lambda}_1\widehat{x}_1\right)\widehat{x}_1 + \tfrac{1-\alpha}{4\widehat{\lambda}_2^D}\left(v - P_0 - \tfrac{\widehat{x}_1}{\widehat{\beta}_1}\right)^2 + \tfrac{\alpha}{4\widehat{\lambda}_2^N}\left(v - P_0 - \widehat{\lambda}_1\widehat{x}_1\right)^2\right] \end{aligned}$$

Taking first order condition with respect to x_1

$$(v - P_0)\left(1 - \frac{1-\alpha}{2\widehat{\lambda}_2^D\widehat{\beta}_1} - \frac{\alpha\widehat{\lambda}_1}{2\widehat{\lambda}_2^N}\right) + \widehat{x}_1\left(-2\widehat{\lambda}_1 + \frac{1-\alpha}{2\widehat{\lambda}_2^D\widehat{\beta}_1^2} + \frac{\alpha\widehat{\lambda}_1^2}{2\widehat{\lambda}_2^N}\right) = 0$$

The second-order condition is

$$-2\widehat{\lambda}_1 + \frac{1-\alpha}{2\widehat{\lambda}_2^D \widehat{\beta}_1^2} + \frac{\alpha \widehat{\lambda}_1^2}{2\widehat{\lambda}_2^N} \leq 0$$

For the mixed strategy $\theta = v + \eta$, $\eta \sim N\left(0, \widehat{\sigma}_\eta^2\right)$ to hold in equilibrium, the manager must be different across all values of $\widehat{x}_1$, as $\widehat{x}_1$ is a function of θ. We seek positive values of $\widehat{\lambda}_1$, $\widehat{\lambda}_2^D$ and $\widehat{\lambda}_2^N$ such that

$$1 - \frac{1-\alpha}{2\widehat{\lambda}_2^D \widehat{\beta}_1} - \frac{\alpha \widehat{\lambda}_1}{2\widehat{\lambda}_2^N} = 0$$

and

$$-2\widehat{\lambda}_1 + \frac{1-\alpha}{2\widehat{\lambda}_2^D \widehat{\beta}_1^2} + \frac{\alpha \widehat{\lambda}_1^2}{2\widehat{\lambda}_2^N} = 0$$

Re-arranging terms

$$\widehat{\beta}_1 = \frac{2\widehat{\lambda}_2^N - \alpha\widehat{\lambda}_1}{\widehat{\lambda}_1\left(4\widehat{\lambda}_2^N - \alpha\widehat{\lambda}_1\right)} \tag{1.30}$$

$$\widehat{\lambda}_1 = \frac{1-\alpha}{\widehat{\beta}_1\left(2\widehat{\lambda}_2^D \widehat{\beta}_1 + 1 - \alpha\right)} \tag{1.31}$$

Using the projection theorem of normal random variables on $\widehat{y}_1$, $\widehat{y}_2^N$ and $\widehat{y}_2^D$, we obtain

$$\widehat{\lambda}_1 = \frac{\frac{\widehat{\beta}_1 \Sigma_0^2}{\Sigma_0 + \widehat{\sigma}_\eta^2}}{\frac{\widehat{\beta}_1^2 \Sigma_0^2}{\Sigma_0 + \widehat{\sigma}_\eta^2} + \sigma_u^2} \tag{1.32}$$

$$\widehat{\Sigma}_1^D = \frac{\widehat{\sigma}_\eta^2}{\Sigma_0 + \widehat{\sigma}_\eta^2}\Sigma_0 \tag{1.33}$$

$$\widehat{\Sigma}_1^N = \Sigma_0 - \frac{\left(\frac{\widehat{\beta}_1 \Sigma_0^2}{\Sigma_0 + \widehat{\sigma}_\eta^2}\right)^2}{\frac{\widehat{\beta}_1^2 \Sigma_0^2}{\Sigma_0 + \widehat{\sigma}_\eta^2} + \widehat{\sigma}_u^2} \tag{1.34}$$

$$\widehat{\lambda}_2^D = \frac{\widehat{\beta}_2^D \widehat{\Sigma}_1^D}{\widehat{\beta}_2^{D^2} \widehat{\Sigma}_1^D + \sigma_u^2} \tag{1.35}$$

$$\widehat{\lambda}_2^N = \frac{\widehat{\beta}_2^N \widehat{\Sigma}_1^N}{\widehat{\beta}_2^{N2} \widehat{\Sigma}_1^N + \sigma_u^2} \tag{1.36}$$

(1.29) and (1.35) imply

$$\widehat{\beta}_2^D = \frac{\sigma_u}{\sqrt{\widehat{\Sigma}_1^D}} \tag{1.37}$$

$$\widehat{\lambda}_2^D = \frac{\sqrt{\widehat{\Sigma}_1^D}}{2\sigma_u} \tag{1.38}$$

while (1.27) and (1.36) imply

$$\widehat{\beta}_2^N = \frac{\sigma_u}{\sqrt{\widehat{\Sigma}_1^N}} \tag{1.39}$$

$$\widehat{\lambda}_2^N = \frac{\sqrt{\widehat{\Sigma}_1^N}}{2\sigma_u} \tag{1.40}$$

Substituting (1.32), (1.33) and (1.38) into (1.31) gives us

$$\widehat{\beta}_1 = \sigma_u \left(\frac{1-\alpha}{\Sigma_0 \widehat{\sigma}_\eta}\right)^{1/3} \sqrt{\frac{\Sigma_0 + \widehat{\sigma}_\eta^2}{\Sigma_0}} \tag{1.41}$$

$$\widehat{\lambda}_1 = \frac{1-\alpha}{\sigma_u \left(\frac{1-\alpha}{\Sigma_0 \widehat{\sigma}_\eta}\right)^{1/3} \left(\widehat{\sigma}_\eta \left(\frac{1-\alpha}{\Sigma_0 \widehat{\sigma}_\eta}\right)^{1/3} + 1 - \alpha\right)} \sqrt{\frac{\Sigma_0}{\Sigma_0 + \widehat{\sigma}_\eta^2}} \tag{1.42}$$

Substituting (1.34), (1.40), (1.41) and (1.42) into (1.30) results in the following equation for $\widehat{\sigma}_\eta^2$

$$\alpha\sqrt{\frac{g}{g+1}} - (1-\alpha)\left(g^{2/3}(1-\alpha)^{-4/3}-1\right)\sqrt{\frac{\frac{g^{2/3}}{1+g}(1-\alpha)^{2/3}+1}{g^{-1/3}(1-\alpha)^{2/3}+1}} = 0 \tag{1.43}$$

where $\widehat{\sigma}_\eta^2 = g\Sigma_0$

Expected profits in first period

$$\begin{aligned}
&E(\widehat{\pi}_1) = E\left[\left(v - \widehat{P}_1\right)\widehat{x}_1|v\right] \\
&= E\left[\left(v - P_0 - \widehat{\lambda}_1\widehat{\beta}_1(\widehat{v}' - P_0)\right)\widehat{\beta}_1(\widehat{v}' - P_0)\right] \\
&= \tfrac{\widehat{\beta}_1\left(1-\widehat{\lambda}_1\widehat{\beta}_1\right)\Sigma_0}{1+g}
\end{aligned}$$

Expected profits in second period with successful application

$$\begin{aligned}
&E\left(\widehat{\pi}_2^N\right) = E\left[\left(v - \widehat{P}_2^N\right)\widehat{x}_2^N|v\right] \\
&= E\left[\tfrac{1}{2}\widehat{\beta}_2^N\left(v - \widehat{P}_1\right)^2\right] \\
&= \tfrac{\widehat{\beta}_2^N\widehat{\Sigma}_1^N}{2}
\end{aligned}$$

Expected profits in second period with unsuccessful application

$$\begin{aligned}
&E\left(\widehat{\pi}_2^D\right) = E\left[\left(v - \widehat{P}_2^D\right)\widehat{x}_2^D|v\right] \\
&= E\left[\tfrac{1}{2}\widehat{\beta}_2^D(v - \widehat{v}')^2\right] \\
&= \tfrac{\widehat{\beta}_2^D\widehat{\Sigma}_1^D}{2}
\end{aligned}$$

1.7.3 Proof of Proposition 1.4

If the SEC constraints the manager's second period trade, the manager's total profits is lower than those obtained from a trading strategy of disclosure as in Huddart et al. (2001) if

$$E\left(\pi_1\right) + \alpha E\left(\pi_2^N\right) + (1-\alpha)\, E\left(\pi_2^D\right) \leq \sigma_u \sqrt{\frac{\Sigma_0}{2}} \tag{1.44}$$

From the plot of the expected profit function in Fig. 1.2, there is a threshold value of α which we will call α^*, below which total expected profits from application are lower than with disclosure. α^* satisfies the equality

$$E\left(\pi_1\right) + \alpha E\left(\pi_2^N\right) + (1-\alpha)\, E\left(\pi_2^D\right) = \sigma_u \sqrt{\frac{\Sigma_0}{2}} \tag{1.45}$$

Substituting the profit functions in Proposition 1.1 into (1.45)

$$\frac{1-\alpha}{\sqrt{1+h}} \left[\frac{2\sqrt{h}}{h+(1-\alpha)^2} + \frac{\alpha}{\sqrt{h+(1-\alpha)^2}} + \sqrt{h} \right] - \sqrt{2} = 0 \tag{1.46}$$

Notice that the exogenous parameters σ_u and Σ_0 are not present in (1.46). From (1.46) and (1.25), we obtain numerically to 3 decimal places:

$$\alpha^* \approx 0.361$$

On the other hand, if the SEC does not restrict his second period trade, we find that

$$E\left(\widehat{\pi}_1\right) + \alpha E\left(\widehat{\pi}_2^N\right) + (1-\alpha)\, E\left(\widehat{\pi}_2^D\right) \geq \sigma_u \sqrt{\frac{\Sigma_0}{2}} \tag{1.47}$$

This means the manager's expected profits will always be higher than in the Huddart et al. (2001) case.

Chapter 2

Strategic Trading and Disclosure of Informed Traders in the Presence of Copycats

2.1 Introduction

Many market participants face mandatory disclosure requirements under US securities laws. They include corporate insiders and mutual fund managers. Corporate insiders are required to disclose their equity trades as they have an unfair advantage over other market participants. They have access to price sensitive information like new contract wins and revenue projections. Therefore, their trades would be closely scrutinised by the market when they are disclosed. On the other hand, the job of fund managers is to gather information on the profit potential of the companies they cover so that their portfolios can beat their respective benchmarks. The trades of well-known investors like Warren Buffett and Bill Miller are on the radar screen of many market participants. Many investors try to free-ride on their expertise by replicating their trades once they are disclosed. Frank, Poterba, Shackelford and Shoven (2004) use the term copycat funds to describe these investors. Warren Buffett is so well regarded by the investment community that even the SEC acknowledged that there have been a number of occasions where disclosure of Berkshire Hathaway's (Warren Buffett's investment vehicle) stock purchase or selling programs resulted in temporary spikes in the market[1].

There are also other up-and-coming talented fund managers who receive less media coverage than the Buffetts and Millers of this world. Even if they have superior information, the disclosure of their trades would likely be followed by a smaller number of copycats and thus have less market impact. We study the effect of trade disclosure by an informed trader, using an exogenous variable to measure the number of copycats that follow their trades. Previous theoretical papers on disclosure have used models where the game is played between the insider or informed agent against the market-maker. For example, Fishman (2006) assumes that any copycats or followers of the informed investor's trades would earn zero profits due to competition, and folds them into market-makers in their model. In our model, we distinguish between the copycats and the market-maker. Using a variation of Kyle (1985)'s model, we depart from the literature by making the assumption that the copycats are able to identify the disclosed trade of the informed trader, while the market-maker is only able to observe the total order flow in each trading period. Although the market-maker knows that the informed investor is trading, he cannot differentiate the latter from other noise traders even after the trade is disclosed. As the number of copycats approaches infinity, our model is equivalent to one where the market-maker is able to identify the disclosed trade of the informed trader.

[1] See http://www.telegraph.co.uk/finance/2861039/Buffett-fails-in-bid-to-curb-copycats.html

Similar to the model in Chapter 1, the model in this chapter is also closely related to Huddart et al. (2001). The dissimulation result in Huddart et al. (2001) is also present in this model, as the informed trader seeks to reduce the information that the copycats receives and increase the information that is private to him so that he can exploit it in the later trading period. An important finding in our paper is that the total expected profits of the informed trader increases with the number of copycats. As the number of copycats increases, the copycats trade more aggressively on the information that the informed trader discloses in his initial trade. Ceteris Paribus, the expected profits gained by the informed trader and each copycat on this common information is reduced with the number of copycats. Therefore, in equilibrium, the informed trader adds more noise in his initial trade, so that he has a greater information advantage over the copycats in the second period. The increase in second period expected profits outweighs the reduction in first period expected profits with the increase in noise. It is widely accepted that the mandatory disclosure requirements faced by fund managers would reduce their potential profits[2]. However, given that there is at least one copycat tracking their trades, we show that they are better off if there are more copycats following them.

Our model is also linked to the Kyle (1985) -type models with multiple informed agents. Holden and Subrahmanyam (1992) extend Kyle's model by increasing the number of identically informed traders. The traders trade aggressively and cause most of their private information to be revealed quickly as the number of informed traders increase. The other models focus on strategic trading between asymmetrically informed traders. Foster and Viswanathan (1994) use a model with two asymmetrically informed traders. The better informed trader knows the information that the less informed trader has. The latter learns from the former through the order flow

[2]See Wermers (2001) for a discussion on this subject.

via transacted prices, while in our model the copycats learn through observing the disclosed trade of the informed trader. Unlike Holden and Subrahmanyam (1992), the better informed trader has an incentive to trade less intensively on his private information in the earlier rounds of trading to reduce the amount of information the less informed trader can learn. Foster and Viswanathan (1996) also study the strategic trading between heterogeneously informed traders and they show that the degree of competition depends on the correlation structure of the traders' signals.

The paper most similar to ours is Zhang (2008). He extends the theoretical frameworks of Foster and Viswanathan (1994) and Huddart et al. (2001) by analysing how less informed outsiders learn from the disclosed trades of the informed trader[3]. The key difference between our model and his is that the market-maker does not observe the informed trader's disclosed trades in our model. In his model, both the outsiders and the market-maker update their information when the informed trader's trades are disclosed. As acknowledged by the author, a drawback of his model is that it requires a sizeable number of outsiders. If the number of outsiders approaches zero, the model does not result in meaningful numerical solutions and practical insights[4]. We do not face this problem in our model as we have meaningful closed-form solutions for the number of copycats ranging from one to infinity.

In our model, it is possible for the copycats to make abnormal profits due to their skill of identifying the informed trader, as long as there are not an infinite number of copycats. This is in line with previous empirical studies. There are several studies that examine the returns of hypothetical copycat funds using data of U.S. mutual funds. Frank et al. (2004) construct hypothetical copycat funds that mimic

[3]Zhang (2008) likens the outsiders to financial analysts gathering information about the particular stock.

[4]Some parameters would have imaginary numbers if the number of outsiders is too small. Parameters like trading intensities and variances may also be negative.

actively managed fund portfolios. They provide evidence that after expenses, copycat funds earned statistically indistinguishable and possibly higher returns. They argue that if investors buy actively managed funds to obtain high net-of-expenses returns, then copycat funds could potentially erode their market share by offering comparable returns net of expenses. Wang and Verbeek (2010) also provide evidence that copycat are able to marginally outperform the funds they mimic, and this relative success has increased after 2004, when all the funds are required to disclose on a quarterly basis. There are also other papers that provide empirical evidence that strategies that mimic the holdings of successful fund managers earn abnormal returns. Wermers, Yao and Zhao (2007) aggregate portfolio holdings across mutual funds, weighted by their past performance, to predict future stock returns. An overweighting by successful managers or an underweighting by unsuccessful managers is considered to be a signal that a stock is currently underpriced. Their investment strategies generate abnormal returns exceeding 7% during the following year. Martin and Puthenpurackal (2008) find that a hypothetical portfolio that mimics the investments of Warren Buffett's Berkshire Hathaway at the beginning of the following month after they are disclosed also earns abnormal returns of 10.75% over the S&P500 index.

The rest of the chapter is structured as follows. Section 2.2 discusses the set-up of the model and equilibrium. Section 2.3 discusses comparative statics of equilibrium and Section 2.4 concludes.

2.2 Model

2.2.1 Set-up

The model set-up is similar to Chapter 1's: two trading periods indexed by $n \in \{1, 2\}$ and one risky asset with a liquidation value of v, where $v \sim N(P_0, \Sigma_0)$. The liquidity traders in this model can be interpreted as an infinite number of investment managers who face mandatory disclosure requirements. They are required to disclose their first period trade before trading in the second period commences. Among these investment managers, only one knows the true value of v. This informed trader places a market order to trade x_n shares of the risky asset at period n. We assume that the rest of the other investment managers are uninformed liquidity traders who summit in aggregate exogenously generated orders u_n in each trading period, where $u_n \sim N(0, \sigma_u^2)$. u_1, u_2 and v are all mutually independent.

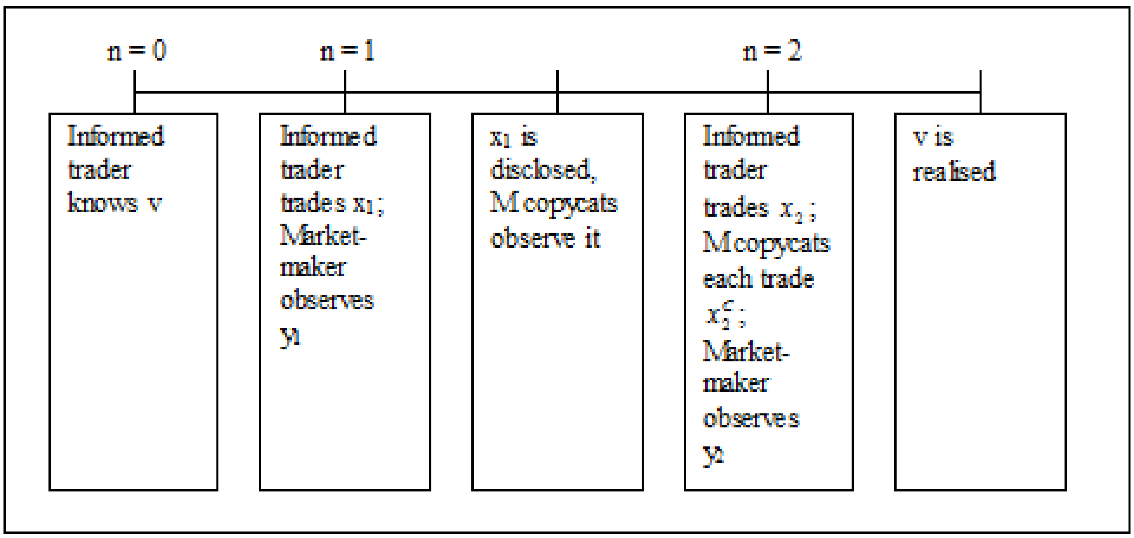
The key feature in this model is that we define copycats as agents who have the special ability of identifying the informed trader amongst the infinite number of uninformed liquidity traders. Let M be the number of identical copycats, indexed by $i = 1, 2, ..., M$, where M is a positive integer. Based on the informed trader's first period trade x_1, the M copycats each form the same expectation of v, and each trade x_2^C in the second period[5].

A competitive risk-neutral market-maker observes the aggregate order flow y_n in each period and sets the price to be equal to the posterior expectation of v. The price is therefore semi-strong efficient and the market-maker makes expected zero profits

[5]In this model, the copycats are not exactly mimicking the trade of the informed trader. Rather, they are trying to guess the true value of v based on the latter's disclosed trade. It is possible for the copycats to short the asset in the second period even though the informed trader bought in the first period.

due to Bertrand competition with potential rival market-makers. Unlike the copycats, the market-maker is unable to distinguish the informed trader's trade from the trades of the other liquidity traders, although he knows that the informed trader is present. Therefore there is no immediate adjustment in the price upon the disclosure of trades in the first period, as in Huddart et al. (2001) and Zhang (2008). Figure 2.1 shows the timeline of events.

Figure 2.1: Timeline of Events of Copycat Model



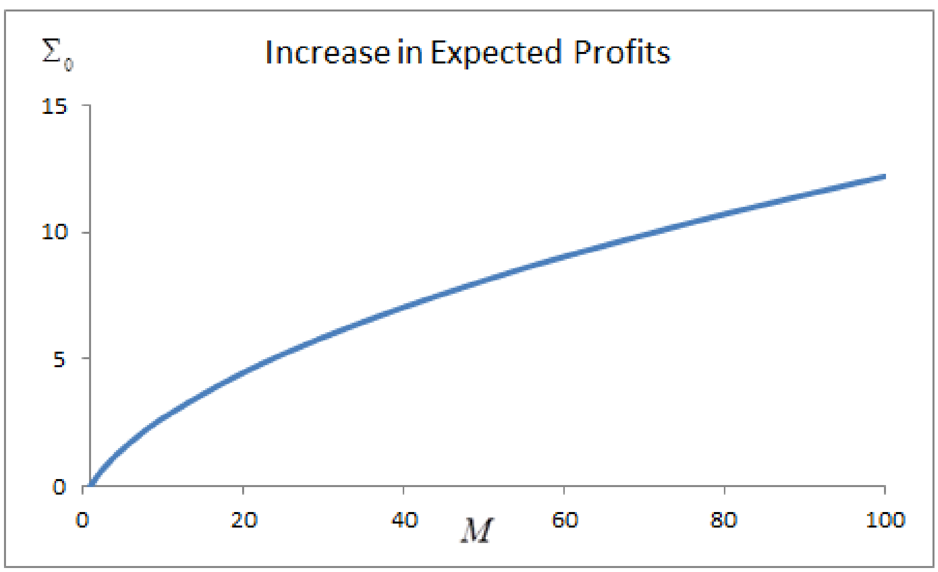
2.2.2 Equilibrium

Proposition 2.1 *An invertible trading strategy of* $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$ *does not constitute a Nash equilibrium for all values of M*

Proof: See Appendix 2.6.1

In Huddart et. al (2001), the authors show that an invertible trading strategy of $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$ does not constitute a Nash equilibrium. This is because the market-maker would be able to infer v perfectly when x_1 is disclosed and set $\overline{\lambda}_2 = 0$. The informed trader would be able to make infinite profits by deviating in his first period trade. In our model, the market-maker does not observe $\overline{x}_1$, but the M copycats is able to do so. If the trader trades $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$, he will lose his information advantage to the copycats in the second period. To prove that an invertible trading strategy of $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$ does not constitute a Nash equilibrium for all values of M, we first consider an equilibrium where the informed trader trades $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$, and all M copycats and the informed trader are equally informed in the second period. We then consider a scenario where the informed trader deviates by trading $x_1 = (1 + \mu) \overline{\beta}_1 (v - P_0)$, keeping the other parameters constant. Fig 2.2 shows the change in expected profits where $\mu = -2$ (i.e. the trader makes an opposite trade: $x_1 = -\overline{\beta}_1 (v - P_0)$). The change in expected profits are positive for all values of M and increases with M. Therefore, similar to Huddart et al. (2001), an invertible trading strategy of $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$ also does not constitute a Nash equilibrium.

Figure 2.2: Increase in Total Expected Profits by Deviating in First Period: $\mu = -2$



We show that an equilibrium exists where the informed trader's first period trade includes a random normal noise component z_1, where $z_1 \sim N\left(0, \sigma_{z_1}^2\right)$ and it is independently distributed of v, u_1 and u_2. This implies that the M copycats would not be able to infer v perfectly. The informed trader thus maintains an informational advantage against the copycats even in the second period. Huddart et al. (2001) term this strategy dissimulation. The informed insider's first period trade is $x_1 = \beta_1 (v - P_0) + z_1$. Having observed x_1, the copycats' expectation of v is

$$s_1 = E(v|x_1) = P_0 + \gamma_1 x_1 \tag{2.1}$$

where

$$\gamma_1 = \frac{\beta_1 \Sigma_0}{\beta_1^2 \Sigma_0 + \sigma_{z_1}^2} \tag{2.2}$$

Let us conjecture that the second period trades of the informed trader and the M copycats are of the form

$$x_2 = \beta_2 (v - s_1) + \delta_2 (s_1 - P_1) \tag{2.3}$$

$$x_2^C = \delta_2^C (s_1 - P_1) \tag{2.4}$$

Following the notation used in Foster and Viswanathan (1994), we define the following variables to measure the remaining information at the end of period 1 for the M copycats and the market-maker. Firstly, Σ_1 is the variance of the liquidation value v, given the first period order flow y_1. Secondly, Λ_1 is the variance of the liquidation value given the copycats' signal x_1. It measures the information advantage of the informed trader over the copycats. Lastly, Ω_1 is the variance of the copycats' signal x_1 given y_1. It measures the information advantage of the copycats over the market-maker.

$$\Sigma_1 = var(v|y_1) = \frac{\left(\sigma_{z_1}^2 + \sigma_u^2\right) \Sigma_0}{\beta_1^2 \Sigma_0 + \sigma_{z_1}^2 + \sigma_u^2} \tag{2.5}$$

$$\Lambda_1 = var(v|x_1) = \frac{\sigma_{z_1}^2 \Sigma_0}{\beta_1^2 \Sigma_0 + \sigma_{z_1}^2} \tag{2.6}$$

$$\Omega_1 = var\left(x_1|y_1\right) = \Sigma_1 - \Lambda_1 = \frac{\beta_1^2\sigma_u^2\Sigma_0^2}{\left(\beta_1^2\Sigma_0 + \sigma_{z_1}^2 + \sigma_u^2\right)\left(\beta_1^2\Sigma_0 + \sigma_{z_1}^2\right)} \tag{2.7}$$

Proposition 2.2 *A subgame perfect linear equilibrium exists in which*

1. *The market-maker's pricing rule is of the linear form*

$$P_n = P_{n-1} + \lambda_n y_n,\ n \in \{1,2\}$$

2. *The trading strategies and the expected profits of the informed trader and the copycats are of the linear form*

$$x_1 = \beta_1\left(v - P_0\right) + z_1 \qquad x_2 = \beta_2\left(v - s_1\right) + \delta_2\left(s_1 - P_1\right)$$

$$x_2^C = \delta_2^C\left(s_1 - P_1\right)$$

$$\lambda_1 = \lambda_2 = \left(\frac{M+2}{2\sqrt{(M+1)^2+(M+2)^2}}\right)\frac{\sqrt{\Sigma_0}}{\sigma_u}$$

$$\beta_1 = \left(\frac{M+1}{\sqrt{(M+1)^2+(M+2)^2}}\right)\frac{\sigma_u}{\sqrt{\Sigma_0}} \qquad \beta_2 = \frac{1}{2\lambda_2}$$

$$\delta_2 = \delta_2^C = \frac{1}{\lambda_2(M+2)}$$

$$\gamma_1 = 2\left(\frac{M+1}{M}\right)\lambda_1$$

$$\sigma_{z_1}^2 = \frac{M\sigma_u^2}{M+2} - \beta_1^2\Sigma_0$$

$$\Sigma_1 = \left[1 - \left(\frac{M+2}{2(M+1)}\right)\frac{\beta_1^2\Sigma_0}{\sigma_u^2}\right]\Sigma_0 \qquad \Lambda_1 = \left[1 - \left(\frac{M+2}{M}\right)\frac{\beta_1^2\Sigma_0}{\sigma_u^2}\right]\Sigma_0$$

$$\Omega_1 = \frac{(M+2)^2}{2M(M+1)}\frac{\beta_1^2\Sigma_0^2}{\sigma_u^2}$$

$$E\left(\pi_1\right) = \left(1 - \lambda_1\beta_1\right)\beta_1\Sigma_0 - \lambda_1\sigma_{z_1}^2 \qquad E\left(\pi_2\right) = \frac{1}{\lambda_2(M+2)^2}\Omega_1 + \frac{1}{4\lambda_2}\Lambda_1$$

$$E\left(\pi_2^C\right) = \frac{1}{\lambda_2(M+2)^2}\Omega_1$$

$$E\left(\pi_1\right) = E\left(\pi_2\right) + ME\left(\pi_2^C\right)$$

Proof: See Appendix 2.6.2

β_2 measures the informed trader's trading aggressiveness on the information that is still private to him in the second period. Conversely, δ_2 measures the trading aggressiveness on the information that is shared with the other M copycats and the magnitude of this is equal to that of each copycat's, i.e. δ_2^C.

The expected profit of each copycat is a function of Ω_1, since it measures the variance of the copycats' signal given the first period order flow. On the other hand, the expected profit of the informed trader in his second period trade is a sum of two components. The first component is equal to the expected profit of each copycat, since the informed trader trades at the same intensity on the information that he shares with the copycats. The second component is a function of Λ_1, since it measures the information of v not contained in x_1. Similar to Huddart et al (2001), the market-maker sets the price impact in the two trading periods to be equal, i.e. $\lambda_1 = \lambda_2$[6]. To sustain this equilibrium, the expected profit of the informed trader's first period trade must be equal to the sum of the expected profits of the informed trader and copycats' trades in the second period.

[6]The informed trader needs to be indifferent across all values of x_1 for the mixed trading strategy of the dissimulation component to hold in equilibrium.

2.3 Comparative Statics

We next analyse the relationship between M and the parameters in Proposition 2.2.

Proposition 2.3 *The following shows the relationship between M and the parameters in Proposition 2.2*

$$\frac{d\beta_1}{dM} > 0 \qquad \frac{d\beta_2}{dM} > 0$$

$$\frac{d\delta_2}{dM} = \frac{d\delta_2^C}{dM} < 0$$

$$\frac{d\lambda_1}{dM} = \frac{d\lambda_2}{dM} < 0$$

$$\frac{d\gamma_1}{dM} < 0$$

$$\frac{d\sigma_{z_1}^2}{dM} > 0$$

$$\frac{d\Sigma_1}{dM} < 0 \qquad \frac{d\Lambda_1}{dM} > 0$$

$$\frac{d\Omega_1}{dM} < 0$$

$$\frac{dE(\pi_1)}{dM} < 0 \qquad \frac{dE(\pi_2)}{dM} > 0$$

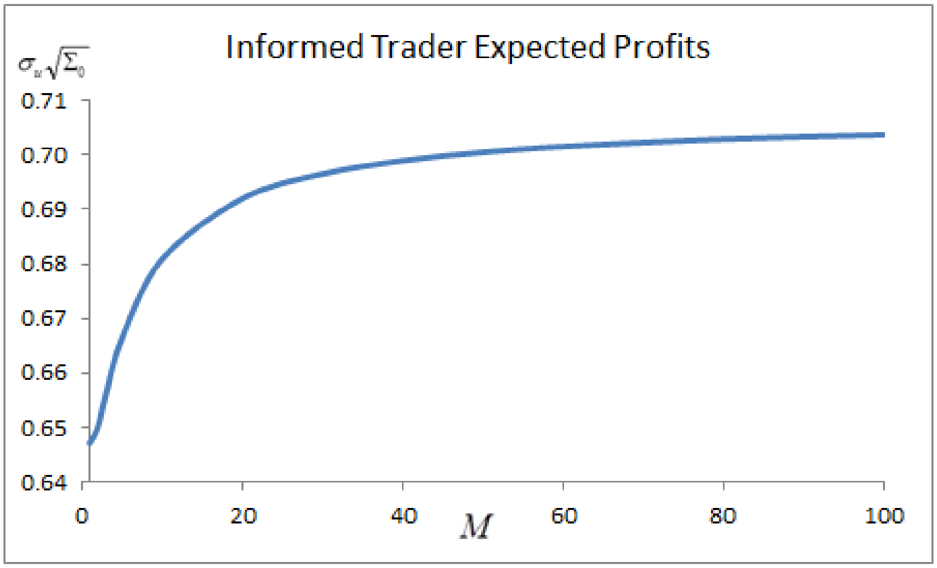
$$\frac{dE\left(\pi_2^C\right)}{dM} < 0$$

$$\frac{d(E(\pi_1)+E(\pi_2))}{dM} > 0 \qquad \frac{d\left(E(\pi_1)+E(\pi_2)+ME\left(\pi_2^C\right)\right)}{dM} < 0$$

Proof: See Appendix 2.6.3

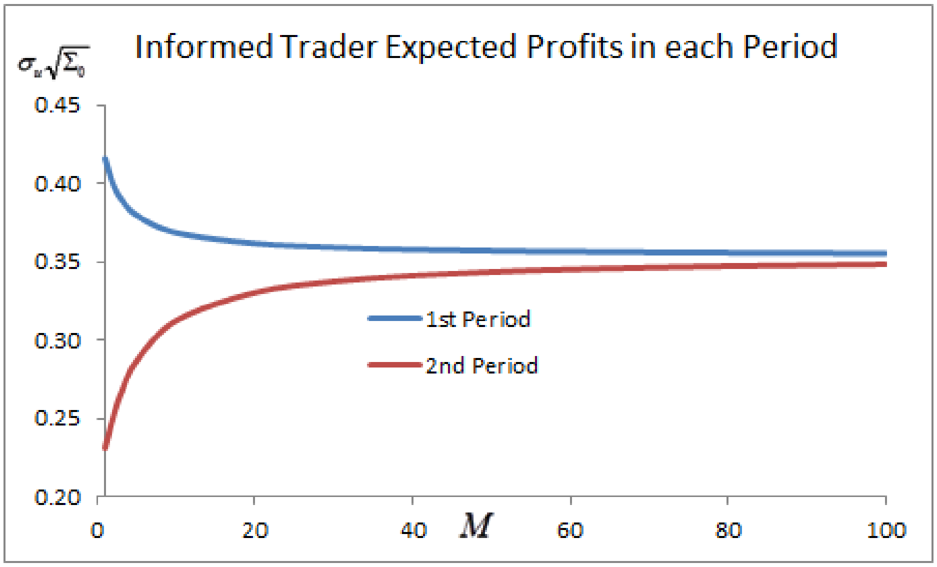
The informed trader increases β_1, the trading aggressiveness on his information as M increases. At the same time he also increases the variance of the dissimulation term σ_z^2. Although the first action increases the informativeness of the copycats' signal, the second action has an opposite effect, as $\Lambda_1 = \frac{\sigma_z^2\Sigma_0}{\beta_1^2\Sigma_0+\sigma_{z_1}^2}$. The magnitude of the second action is greater, since Λ_1 increases with M. Therefore the informed trader reveals less information about v in his first trade as M increases. In the second period, as M increases, the informed trader increases β_2, the trading aggressive on the information that is still private to him. In addition, he also decreases δ_2, the trading aggressiveness on the information he shares with the M copycats.

Figure 2.3: Relationship between Expected Profits of Informed Trader and M



Similar to Holden and Subrahmanyam (1992), the total expected profits of all the informed agents (informed trader and M copycats) decrease as the number of copycats M increases: $\frac{d\left(E(\pi_1)+E(\pi_2)+ME\left(\pi_2^C\right)\right)}{dM} < 0$. As the number of copycats increases, the copycats trade more aggressively on the information that the informed trader discloses in his initial trade. Ceteris Paribus, the expected profits gained by the informed trader and each copycat on this common information is reduced with the number of copycats. Interestingly, although the total pie is shrinking, the expected profits of the informed trader over the two trading periods increases with M (see Fig 2.3). The expected profits in the first period decrease with M (see Fig 2.4) because the informed trader increases $\sigma_{z_1}^2$ (see Fig 2.5), the variance of the dissimulation in his initial trade. However, in the second period, an increase in $\sigma_{z_1}^2$ results in an increase in the information that is private to the informed trader (higher Λ_1) and reduces the information he shares with the copycats (lower Ω_1). This increases the expected profits in the second period. The magnitude of this increase outweighs the reduction in profits in the first period. All this means that although disclosure decreases the

Figure 2.4: Relationship between Expected Profits of Informed Trader in each Period and M



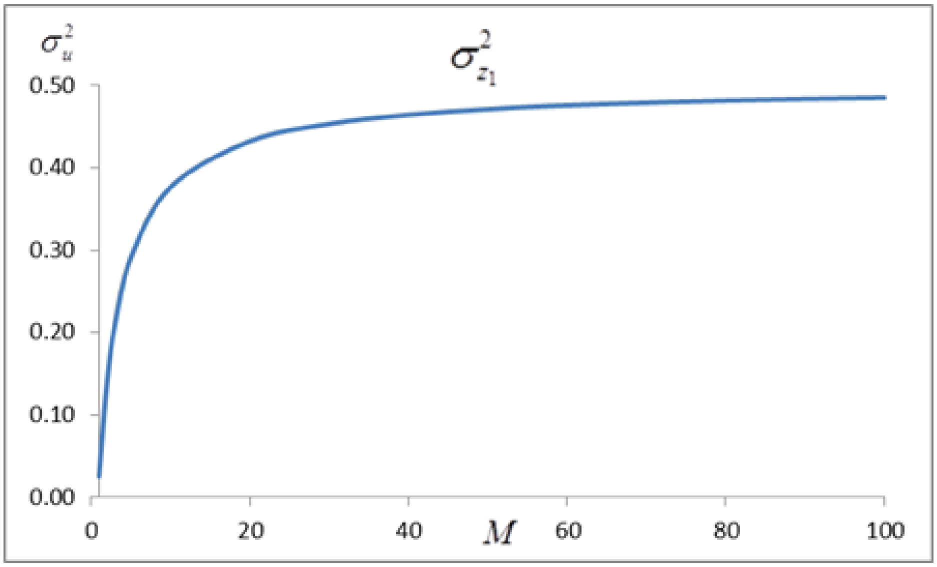
expected profits of the informed trader if he has at least 1 copycat tracking his trades, he is better off having more rather than less copycats tracking his trades. In our two period model, if there is no disclosure, the total expected profits is 0.8776 $\sigma_u\sqrt{\Sigma_0}$[7]. If there is 1 copycat, under the dissimulation equilibrium, the total expected profits fall to $0.6472\sigma_u\sqrt{\Sigma_0}$. As M approaches infinity, the total expected profits increase to $\frac{\sqrt{2}}{2}\sigma_u\sqrt{\Sigma_0} \approx 0.7071\sigma_u\sqrt{\Sigma_0}$.

The total expected profits of all the copycats decrease as M increases since the informed trader injects more noise in his initial trade (see Fig 2.6). The expected profits of each copycat fall at a greater rate as there are now more of them sharing a shrinking pie.

Another important point to note is that liquidity improves as M increases, since $\frac{d\lambda_1}{dM} = \frac{d\lambda_2}{dM} < 0$. The improvement in liquidity is in line with the result that the aggregate expected profits of the informed agents decrease as M increases. Noise

[7]We get this figure by setting $M = 0$. You can also use the parameters in Proposition 1 of Huddart et al. (2001), but please note the typo: $E(\bar{\pi}_1) = \frac{\sqrt{2K(2K-1)}}{4K-1}\sigma_u\sqrt{\Sigma_0}$, not $E(\bar{\pi}_1) = \frac{2K(2K-1)}{(4K-1)^2}\sigma_u\sqrt{\Sigma_0}$.

Figure 2.5: Relationship between $\sigma_{z_1}^2$ and M



traders are therefore better off if there are more copycats.

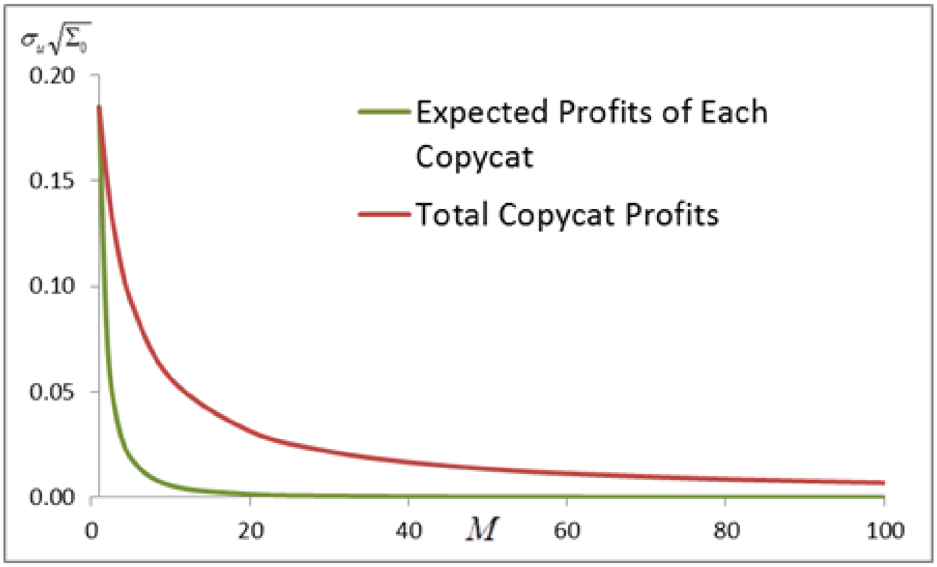
Proposition 2.4 *As M approaches infinity, the equilibrium is equivalent to one where the market-maker is able to observe the informed trader's disclosed trade.*

Proof: See Appendix 2.6.4

As M approaches infinity, the parameters in Proposition 2.2 are similar to the ones in Proposition 2 of Huddart et al. (2001)[8]. In their model, they assume that the market-maker is able to observe the informed trader's first period trade when it is disclosed and there are no copycats. If there are an infinite number of copycats who can identify the informed trader's trade, it is intuitive that none of them can make any abnormal profits. Therefore, they will not make any trade in the second period. In addition, the informed trader's second period trade is a function of $v - E(v|x_1)$, since $E(v|x_1)$ is common knowledge to all market participants. Thus, the informed trader's trading intensity on $E(v|x_1) - P_1$ is zero, like all the other copycats. The

[8]In their paper, they define $\Sigma_1 = var(v|x_1)$, while we define and $\Sigma_1 = var(v|y_1)$ and $\Lambda_1 = var(v|x_1)$.

Figure 2.6: Relationship between Expected Profits of Copycats and M



assumption of the market-maker being able to identify the disclosed trades of the informed trader is therefore a special case in our model.

2.4 Conclusion

Besides corporate insiders, our model is applicable to other informed traders who face mandatory disclosure requirements, e.g. mutual funds and other investment holding companies. The trades of famous investors like Warren Buffet and Bill Miller are closely scrutinised by the market, but there are also other up-and-coming talented fund managers who may have less market coverage. Therefore, even if they know the true value of the asset, informed traders with different media exposure do not have the same market impact when they disclose their trades. We propose to use parameter M in our model as a measure of the number of copycats that track the trades of the informed trader. We show that the optimum strategy of the informed trader is to add a dissimulation term to his initial trade to reduce the amount of information available to the copycats. This will increase the information that is private to him so that he can exploit it in the later trading period. In addition, we also show that it is possible for the copycats to earn abnormal profits as they have a special ability to identify the disclosed trades of the informed trader, compared to the market-maker. As the number of copycats approaches infinity, the profits of each copycat fall to zero and the equilibrium is equivalent to one where the market-maker is able to identify the disclosed trades of the informed trader (as in Huddart et al. (2001)).

An important finding in our paper is that the total expected profits of the informed trader increases with the number of copycats. It is widely accepted that the mandatory disclosure requirements faced by fund managers would reduce their potential profits. However, given that there is at least one copycat tracking their trades, we show that they are better off if there are more copycats following them. This has several implications. Besides raising new fund flows, an extra benefit of the marketing activities of fund managers is to increase media coverage. This might result in more copycats studying their trades. Top fund managers with a greater number of copycats are also better placed to sustain their performance against other good managers with a smaller following. Lastly, it pays for copycats to expend effort to find the next Warren Buffett and study his trades.

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2.6 Appendix

2.6.1 Proof of Proposition 2.1

Suppose the informed trader does not dissimulate his initial signal and trades $\overline{x}_1 = \overline{\beta}_1 (v - P_0)$. Having observed $\overline{x}_1$, the M copycats are able to abstract v perfectly. The informed trader and the M copycats would thus share the same information in the second trading period. All $M+1$ agents would make the same trade $\overline{x}_2 = \overline{\beta}_2 (v - P_1)$.

We proceed by backward induction. The informed trader's objective function in the second period is

$$\max_{\overline{x}_2} E\left(\overline{\pi}_2 | P_1, v\right) = \max_{\overline{x}_2} E\left(\left(v - P_1 - \overline{\lambda}_2\left(\overline{x}_2 + M\overline{x}_2^C\right)\right)\overline{x}_2\right)$$

Taking first order condition with respect to $\overline{x}_2$, and then setting $\overline{x}_2 = \overline{x}_2^C$

$$\overline{x}_2 = \frac{v - P_1}{\overline{\lambda}_2 (M+2)}$$

$$\overline{\beta}_2 = \frac{1}{\overline{\lambda}_2 (M+2)} \tag{2.8}$$

The informed trader's objective function in the first period is

$$\begin{aligned} & \max_{\overline{x}_1} E\left(\overline{\pi}_1 | v\right) + E\left(\overline{\pi}_2 | P_1, v\right) \\ = \ & \max_{\overline{x}_1} E\left(\left(v - P_0 - \overline{\lambda}_1 \overline{x}_1\right)\overline{x}_1\right) + \frac{1}{\overline{\lambda}_2 (M+2)^2} E\left(\left(v - P_0 - \overline{\lambda}_1 \overline{x}_1\right)^2\right) \end{aligned}$$

Taking first order condition with respect to $\overline{x}_1$

$$\overline{x}_1 = \frac{\overline{\lambda}_2 (M+2)^2 - 2\overline{\lambda}_1}{2\overline{\lambda}_1 \left(\overline{\lambda}_2 (M+2)^2 - \overline{\lambda}_1\right)} (v - P_0)$$

$$\overline{\beta}_1 = \frac{\overline{\lambda}_2 (M+2)^2 - 2\overline{\lambda}_1}{2\overline{\lambda}_1 \left(\overline{\lambda}_2 (M+2)^2 - \overline{\lambda}_1\right)} \tag{2.9}$$

Using the projection theorem of normal random variables, we obtain

$$\overline{\Sigma}_1 = \left(1 - \overline{\beta}_1 \overline{\lambda}_1\right) \Sigma_0 \tag{2.10}$$

$$\overline{\Sigma}_2 = \frac{\overline{\Sigma}_1}{M+2} \tag{2.11}$$

$$\overline{\lambda}_1 = \frac{\overline{\beta}_1 \overline{\Sigma}_1}{\sigma_u^2} \tag{2.12}$$

$$\overline{\lambda}_2 = \frac{(M+1)\,\overline{\beta}_2 \overline{\Sigma}_2}{\sigma_u^2} \tag{2.13}$$

Following Huddart et al. (2001), (2.8), (2.11), (2.12) and (2.13) gives $\overline{\beta}_1 = \frac{M+1}{(M+2)^2} \frac{\overline{\lambda}_1}{\overline{\lambda}_2^2}$. Equating the right-hand sides of this and (2.9) results in a cubic polynomial in terms of $K = \frac{\overline{\lambda}_2}{\overline{\lambda}_1}$

$$(M+2)^4 K^3 - 2(M+2)^2 K^2 - 2(M+1)(M+2)^2 K + 2(M+1) = 0 \tag{2.14}$$

Lets us suppose that the informed trader deviates by trading $x_1 = (1+\mu)\,\overline{\beta}_1 (v - P_0)$. When x_1 is disclosed, the M copycats' signal of v is $(1+\mu)(v - P_0) + P_0$. In the second period, the M copycats trade $\overline{x}_2^C = \overline{\beta}_2 ((1+\mu)(v - P_0) + P_0 - P_1)$.

The informed trader's objective function in the second period is

$$\max_{x_2} E\left(\pi_2 | P_1, v\right) = \max_{x_2} E\left(\left(v - P_1 - \overline{\lambda}_2\left(x_2 + M\overline{x}_2^C\right)\right)x_2\right)$$

Taking first order condition with respect to x_2

$$x_2 = \frac{v - P_1}{2\overline{\lambda}_2} - \frac{M\overline{x}_2^C}{2}$$

The informed trader's total expected profits by deviating is

$$\begin{aligned} & E\left(\pi_1 | v\right) + E\left(\pi_2 | P_1, v\right) \\ = \; & E\left(\left(v - P_0 - \overline{\lambda}_1 x_1\right)x_1\right) + \frac{1}{\overline{\lambda}_2\left(M+2\right)^2} E\left(\left(\left(1 - \frac{M\mu}{2}\right)\left(v - P_0\right) - \overline{\lambda}_1 x_1\right)^2\right) \end{aligned}$$

The change in total expected profits by deviating is

$$\Delta E\left(\pi\right) = \left[\begin{array}{c} -\mu\overline{\beta}_1\left(2\overline{\beta}_1\overline{\lambda}_1 + \mu\overline{\beta}_1\overline{\lambda}_1 - 1\right) \\ +\frac{1}{4\overline{\lambda}_2(M+2)^2}\mu\left(M + 2\overline{\beta}_1\overline{\lambda}_1\right)\left(4\overline{\beta}_1\overline{\lambda}_1 + M\mu + 2\mu\overline{\beta}_1\overline{\lambda}_1 - 4\right) \end{array}\right]\Sigma_0$$

Suppose $\mu = -2$. This means that the informed trader makes an opposite trade of equal magnitude in the first period

$$\Delta E\left(\pi\right) = \left[\frac{M + 2\overline{\beta}_1\overline{\lambda}_1}{\overline{\lambda}_2\left(M+2\right)} - 2\overline{\beta}_1\right]\Sigma_0$$

From the plot in Fig 2.1, it can be seen that the change in total expected profits by deviating in first period is positive for all values of M.

2.6.2 Proof of Proposition 2.2

Applying backward induction, we solve for the informed trader's and the copycats' optimisation problems in the second period. The informed trader's objective function in the second period is

$$\max_{x_2} E\left(\pi_2 | P_1, v\right) = \max_{x_2} E\left(\left(v - P_1 - \lambda_2\left(x_2 + M x_2^C\right)\right) x_2\right)$$

Taking first order condition with respect to x_2,

$$x_2 = \frac{v - P_1}{2\lambda_2} - \frac{M x_2^C}{2} \tag{2.15}$$

On the other hand, the objective function of each copycat in the second period is

$$\max_{x_2^C} E\left(\pi_2^C | P_1, x_1\right) = \max_{x_2^C} E\left(\left(s_1 - P_1 - \lambda_2\left(\delta_2\left(s_1 - P_1\right) + \hat{x}_2^C + \left(M - 1\right)\hat{x}_2^C\right)\right) x_2^C\right)$$

where $\hat{x}_2^C$ is the optimal trade of the other $M - 1$ copycats.

Taking first order condition with respect to x_2^C and equating $x_2^C = \hat{x}_2^C$

$$x_2^C = \frac{1 - \lambda_2\delta_2}{\lambda_2\left(M + 1\right)}\left(s_1 - P_1\right) \tag{2.16}$$

Substituting (2.16) into (2.15) yields

$$x_2 = \frac{v - s_1}{2\lambda_2} + \left(\frac{1}{2\lambda_2} - \frac{M}{2}\left(\frac{1 - \lambda_2\delta_2}{\lambda_2\left(M + 1\right)}\right)\right)\left(s_1 - P_1\right) \tag{2.17}$$

Comparing (2.17) with (2.3) implies

$$\beta_2 = \frac{1}{2\lambda_2} \tag{2.18}$$

$$\delta_2 = \delta_2^C = \frac{1}{\lambda_2 \left(M+2\right)} \tag{2.19}$$

Since $y_1 = \beta_1 \left(v - P_0\right) + z_1 + u_1$ and $y_2 = \beta_2 \left(v - s_1\right) + \left(M+1\right) \delta_2 \left(s_1 - P_1\right) + u_2$, using the projection theorem of normal random variables we obtain

$$\lambda_1 = \frac{\beta_1 \Sigma_0}{\beta_1^2 \Sigma_0 + \sigma_{z_1}^2 + \sigma_u^2} \tag{2.20}$$

$$\lambda_2 = \frac{\beta_2 \Lambda_1 + \left(M+1\right) \delta_2 \Omega_1}{\beta_2^2 \Lambda_1 + \left(M+1\right)^2 \delta_2^2 \Omega_1 + \sigma_u^2} \tag{2.21}$$

The informed trader's objective function in the first period is

$$\begin{aligned}
&\max_{x_1} E\left(\pi_1|v\right) + E\left(\pi_2|v\right) \\
&= \max_{x_1} E\left(\left(v - P_0 - \lambda_1\left(x_1 + u_1\right)\right) x_1|v\right) + \tfrac{1}{4\lambda_2}\left(v - P_0 - \gamma_1 x_1\right)^2 + \tfrac{1}{(M+2)^2\lambda_2}\left(\left(\gamma_1 - \lambda_1\right) x_1\right)^2 \\
&+ \tfrac{1}{(M+2)\lambda_2}\left(v - P_0 - \gamma_1 x_1\right)\left(\left(\gamma_1 - \lambda_1\right) x_1\right)
\end{aligned}$$

Taking first order condition with respect to x_1,

$$\left(v - P_0\right)\left(1 - \frac{\gamma_1}{2\lambda_2} + \frac{\left(\gamma_1 - \lambda_1\right)}{\left(M+2\right)\lambda_2}\right) + x_1\left(-2\lambda_1 + \frac{\gamma_1^2}{2\lambda_2} + \frac{2\left(\gamma_1 - \lambda_1\right)^2}{\left(M+2\right)^2 \lambda_2} - \frac{2\gamma_1\left(\gamma_1 - \lambda_1\right)}{\left(M+2\right)\lambda_2}\right) = 0$$

The second order condition is

$$-2\lambda_1 + \frac{\gamma_1^2}{2\lambda_2} + \frac{2\left(\gamma_1 - \lambda_1\right)^2}{\left(M+2\right)^2 \lambda_2} - \frac{2\gamma_1\left(\gamma_1 - \lambda_1\right)}{\left(M+2\right)\lambda_2} \leq 0$$

For the mixed strategy $x_1 = \beta_1\left(v - P_0\right) + z_1$, $z \sim N\left(0, \sigma_{z_1}^2\right)$ to hold in equilibrium, the informed trader must be indifferent across all values of x_1. Therefore

$$1-\frac{\gamma_1}{2\lambda_2}+\frac{(\gamma_1-\lambda_1)}{(M+2)\,\lambda_2}=0 \tag{2.22}$$

and

$$-2\lambda_1+\frac{\gamma_1^2}{2\lambda_2}+\frac{2\,(\gamma_1-\lambda_1)^2}{(M+2)^2\,\lambda_2}-\frac{2\gamma_1\,(\gamma_1-\lambda_1)}{(M+2)\,\lambda_2}=0 \tag{2.23}$$

(2.22) and (2.23) imply that

$$\lambda_1=\lambda_2 \tag{2.24}$$

$$\gamma_1=2\left(\frac{M+1}{M}\right)\lambda_1 \tag{2.25}$$

(2.25) and (2.20) yields

$$\gamma_1=2\left(\frac{M+1}{M}\right)\frac{\beta_1\Sigma_0}{\beta_1^2\Sigma_0+\sigma_{z_1}^2+\sigma_u^2} \tag{2.26}$$

Comparing (2.26) with (2.2) implies

$$\sigma_{z_1}^2=\frac{M\sigma_u^2}{M+2}-\beta_1^2\Sigma_0 \tag{2.27}$$

Given (2.6), (2.7) and (2.21) we have

$$\lambda_2=\frac{\sqrt{\left(1-\frac{\beta_1^2\Sigma_0}{\sigma_u^2}\right)\Sigma_0}}{2\sigma_u} \tag{2.28}$$

Given (2.2) and (2.25) we have

$$\lambda_1=\frac{M+2}{2\,(M+1)}\frac{\beta_1\Sigma_0}{\sigma_u^2} \tag{2.29}$$

Since $\lambda_1 = \lambda_2$,

$$\frac{\sqrt{\left(1-\frac{\beta_1^2\Sigma_0}{\sigma_u^2}\right)\Sigma_0}}{2\sigma_u} = \frac{M+2}{2\left(M+1\right)}\frac{\beta_1\Sigma_0}{\sigma_u^2}$$

$$\beta_1 = \left(\frac{M+1}{\sqrt{\left(M+1\right)^2+\left(M+2\right)^2}}\right)\frac{\sigma_u}{\sqrt{\Sigma_0}} \tag{2.30}$$

Expected profits of the informed trader in the first period

$$E\left(\pi_1\right) = E\left(\left(v-P_0-\lambda_1\left(\beta_1\left(v-P_0\right)+z_1+u_1\right)\right)\left(\beta_1\left(v-P_0\right)+z_1\right)|v\right)$$

$$E\left(\pi_1\right) = \left(1-\lambda_1\beta_1\right)\beta_1\Sigma_0 - \lambda_1\sigma_{z_1}^2 \tag{2.31}$$

Expected profits of the informed trader in the second period

$$\begin{aligned}
&E\left(\pi_2\right) = E\left(\left(v-P_1-\lambda_2\left(x_2+Mx_2^C+u_2\right)\right)x_2|v\right)\\
&= E\left(\left(\tfrac{v-s_1}{2}+\tfrac{1}{M+2}\left(s_1-P_1\right)\right)\left(\beta_2\left(v-s_1\right)+\delta_2\left(s_1-P_1\right)\right)|v\right)\\
&= E\left(\tfrac{\beta_2}{2}\Lambda_1+\tfrac{\delta_2}{M+2}\Omega_1+\left(\tfrac{\delta_2}{2}+\tfrac{\beta_2}{M+2}\right)\left(v-s_1\right)\left(s_1-P_1\right)|v\right)
\end{aligned}$$

Since $E\left(\left(v-s_1\right)\left(s_1-P_1\right)|v\right)=0$

$$E\left(\pi_2\right) = \frac{1}{4\lambda_2}\Lambda_1 + \frac{1}{\lambda_2\left(M+2\right)^2}\Omega_1 \tag{2.32}$$

Expected profits of each copycat in the second period

$$\begin{aligned}
&E\left(\pi_2^C\right) = E\left(\left(v-P_2\right)x_2^C|x_1\right)\\
&= E\left(\left(s_1-P_1-\lambda_2\left(\beta_2-\delta_2\right)\left(s_1-P_1\right)\right)\delta_2^C\left(s_1-P_1\right)\right)\\
&= \left(1-\lambda_2\left(\beta_2-\delta_2\right)\right)\delta_2^C\Omega_1
\end{aligned}$$

$$E\left(\pi_2^C\right) = \frac{1}{\lambda_2\left(M+2\right)^2}\Omega_1 \tag{2.33}$$

With (2.30), we can solve the rest of the parameters in Proposition 2.2.

2.6.3 Proof of Proposition 2.3

Let us express the parameters in Proposition 2.2 in terms of the exogenous variables M, Σ_0 and σ_u.

$$\lambda_1 = \lambda_2 = \left(\frac{M+2}{2\sqrt{(M+1)^2 + (M+2)^2}} \right) \frac{\sqrt{\Sigma_0}}{\sigma_u} \tag{2.34}$$

$$\beta_2 = \left(\frac{\sqrt{(M+1)^2 + (M+2)^2}}{M+2} \right) \frac{\sigma_u}{\sqrt{\Sigma_0}} \tag{2.35}$$

$$\gamma_1 = \left(\frac{(M+1)(M+2)}{M\sqrt{(M+1)^2 + (M+2)^2}} \right) \frac{\sqrt{\Sigma_0}}{\sigma_u} \tag{2.36}$$

$$\delta_2 = \delta_2^C = \left(\frac{2\sqrt{(M+1)^2 + (M+2)^2}}{(M+2)^2} \right) \frac{\sigma_u}{\sqrt{\Sigma_0}} \tag{2.37}$$

$$\sigma_{z_1}^2 = \left(\frac{M}{M+2} - \frac{(M+1)^2}{(M+1)^2 + (M+2)^2} \right) \sigma_u^2 \tag{2.38}$$

$$\Sigma_1 = \left(1 - \frac{(M+1)(M+2)}{2\left((M+1)^2 + (M+2)^2\right)} \right) \Sigma_0 \tag{2.39}$$

$$\Lambda_1 = \left(1 - \frac{(M+1)^2 (M+2)}{M\left((M+1)^2 + (M+2)^2\right)} \right) \Sigma_0 \tag{2.40}$$

$$\Omega_1 = \frac{(M+1)(M+2)^2}{2M\left((M+1)^2 + (M+2)^2\right)} \Sigma_0 \tag{2.41}$$

$$E(\pi_1) = \left(\frac{M+2}{2\sqrt{(M+1)^2 + (M+2)^2}} \right) \sigma_u \sqrt{\Sigma_0} \tag{2.42}$$

$$E\left(\pi_2\right)=\left(\frac{M^2+2M+2}{2\left(M+2\right)\sqrt{\left(M+1\right)^2+\left(M+2\right)^2}}\right)\sigma_u\sqrt{\Sigma_0} \tag{2.43}$$

$$E\left(\pi_2^C\right)=\left(\frac{M+1}{M\left(M+2\right)\sqrt{\left(M+1\right)^2+\left(M+2\right)^2}}\right)\sigma_u\sqrt{\Sigma_0} \tag{2.44}$$

With the above equations, we can obtain the derivatives with respect to M in Proposition 2.3.

2.6.4 Proof of Proposition 2.4

Using the equations in Appendix 2.6.3, we derive the limits of the parameters as M approaches infinity

$$\lim_{M\to\infty}\beta_1=\frac{\sqrt{2}}{2}\frac{\sigma_u}{\sqrt{\Sigma_0}} \tag{2.45}$$

$$\lim_{M\to\infty}\beta_2=\sqrt{2}\frac{\sigma_u}{\sqrt{\Sigma_0}} \tag{2.46}$$

$$\lim_{M\to\infty}\delta_2=\lim_{M\to\infty}\delta_2^C=0 \tag{2.47}$$

$$\lim_{M\to\infty}\lambda_1=\lim_{M\to\infty}\lambda_2=\frac{\sqrt{2}}{4}\frac{\sqrt{\Sigma_0}}{\sigma_u} \tag{2.48}$$

$$\lim_{M\to\infty}\gamma_1=\frac{\sqrt{2}}{2}\frac{\sqrt{\Sigma_0}}{\sigma_u} \tag{2.49}$$

$$\lim_{M\to\infty}\sigma_{z_1}^2=\frac{\sigma_u^2}{2} \tag{2.50}$$

$$\lim_{M\to\infty}\Sigma_1=\frac{3}{4}\Sigma_0 \tag{2.51}$$

$$\lim_{M\to\infty}\Lambda_1=\frac{\Sigma_0}{2} \tag{2.52}$$

$$\lim_{M \to \infty} \Omega_1 = \frac{\Sigma_0}{4} \tag{2.53}$$

$$\lim_{M \to \infty} E\left(\pi_1\right) = \frac{\sqrt{2}}{4}\sigma_u\sqrt{\Sigma_0} \tag{2.54}$$

$$\lim_{M \to \infty} E\left(\pi_2\right) = \frac{\sqrt{2}}{4}\sigma_u\sqrt{\Sigma_0} \tag{2.55}$$

$$\lim_{M \to \infty} E\left(\pi_2^C\right) = 0 \tag{2.56}$$

$$\lim_{M \to \infty} \left(E\left(\pi_1\right) + E\left(\pi_2\right)\right) = \frac{\sqrt{2}}{2}\sigma_u\sqrt{\Sigma_0} \tag{2.57}$$

$$\lim_{M \to \infty} \left(E\left(\pi_1\right) + E\left(\pi_2\right) + ME\left(\pi_2^C\right)\right) = \frac{\sqrt{2}}{2}\sigma_u\sqrt{\Sigma_0} \tag{2.58}$$

It follows that the limits of the parameters as M approaches infinity are similar to those of a two-period Huddart et al. (2001) model.

Chapter 3

The Impact of More Frequent Portfolio Disclosure on Mutual Fund Performance

3.1 Introduction

In 2004 the Securities and Exchange Commission (SEC) amended the Investment Company Act of 1940 and required mutual funds to file its complete portfolio holdings schedule with the Commission on a quarterly basis [1]. There were several arguments in support of the increase in the disclosure frequency. First, more frequent disclosure would allow shareholders to observe the securities held by various funds more accurately. This in turn would help them with the asset allocation and diversification choice of their overall portfolios. Second, shareholders would be able to better monitor whether, and how, a fund is complying with its stated investment objective.

[1] within 60 days of the end of the fiscal quarter.

Third, quarterly disclosure would make it easier to track whether funds are engaging in various forms of portfolio manipulation such as window dressing.[2]

With the increase in the disclosure frequency, it was feared that funds would be forced to incur higher cost. Apart from the increase in direct expenses associated with producing and distributing holding related information, there would be costs coming from higher exposure to activities such as front running and free riding.

Front running refers to the scenario where other traders buy (sell) securities in anticipation of buy (sell) trades by the fund. The fund may therefore be forced to trade at unfavorable prices. Periodic releases of fund holdings data, together with daily releases of the funds net asset values (NAV) and returns, allow other market participants to anticipate the funds trades in real time using computer programs that specialize in estimating portfolio changes. Increasing the frequency of disclosure will improve the precision of such front running models, yielding higher returns at the cost of the mutual funds.

There are previous empirical studies that provide evidence on the front-running activities in the market. Cai (2003) uses a unique data set to examine the behavior of the market makers in the Treasury bond futures market when LTCM faced difficulties in 1998. He finds that market makers engaged in front running against customer orders coming from a particular clearing firm- orders that closely matched various features of LTCMs trades through Bear Stearns. Coval and Stafford (2007) show that mutual funds that experience large outflows (inflows), tend to decrease (increase) existing positions. This creates opportunities for outsiders to front run the anticipated forced trades by mutual funds experiencing extreme fund flows. Their hypothetical front running strategy earns between 0.35% to 1.07% a month. Chen, Hanson, Hong

[2]See 17 CFR Parts 210, 239, et al. Shareholder Reports and Quarterly Portfolio Disclosure of Registered Management Investment Companies; Final Rule, March 9 2004

and Stein (2008) find indirect evidence that hedge funds do pursue front running strategies of the kind mentioned in Coval and Stafford (2007) and profit during periods of mutual fund distress.

Free riding refers to the situation where some funds mimic the holdings of an actively managed fund. They rebalance their holdings based on periodic portfolio disclosure of the actively managed funds. Frank, Poterba, Shackelford and Shoven (2004) use mutual fund holdings data and construct hypothetical copycat funds that mimic actively managed fund portfolios. They provide evidence that after expenses, copycat funds earn statistically indistinguishable and possibly higher returns. They argue that copycat funds could potentially erode the market share of actively managed funds (with high expense ratios) by offering comparable returns net of expenses. In a bigger sample Wang and Verbeek (2010) find that copycat funds on average marginally outperform their actively managed counterparts net of trading costs and expenses. The average relative performance of the copycat funds increases significantly (by 5 basis points a month) after the increase in disclosure frequency in 2004.

Copycats may adversely affect fund performance if they can cause the price to move before the fund could fully benefit from its research/ investment strategy. Some argue that most positions could be bought or sold in a short span of time without incurring much trading cost. However, others do not agree and argue that more frequent disclosure might expose funds to substantial market impact costs. [3]

There is also an indirect channel in which free riding activities can reduce the fund returns. If copycat funds can generate comparable net returns (they have zero research expenses) as the original actively managed funds, they will attract new investments. The resulting competition will lead to lower or slowly increasing assets for the original

[3]For example see Craig S. Tyle, Comment Letter Re: Shareholder Reports and Quarterly portfolio Disclosure of Regulated Investment Companies (Investment Company Inst, 2003)

active funds. This implies that the existing shareholders of the active funds will have to bear a larger chunk of the research related expenses.

However, in some situations fund returns may be enhanced by copycat activities if their trades increase the price of the stocks held by the original active funds. In those cases portfolio disclosure in fact enables the fund managers to realize favorable return on their security positions in a shorter time frame.

In this paper we study the impact of more frequent portfolio disclosure on mutual fund performance.

We compare the performance of the semi-annual funds with that of the quarterly funds between 1990 and 2003 and between 2005 and 2008. If a fund discloses less often, it is likely that it will be less exposed to activities such as front running. However, fund shareholders may incur higher agency costs as they won't be able to monitor fund activities more frequently. To identify the impact of lower disclosure frequency on performance, we focus on the successful (skilled funds). It is more probable that in successful funds, agency effects will not outweigh the benefits from lower exposure to activities such as front running. Thus our hypothesis is - successful semi-annual funds will be less exposed to activities such as front running compared to successful quarterly funds and hence will perform better. The same may not be true for the poorly performing semi-annual funds. Less monitoring by the investors owing to less frequent disclosure might lead the managers in poorly managed funds to indulge in value destroying activities and this agency cost might outweigh some or all of the benefits accrued from less exposure to activities such as front running activities.

Between 1990 and 2003 we find that the successful semi-annual funds outperform the successful quarterly funds by 17 to 20 basis points a month. Then we compare the performance of the successful semi-qtly funds (funds that were semi-annual before and have become quarterly after 2004) and the successful qtly- qtly (funds that were quarterly even before 2004) funds between 2005 and 2008. Unlike before 2004, we do not find any significant difference in their performance. We do a difference-in-difference test with semi-annual funds which were forced to disclose quarterly after 2004 as the treatment group and funds which have been quarterly throughout as the control group. We find that the performance of successful previously semiannual funds have come down by about 22 basis point a month after 2004. That is the performance of the previously semi-annual successful funds has come down after 2004 to the extent that they are no longer different from the quarterly successful funds after 2004. This suggests that the previously semi-annual funds are now more exposed to activities such as front running and this is affecting their performance adversely.

Then we turn our attention to the illiquid and liquid funds (funds who invests in illiquid and liquid assets respectively). Trades by illiquid funds will incur larger price impacts and will attract more front runners. It is likely that illiquid funds will benefit more by disclosing less frequently compared to other funds and particularly compared to liquid funds.

Between 1990 and 2003 we find that successful illiquid semi-annual funds outperform the successful quarterly funds by 32 basis points a month. At the same time we don't find any significant difference between the performance of successful liquid semi-annual and quarterly funds. In a difference in difference test we find that the performance of successful previously semiannual illiquid funds have come down by about 34 basis points a month after 2004. We do not see any such reduction in performance for the liquid semiannual funds. We repeat this exercise for the small cap and large cap funds. By their investment styles, small cap funds invest in small cap stocks which are relatively illiquid and large cap funds in large cap stocks which are relatively liquid. We find similar results as in our earlier illiquid and liquid fund tests.

We then look at the total assets under management of the funds. Semi-annual funds seem to be bigger in size compared to quarterly funds. Ge and Zheng (2006) find that large funds are more likely to disclose less frequently. Funds with large assets under management are more likely to trade in bigger sizes with larger price impact. This will attract more front-runners. Hence if these large funds disclose less often they will save more on trading costs. We find that the outperformance of successful semi-annual funds over the successful quarterly funds increases with the size of the funds. We don't find any such relationship after 2004.

Between 1990 and 2003 we do not find any significant difference between the performance of poorly performing semi-annual and quarterly funds. It appears that any gain on less front running for the semi-annual fund is negated by larger agency cost incurred by the fund managers as a result of less monitoring. The increase of disclosure frequency after 2004 was expected to reduce the agency cost in the previously semi-annual poorly performing funds and hence to improve their performance after 2004. However this would also expose the funds to activities such as front-running and it was not obvious which effect would dominate. We compare the performance of poorly performing semi-qtly funds and poorly performing qtly- qtly funds between 2005 and 2008. We do not find any significant difference in their performance (as was the case prior to 2004). This suggests that any improvement in the agency cost of the poorly performing previously semi-annual funds after 2004 has been negated by the increase in the trading costs owing to activities such as front running.

As a robustness check we examine the impact of disclosure frequency on the unobserved action of the mutual funds captured by return gap (the difference between the reported fund return and the return on a portfolio that invests in the previously disclosed fund holdings).

During 1990-2003 period, we find that the return gap of the successful semi annual funds to be higher than that of successful quarterly funds by about 12 basis points a month. This difference in return gap between semi-annual successful and quarterly successful funds persists over time and predicts the difference in their future performance. This implies that unobserved actions of the successful semi-annual funds create more value compared to their quarterly counterparts. However, after 2004 we do not see any such difference in return gap between previously semi-annual funds and funds that have been quarterly throughout.

Our paper is related to Ge and Zheng (2006). Using data between 1985 and 1999, they find that past winners (losers) who disclose less frequently outperform (underperform) past winners (losers) who disclose more frequently. We take the change in mandatory disclosure policy as an exogenous event to examine the impact of disclosure frequency on the performance of mutual funds. Ours is a cleaner test because prior to 2004 the funds could choose between quarterly and semi-annual frequency (for that matter any frequency higher than semi-annual).

Rest of the paper is structured as follows: Section 3.2 discusses the hypotheses, Section 3.3 discusses the methodology, Section 3.4 describes the data , Section 3.5 presents the results and Section 3.6 concludes.

3.2 Hypotheses

We would like to test the impact of frequency of mandatory disclosure on mutual fund performance. We conjecture that if a fund discloses less often, it will be less exposed to activities such as front running. This will lead to superior performance compared to a fund which discloses more often. On the other hand there are concerns that agency costs may go up in the funds with less frequent disclosure as fund shareholders will not be able to monitor fund activities more frequently.

The net result of these two opposing effects - lower trading cost (owing to less front running) and higher agency cost (owing to less monitoring) is not obvious in funds which discloses less often. Hence to examine the effects of lower disclosure frequency on performance, we focus on the successful (skilled funds). It is more likely that in successful funds, agency effects will not outweigh the benefits from lower trading cost. Thus we should expect successful semi-annual finds to outperform successful quarterly funds.

Prior to 2004 (1985-2004), mandatory frequency of disclosure was semi-annual. However some 60% of the funds opted to disclose quarterly. So one could possibly compare the performance of the successful semi-annual and quarterly funds during this period to examine the effects of disclosure frequency on fund performance. However, this test will not give us the correct picture as disclosure frequency is not determined exogenously.[4] Still we should expect a statistical association between the two, particularly if there is a cost to switch from one disclosure frequency to the other.

We look at the performance of semi-annual and quarterly funds before 2004, however, we address the problem arising from endogenous choice of disclosure frequency by using the change in mandatory disclosure frequency in 2004 as a natural experiment. After 2004, all the funds have to disclose their holdings every quarter. We consider the funds which disclosed semi-annually before 2004 as our treatment group and the funds which disclosed quarterly even before 2004 as our control group and test the following hypothesis.

Hypothesis 1: The change in mandatory disclosure frequency in 2004 will have

[4]Funds could choose any frequency higher than semi-annual during this period.

a detrimental effect on the performance of successful previously semi-annual funds compared to successful funds which have been quarterly throughout.

Free riding and front running could be two channels by which portfolio disclosure can affect the fund performance. Free riding will be costly for the funds if it can cause the price to move before the fund could fully benefit from its research and investment strategies. There is also an indirect channel through which free riding activities can reduce the net fund returns. There is evidence that copycat funds can generate comparable net returns as the original active funds. This implies that both the original active and copycat funds will compete for investments in the market. This will lead to lower assets for the active funds or slower growth of their assets and its existing shareholders will have to bear a larger part of the research expenses. Also, as we have discussed already, there are scenarios where original active fund returns may be enhanced by free riding activities. Thus the impact of free riding activities on the fund returns is not obvious.

However front running activities are always costly for the funds and it will be severe for funds holding illiquid assets. Trades by illiquid funds will incur larger price impact and will appear as lucrative profit making opportunities to the front runners. By the same logic, funds holding relatively liquid assets will attract less front runners and its performance will suffer less from these activities. We formulate the following hypothesis to test this.

Hypothesis 2: The effect predicted in Hypothesis 1 will be stronger for semi-annual funds holding illiquid assets than those holding liquid assets.

3.3 The Difference-in-Difference test

A clean way to examine the impact of change in the disclosure frequency on mutual fund performance will be to implement a difference-in-difference test. This is possible because in the sample we have funds who disclosed semi-annually before 2004 and were subsequently forced to change to quarterly disclosure frequency after 2004 . This group of funds (semi-qtly funds)will be our treatment group. There are also funds who had been voluntarily disclosing quarterly before 2004. So the change in the policy will not affect the performance of this group of funds (qtly-qtly). We treat them as our control group.

As discussed before, to identify the effect of change of disclosure frequency better, we focus on the successful semi-annual and quarterly funds only. That is, we restrict our sample to the top ranking funds based on their past 12-month four factor abnormal return. Our econometric specification is the following.

$Alpha_{i,t} = Constant + \beta 1 * Semi_i + \beta 2 * POST2004 + \beta 3 * Semi_i * POST2004 + \beta 4 * X_{i,t} + \epsilon_{i,t}$

Where $Alpha_{i,t}$ is fund i's four factor abnormal return in month t . $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. POST2004 is an indicator value and takes a value of one if t is later than 2004. $X_{i,t}$ is a set of control variables such as Total net asset, Expense ratio etc. All the control variables are lagged by a month. We include year dummies in the regression and use panel corrected standard errors. Here the coefficient of interest is $\beta 3$, which captures the impact of change in disclosure frequency on the performance of successful previously semi-annual funds. We expect it to be negative.

We repeat the above test by restricting our sample to poorly performing funds (bottom ranking funds, based on their past 12-month four factor abnormal return) only. In this case $\beta3$ will capture the impact of change in disclosure frequency on the performance of poorly performing previously semi-annual funds.

If we do not restrict our sample to successful or poorly performing funds only, the econometric specification corresponds to that of a Difference-in-Difference-in-Difference (triple difference) test as specified below.

$$Alpha_{i,t} = Constant + \beta1 * Semi_i + \beta2 * POST2004 + \beta3 * Rank4_{i,t-1} + \gamma1 * Rank4_{i,t-1} * Semi_i + \gamma2 * Rank4_{i,t-1} * POST2004 + \gamma3 * Semi_i * POST2004 + \delta1 * Semi_i * POST2004 * Rank4_{i,t-1} + \delta2 * X_{i,t} + \epsilon_{i,t}$$

Where the new independent variable $Rank4_{i,t-1}$ is an indicator variable and takes a value of one if fund i belongs to the top quintile based on the past 12 months four factor abnormal return. Otherwise, it takes a value of zero. Here the coefficient of interest is $\delta1$ which is equivalent to $\beta3$ in the previous equation and captures the same effect (the impact of change in disclosure frequency on the performance of successful previously semi-annual funds). As before we expect it to be negative.

Also we test the impact of change in disclosure frequency on the performance of poorly performing previously semi-annual funds by the following specification.

$$Alpha_{i,t} = Constant + \beta1 * Semi_i + \beta2 * POST2004 + \beta3 * Rank0_{i,t-1} + \gamma1 * Rank0_{i,t-1} * Semi_i + \gamma2 * Rank0_{i,t-1} * POST2004 + \gamma3 * Semi_i * POST2004 + \delta1 * Semi_i * POST2004 * Rank0_{i,t-1} + \delta2 * X_{i,t} + \epsilon_{i,t}$$

Here the new independent variable $Rank0_{i,t-1}$ is an indicator variable and takes a value of one if fund i belongs to the bottom quintile based on the past 12 months four factor abnormal return. Otherwise it takes a value of zero. Here the coefficient of interest is again $\delta 1$.

3.4 Data and Summary Statistics

Our sample covers the time period between 1990 and 2009. The mandatory portfolio disclosure frequency for the mutual funds was semi annual until 2004. So we divide our sample into two - 1990 and 2003 and 2005-2008. We follow Kacperczyk , Sialm and Zheng (2007) and merge the Center for Research in Security Prices (CRSP) Survivorship Bias Free Mutual Fund Database with the Thompson Financial CDA/Spectrum holdings database and the CRSP stock price data. The CRSP mutual fund database includes information on fund returns, total net assets (TNA), different types of fees, investment objectives, and other fund characteristics. The CDA/Spectrum database provides stock holdings of mutual funds. The data are collected both from reports filed by mutual funds with the SEC and from voluntary reports generated by the funds.

We focus on open-end US domestic equity mutual funds. We eliminate balanced, bond, money market, international, and sector funds, as well as funds not invested primarily in equity securities. To be more precise we base our selection criteria on the objective codes and on the disclosed asset compositions. We select funds with the following ICDI objectives: AG, GI, LG, or IN. If a fund does not have any of the above ICDI objectives, we select funds with the following Strategic Insight objectives: AGG, GMC, GRI, GRO, ING, or SCG. If a fund has neither the Strategic Insight nor the ICDI objective, then we go to the Wiesenberger Fund Type Code and pick funds with the following objectives: G, G-I, AGG, GCI, GRI, GRO, LTG, MCG, and SCG. If none of these objectives is available and the fund has a CS policy (Common

Stocks are the securities mainly held by the fund), then the fund is included.

We exclude funds that have the following Investment Objective Codes in the Spectrum Database: International, Municipal Bonds, Bond and Preferred, and Balanced. The reported objectives do not always indicate whether a fund portfolio is balanced or not, and hence we exclude funds that, on average, hold less than 80% or more than 105% in stocks. We also exclude funds that hold fewer than 10 stocks and those which in the previous month managed less than $5 million.

If a fund has multiple share classes, we eliminate the duplicate funds and compute the fund-level variables by aggregating across the different share classes - for the TNA under management, we sum the TNAs of the different share classes. For the other quantitative attributes of funds (e.g., returns, expenses etc), we take the weighted average of the attributes of the individual share classes, where the weights are the lagged TNAs of the individual share classes.

To identify illiquid and liquid funds, we adopt the following two approaches. First, we retrieve from the Thompson database the detailed holding data for each fund in the sample and obtain the Gibb's estimate[5] for each of the stocks held by funds.[6] The liquidity measure of the fund is then calculated as the value weighted average liquidity measure of the funds' underlying securities. Every month we divide the funds into tertiles based on their liquidity measure and call the top tertile funds as

[5]We download the estimates from Joel Hasbrouck's website at http://pages.stern.nyu.edu/ jhasbrou/. The Gibbs estimator is a Bayesian version of Rolls (1984) transactions cost measure

$$c = \begin{cases} \sqrt{-cov(r_t, r_{t-1})} & \text{if } cov(r_t, r_{t-1}) < 0 \\ 0 & \text{otherwise} \end{cases}$$

This measure derives from a model in which $r_t = c * \delta q + u_t$ where q_t is a trade direction indicator (buyer or seller initiated), c the parameter to be estimated, δq_t the change in the indicator from period $t-1$ to t, and u_t an error term. A couple of algebraic steps leads to the previous expression under the assumption that buyer and seller initiated trades are equally likely.

[6]We also use the Amihud liquidity measure instead of Gibbs estimate and find similar results

illiquid funds and the bottom tertile funds as liquid funds.

Second, we identify the small cap and large cap funds from the sample by Strategic Insight objective code and Lipper class code from the CRSP Mutual Fund Data Base. We also check the names of the funds and Morningstar investment style data to confirm their investment styles. We find 77 semi-annual and 215 quarterly small cap funds. Similarly we find 87 semi-annual and 206 quarterly large cap funds. We consider funds which invest in small cap stocks as illiquid funds and which invest in large cap stocks as liquid funds.

3.4.1 Summary Statistics

Table 3.1 reports summary statistics of the main fund attributes.There are 2901 unique funds in our sample. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its whole life span. Changing this threshold to say 70% or 80% does not qualitatively change our results. So for most part of the analysis we stick to the 75% threshold.[7] At this level we have around 1200 quarterly funds and 600 semi-annual funds in Thompson Financial CDA/Spectrum database. However after merging with CRSP database and screening the sample following the procedure mentioned above, we have 777 quarterly and 392 semi-annual domestic equity funds. This number goes up when we define semi-annual and quarterly funds at a lower threshold - say at 70%.

Panel A of this table displays the mean, the median, the standard deviation, the 25th and the 75th percentile of the TNA (Total Net Assets), number of stock

[7] Owing to missing data and other reasons such as change in the fiscal year, we do not see a fund disclosing at the same frequency throughout its existence. So we allow for some of the disclosures to be at different frequencies and still call a fund semi-annual / quarterly as the case may be. When we increase the threshold beyond 80% we have fewer funds and our statistical tests lack power.

holdings, expense ratio, new money flow, annual turnover and age of all the funds in the sample. Panel B, reports the same details for the the quarterly funds and Panel C for the the semi-annual funds. We calculate new money flow as follows: $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$.

Table 3.2 compares the characteristics of all the funds in the sample with that of the quarterly and semi-annual funds and reports p value of the difference in the means of quarterly and semi-annual funds.

We see that the semi funds are considerably bigger in size(TNA) compared to the quarterly funds. This may be because big funds are more exposed to activities such as front running and they prefer to disclose less often to minimize their trading cost.

The expense ratio of the semi-annual funds seems to be higher than that of the quarterly funds. If we can take expense ratio to be a proxy for agency cost, we probably can infer that funds who are more likely to incur agency cost are the ones more likely to disclose less frequently. But expense ratio includes marketing and distribution cost, and higher marketing expenses may not necessarily lead to poor performance.

The annual turnover ratio of semi-annual funds seem to be higher than that of the quarterly funds. If we can consider turnover ratio to be a proxy for information related trades, we probably can infer that funds engaged in more information based trades prefer to be semi-annual.[8]

We see that flows to the semi-annual funds are more volatile. It may be because funds experiencing volatile flow strategically disclose less frequently to counter flow based front running.

[8]see Ge & Zheng (2006) for a discussion on expense ratio, turnover ratio etc.

Lastly semi-annual funds appear to be holding more number of stocks and are younger compared to their quarterly counterparts.

3.5 Results

3.5.1 Frequency of Disclosure and Mutual Fund Performance

We divide our sample into two periods - between 1990 and 2003 and between 2005 and 2008 - and compare the performance of semi-annual and quarterly funds in each of these periods.

Before 2004

First, we identify the semi-annual and quarterly funds during 1990-2003. Every month we rank the funds into quintiles based on their past 12 month abnormal returns using the Carhart (1997)four factor model.The Carhart model has the following general specification:

$$R_{i,t}-R_{F,t} = \alpha_i+\beta_{i,M}(R_{M,t}-R_{F,t})+\beta_{i,SMB}SMB_t+\beta_{i,HML}HML_t+\beta_{i,MOM}MOM_t+\epsilon_{i,t}$$

where the dependent variable is the return of fund i in month t minus the risk-free rate, and the independent variables are given by the returns of the following four zero-investment factor portfolios. The term $R_{M,t} - R_{F,t}$ denotes the excess return of the market portfolio over the risk-free rate, SMB is the return difference between small and large capitalization stocks, HML is the return difference between high and low book-to-market stocks, and MOM is the return difference between stocks with high and low past returns.[9] The intercept of the model, α_i, is Carhart's measure of

[9] The factor returns are taken from Kenneth Frenchs Web site:

abnormal performance. The CAPM uses only the market factor, while the Fama and French model uses the first three factors.

We hold an equally weighted portfolio of the funds in a quintile for the next one month. Then we regress these monthly portfolio returns on the market factor (CAPM), three factors (Fama and French) and four factors (Carhart). The results are reported in Table 3.3.

At the bottom of the table we see that there is no unconditional difference between the performance of semi-annual and quarterly funds. However top quintile semi-annual funds outperform top quintile quarterly funds by 17-20 basis points a month. This supports our conjecture that top quintile quarterly funds suffer more from activities such as front running. We report results for mean raw returns, mean excess returns in the first two columns. However we concentrate on the CAPM alpha, three factor alpha and four factor alpha in the last three columns.

We do not find any significant difference between the performance of poorly performing semi-annual and quarterly funds. This probably implies that any gain on less front running for the semi-annual fund is negated by larger agency cost incurred by the fund managers owing to less monitoring.

For robustness check we repeat the portfolio analysis for semi-annual and quarterly funds who disclose semi-annually or quarterly for more than 80% of the time during their existence. We find similar results as reported in table 3.4. The top quintile semi funds outperform top quintile quarterly funds by 16-19 basis points a month. And there is no significant difference in performance between the bottom quintile semi-annual and quarterly funds. In unreported results we repeat this analysis for frequency thresholds starting from 70% and increasing by steps of 1% and get similar

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http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data Library.

findings. As a further step to check robustness of our results, we repeat the above analysis by ranking the funds based on their past 12-month four factor abnormal returns into deciles and compare the performance of the top and bottom decile semi-annual funds with that of top and bottom deciles quarterly funds. We do not report the results. However, the top decile semi-annual fund outperforms the top decile quarterly fund by even a larger margin(by 24-28 basis point a month compared to 17-20 basis points a month earlier). There is no statistically significant difference in performance between the bottom decile semi-annual and quarterly funds.

The results we obtain for the successful funds here is similar to Ge and Zheng(2006), but we do not find their results for poorly performing funds. They examine the relationship between disclosure frequency and future fund performance conditioned upon fund investment skills. They take past performance as a proxy for fund investment skills and show that past winners who disclose less frequently outperform past winners who disclose more frequently and past losers who disclose less frequently under perform past losers who disclose more frequently. The difference in result for the poorly performing funds could be attributed to the more recent data (our sample spans from 1990-2003 and theirs from 1985-1999) and the different methodology we use in this study.

After 2004

Between 1990 and 2003 we see that semi-annual successful funds outperform quarterly successful funds by 17-20 basis points a month. This may be because semi-annual successful funds were less exposed to activities such as front running. If this is true we should expect the difference in performance (between semi-annual successful funds and quarterly successful funds) to be reduced or become insignificant after 2004, as all the funds are required to disclose quarterly since then.

We compare the performance of previously (prior to 2004) semi-annual successful funds with quarterly successful funds between 2005 and 2008. We rank the semi-annual and quarterly funds into quintiles based on their four factor abnormal return during the previous 12 months.We hold an equally weighted portfolio of the funds in a quintile for the next one month. Then we regress these monthly portfolio returns on the market factor (CAPM), three factors (Fama and French) and four factors (Carhart).

We see in Table 3.5 that there is no statistical or economic significant difference in performance between the semi-annual successful funds and quarterly successful funds any more. The difference in abnormal returns has reduced from 17-20 basis points a month prior to 2004 to 2-4 (none of which is statistically significant) basis points a month after 2004.

In unreported analysis, we divide the sample period from 1990 to 2008 into three – 1990-1997, 1998-2003 and 2005-2008. We find that the semi-annual successful funds outperform the quarterly successful funds during the first two sub periods. However, between 2005 and 2008, there is no significant difference in their (previously semi-annual and quarterly funds) performances.

The increase of disclosure frequency after 2004 was expected to reduce the agency cost in the previously semi-annual poorly performing funds and hence to improve their performance. However this would also expose the funds to activities such as front running and it was not obvious which effect would dominate.We compare the performances of poorly performing semi-quarterly funds and poorly performing qtly-qtly funds between 2005 and 2008. In Table 3.5 we do not find any significant difference in their performance (as was the case prior to 2004). This suggests that any improvement in the agency cost of the poorly performing previously semi-annual funds after 2004 has probably been negated by the increase in the trading costs owing to activities such as front running.

For robustness purposes we repeat the analysis for semi-annual and quarterly funds, defined with a threshold of 80% and obtain similar results.There is no significant difference in performance between the semi-annual successful funds and quarterly successful funds any more. We rank the funds into deciles based on their past 12-month four factor abnormal return and repeat the analysis. We again obtain similar results.

The Difference-in-Difference Estimator

So far we have learned that successful semi-annual funds have a performance advantage over successful quarterly funds prior to 2004. We also saw that this performance advantage goes away after 2004. Now we need to establish that this is indeed caused by the change in disclosure policy in 2004. In this sub-section we try to show that through difference-in-difference and triple difference tests. We are able to implement these tests because the change in the policy is an exogenous event, which affects only the semi-annual funds (our treatment group) and not the quarterly funds (our control group). As discussed before, for better identification of the impact of higher disclosure frequency on performance, we focus on the successful semi-annual and quarterly funds.

Table 3.6 shows results for the difference-in-difference test. Here our main variable of interest is the double interaction term($Semi_i * POST2004$). In panel A, we have restricted our sample to the successful funds only and in Panel B, to poorly performing funds only. We can see that the above coefficient is negative and significant in Panel

A and not significant in Panel B. This implies an performance drop of around 22 bps a month after 2004 for the successful funds who were semi-annual before 2004. In Panel B we do not see any such change in the performance of the poorly performing funds which were semi-annual before 2004.

Table 3.7 shows results for the difference-in-difference-in-difference test. For this test we use the whole sample of semi-annual and quarterly funds. Here our main variables of interest are the triple interaction terms($Semi_i * POST2004 * Rank4_{i,t-1}$ and $Semi_i * POST2004 * Rank0_{i,t-1}$). These are similar to the double interaction term in Table 3.6. As we can see, the coefficient on $Semi_i * POST2004 * Rank4_{i,t-1}$ is negative and significant in all the specifications. This implies that successful funds which were semi-annual before 2004 appear to have lost around 22-23 bps a month after 2004. The coefficient on $Semi_i * POST2004 * Rank0_{i,t-1}$ is not significant. And this implies that the change in the regulation did not have any impact on the poorly performing funds which were semi-annual before 2004.

These evidence support the hypothesis that successful previously semi-annual funds are more exposed to activities such as front running after 2004 and this is adversely affecting their performance. In the next section we will look at the cross-section of semi-annual and quarterly funds and will give further evidence in support of this argument.

3.5.2 Frequency of Disclosure, Mutual Fund Performance and Illiquid Fund Holdings

In this section we test our second hypothesis which says that the change in the disclosure policy will affect the funds holding illiquid assets (Illiquid Funds) more than funds holding liquid assets(Liquid Funds).

First, we examine if there is any difference in the performance between the illiquid semi-annual and illiquid quarterly funds prior to the policy change. We then go on to implement a difference-in-difference test to see if the performance of the successful previously semi-annual illiquid funds has come down after the policy change in 2004. We repeat the above exercise for liquid semi-annual and quarterly funds. At the end we implement difference-in-difference tests for small cap and large cap funds.

Relative performance of Illiquid and Liquid semi-annual and quarterly Funds before 2004

We identify the illiquid and liquid semi-annual and quarterly funds following the methods explained in sections 3.4. Every month we rank these funds into tertiles based on their past 12 month abnormal returns using the Carhart (1997)four factor model. We hold an equally weighted portfolio of the funds in a tertile for the next one month. We regress these monthly portfolio returns on the market factor (CAPM), three factors (Fama and French) and four factors (Carhart).

Table 3.8 shows the results for the performance difference between illiquid semi-annual and illiquid quarterly funds in Panel A and between liquid semi-annual and liquid quarterly funds in Panel B. We can see that the successful semi-annual illiquid funds have significant 3-factor and 4-factor performance advantage (of around 33 basis points) over their quarterly counter parts. We do not see any such difference for the liquid successful funds. This lend credence to the hypothesis that illiquid quarterly funds attract more front runners and hence suffer more compared to the illiquid semi-annual funds.

The Difference-in-Difference Test for the Illiquid Funds

We just learned that successful illiquid semi-annual funds have a performance advantage over successful illiquid quarterly funds prior to 2004. In this section we will examine the impact of the change in disclosure policy in 2004 on the performance of illiquid semi-annual funds through difference-in-difference and triple difference tests. We are able to implement these tests because the change in the policy is an exogenous event, which affects only the semi-annual illiquid funds (our treatment group) and not the quarterly illiquid funds (our control group). As discussed before, for better identification of the impact of higher disclosure frequency on performance, we focus on the successful semi-annual and quarterly illiquid funds.

Table 3.9 shows results for difference-in-difference estimation for the successful illiquid funds in Panel A and poorly performing illiquid funds in Panel B (the sample has been restricted to the successful illiquid funds for Panel A and poorly performing illiquid funds for Panel B). As discussed earlier the coefficient of interest is that of the double interaction term($Semi_i * POST2004$). We can see that it is negative and significant for the successful illiquid semi-annual funds (Panel A) and insignificant for the poorly performing illiquid semi-annual funds(in Panel B). This result (about -34 bps a month) is similar but stronger than the results we had obtained for the whole sample of successful semi-annul funds(about -22 bps a month). This further supports the hypothesis that successful semi-annual funds, particularly illiquid funds suffer more from activities such as front running after the policy change in 2004.

Table 3.10 shows results for the triple difference test for the illiquid funds. For this test we use the whole sample of semi-annual and quarterly illiquid funds. Here our main variables of interest are the triple interaction terms($Semi_i * POST2004 * Rank2_{i,t-1}$ and $Semi_i * POST2004 * Rank0_{i,t-1}$).These are similar to the double interaction term in Table 3.9. As we can see, the coefficient on $Semi_i * POST2004 * Rank2_{i,t-1}$ is negative and significant in all the specifications. This implies that successful illiquid funds who were semi-annual before 2004 appear to have lost around 36 bps a month after 2004. The coefficient on $Semi_i * POST2004 * Rank0_{i,t-1}$ is not significant. And this implies that the change in the regulation did not have any net impact on the poorly performing illiquid funds who were semi-annual before 2004.

The Difference-in-Difference Test for the Liquid Funds

We repeat the tests for the liquid funds. The results are reported in the tables 3.11 and 3.12. We do not find the results we find for the illiquid funds. In fact in Table 3.12 we find some improvement in performance for the successful previously semi-annual funds and deterioration in performance for the poorly performing previously semi-annual funds.

The Difference-in-Difference Test for Small Cap and Large Cap Funds

In this subsection we use illiquid and liquid funds identified based on their investment styles. small cap funds primarily invest in small cap stocks which are relatively illiquid and large cap funds primarily invest in large cap stocks which are relatively liquid. Our hypothesis would predict that the change in frequency will have a higher impact on the small cap funds compared to the large cap funds.

We conduct similar tests on these funds as we did in the previous section. Table 3.13 shows the results. We see that the results for the small cap fund is similar to what we had previously obtained for illiquid funds. The performance of successful previously semi-annual small cap fund has gone down by around 36 bps a month after 2004. And there appears to be no impact of the change in disclosure frequency on the performance of successful previously semi-annual large cap funds. Similarly we do not find any net impact on the performance of poorly performing previously semi-annual small cap and large cap funds.

3.5.3 Frequency of Disclosure, Mutual Fund Performance and Size of the Funds

In this subsection, we turn our attention to asset under management. From the descriptive statistics of the funds, we see that the semi-annual funds are significantly larger than the quarterly funds. Ge and Zheng (2006) show that large funds are more likely to disclose less frequently . So it is likely that prior to 2004 successful large funds which disclose less frequently will outperform successful large funds which discloses more frequently by a bigger margin. That is the relative performance between semi-annual and quarterly funds will increase with asset under management.

To test this we rank both the semi-annual and quarterly funds based on their past 12 months (four factor) abnormal return. We choose only the top quintile semi-annual and quarterly funds from the sample. We again rank these top quintile funds based on their total net assets. As we are doing a double sort, we consider funds between 1998-2003 to have more number of funds in each size groups. In all, we have 33011 observations for quarterly funds (693 unique funds) and 15220 observations for the semi-annual funds(339 unique funds). We compare the performance of successful semi-annual funds with that of successful quarterly funds in the same size(TNA) group.

In panel A of the Table 3.14, we divide the successful semi-annual and quarterly funds into three groups based on their recent size(TNA) and hold an equally weighted portfolio of funds in each group for the next month. We report the mean raw return, mean excess return, CAPM alpha, three factor alpha and four factor alpha.

We see that the magnitude of the outperformance of successful semi-annual funds over successful quarterly funds increases almost monotonically over the size of the funds. For example for the 3 factor regression it is 7 basis points a month for the lowest size group and 37 basis points for the highest size group.

In panel B we divide the successful funds into two groups based on their recent size(TNA) and repeat the same exercise. We find similar results. The out performance of the semi-annual funds in the bigger size group is more than double that of the smaller size group.

The results support our conjecture that successful large funds are more exposed to activities such as front running and incur more on trading costs compared to successful small funds. The results are economically significant and of mixed statistical significance.

After 2004, we do not find any difference in performance between the semi-annual and quarterly successful funds and also, we do not find any relationship between their size and relative performance.

3.5.4 Frequency of Disclosure and Return Gap

As a robustness check in this section we study if semi-annual and quarterly funds differ in creating or destroying value relative to the previously disclosed holdings.

Kacperczyk, Sialm & Zheng(2007) estimate the impact of unobserved actions on fund returns using a measure they call return gap. It is the difference between the reported fund return and the return on a portfolio that invests in the previously disclosed fund holdings. They document that unobserved actions of some funds persistently create value, while such actions of other funds destroy value. Their main result shows that return gap is persistent and it predicts future fund performance.

We conjecture that activities such as front running and in certain circumstances free riding will affect firms' abilities to create value relative to the previously disclosed holdings. Copycat and front running strategies are less effective against the semi-annual funds compared to the quarterly funds and to the extent these strategies affect only the fund returns and not the holding period returns, we will see return gaps of the semi-annual successful funds to be persistently higher than that of quarterly successful funds.

For the poorly performing semi-annual funds, the advantage of less front running may be negated by more value destroying activities by the fund manager (as a result of less monitoring by the investors) and it is not obvious if the return gap of the semi-annual poor funds will be different from that of the quarterly poor funds.

Persistence of difference in Return Gap between the semi-annual and quarterly funds

In this section we examine if there is any difference in the monthly return gap between the successful[10] semi-annual funds and successful quarterly funds and if this difference persist over time. If there is a systematic difference between both the groups then we would expect the relative return gap to persist over time.

[10] In this section a successful fund means a fund who belongs to the top quintile / decile of the funds sorted on past 12-month average return gap.Similarly a poorly performing fund belongs to the bottom quintile / decile.

We rank the funds based on their lagged 12-month average return gap and report equally weighted return gap for each quintile group in the Table 3.15.We find that the return gaps of the top quintile semi-annual funds are more than double that of the top quintile quarterly funds. This difference persists over a period of 24 months. This suggests a systematic difference in the abilities of these two groups of funds in creating value relative to the last disclosed holdings and we attribute this to the less exposure of semi-annual funds to activities such as front running.

We do not find any such difference between the poorly performing funds in both the groups. This supports our conjecture that for semi-annual poor funds the positive effect on the return gap owing to less effective front running is negated by the value destroying activities by the managers.

To confirm that this persistent difference in the return gap captures a systematic difference in both the groups of funds, we test if this difference in return gap between the successful semi-annual and successful quarterly funds predict any difference in their future performance.

Predictability based on difference in Return Gap

We examine the performance of a trading strategy based on the past return gap difference between the successful semi-annual funds and successful quarterly funds. We sort semi-annual and quarterly funds in our sample into deciles according to their average monthly return gap during the previous 12 months (with a lag of 2 month to allow for the 60 days lag in the reporting requirements). We then compute for each month the average subsequent monthly return by weighting all the funds in a decile equally. Table 3.16 show that one can earn between 24 to 34 basis points a month by going long on the top decile semi-annual funds and short on the top decile quarterly funds.

This tables establish that value creation by the successful funds relative to the previous disclosed holdings is hampered by activities such as front running by other agents in the market.We do not find any statistically and economically significant difference in the performance between poorly performing semi-annual and quarterly funds. It suggests that any gain for the poorly performing semi-annual funds from activities such as front running is negated by more agency cost / value destruction.

This difference in return gap between semi-annual and quarterly funds disappear after 2004.

3.6 Conclusion

To our knowledge this is the first paper that examines the performance of mutual funds before and after the regulatory change in the disclosure frequency in 2004. We show that successful semi-annual funds had a distinct performance advantage over successful quarterly funds prior to the policy change. This advantage disappears after 2004. The reduction in performance is higher for semi-annual funds holding illiquid assets than those holding liquid assets. This suggests that semi-annual funds are more exposed to activities such as front running after 2004.

One would have expected the change in policy to help reduce the agency cost of poorly managed semi-annual funds. However, we do not find any improvement in the performance of the previously semi-annual poorly performing funds (funds, in which the agency problem should have been be higher). This suggests that any improvement in the agency cost of the poorly performing previously semi-annual funds after 2004 has been negated by the increase in the trading costs owing to activities such as front running.

Our results have implications for any change in the disclosure frequency in the future, for example from quarterly to monthly. Policy makers will have to strike a balance between potential advantages of more frequent portfolio disclosure and the possible harmful side-effects coming from activities such as front-running.

Lastly, our results could also be interpreted as indirect evidence in support of activities such as front running taking place in the market. Prior works in front-running literature have so far focused on the the agents who front run or profit accruing from hypothetical front-running strategies. In this paper we complement those by showing the impact of these sorts of activities on the performance of the mutual funds.

3.7 References

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3.8 Tables

Table 3.1: Summary Statistics

This table displays the mean, median, standard deviation, the 25th and the 75th percentile of total net assets, number of stock holding, expense ratio, new money flow, annual turnover and age of the funds for the whole sample in panel A, and for the quarterly and the semi-annual funds in panel B and C respectively. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its existence. We calculate new money flow as follows: $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$

Panel A: All	mean	median	Std Dev	25%	75%
TNA in million	905	918	381	522	1227
No of stocks	114	117	21	102	129
Expense ratio	1.30%	1.30%	0.07%	1.28%	1.34%
Flow	3.98%	2.29%	8.15%	1.34%	3.52%
Turn over	91%	88.50%	13.70%	80.50%	101%
Age	15.4	9.58	15.3	4.58	21.5

Panel B: Qtly	mean	median	Std Dev	25%	75%
TNA in million	948	988	382	633	1252
No of stocks	90	86	16	81	107
Expense ratio	1.30%	1.30%	0.08%	1.27%	1.34%
Flow	2.77%	1.55%	14.55%	0.75%	2.19%
Turn over	82%	78.00%	16.50%	68.00%	95%
Age	17	16.2	3.63	12.74	20.27

Panel C: Semi	mean	median	Std Dev	25%	75%
TNA in million	1248	1239	559	741	1686
No of stocks	114	113	31	90.5	135
Expense ratio	1.41%	1.38%	0.15%	1.30%	1.42%
Flow	7.33%	2.55%	23.16%	1.12%	4.63%
Turn over	117%	116.00%	12.00%	111.00%	121%
Age	12.52	12.62	0.868	12.27	13.12

Table 3.2: Summary Statistics: Semi-annual Vs. Quarterly Funds

This table compares the average total net asset(TNA), number of stock holdings, expense ratio, number of unique funds, new money flow, annual turn over and age of all the funds in the sample with that of the quarterly and semi-annual funds. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its existence. We calculate new money flow as follows: $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$

	All	Qtly	Semi	Qtly-Semi	p value
No of funds	2901	777	392		
TNA in million	905	948	1248	-338	< 0.0001
No of stocks	114	90	114	-24	< 0.0001
Expense ratio	1.30%	1.30%	1.41%	-0.11%	< 0.0001
Flow	3.98%	2.77%	7.33%	-4.43%	0.046
Turn over	91%	82%	117%	-35%	< 0.0001
Age	15.4	17	12.518	4.48	< 0.0001

Table 3.3: Disclosure Frequency and Fund Performance (1990-2003)

This table reports mean monthly returns for quintile portfolio of mutual funds sorted on their past 12 month abnormal return during the period 1990-2003. We use the four factor model of Carhart (1997) to determine past 12-month abnormal return. The table reports results for all the funds in the sample and for semi-annual and quarterly funds separately. At the end it reports the difference in performance between semi-annual funds and quarterly funds. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its whole life span. In the second column we show the mean raw return, in the third, the mean excess return. Fourth, fifth and the last columns show the CAPM alpha, three factor alpha of Fama and French and four factor alpha of Carhart (1997) respectively. The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

	past perf rank	Raw Ret	Ex Ret	CAPM	3F	4F
All the Funds	0	0.73**	-0.21**	-0.21*	-0.31***	-0.26**
	1	0.84**	-0.11*	-0.08	-0.15**	-0.12**
	2	0.9**	-0.05	-0.01	-0.08*	-0.06
	3	0.96**	0.01	0.04	-0.02	-0.03
	4	1.2**	0.27*	0.23	0.23**	0.13
	past perf rank	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly Funds	0	0.74**	-0.2*	-0.19*	-0.28**	-0.23**
	1	0.83**	-0.12*	-0.08	-0.16**	-0.12**
	2	0.88**	-0.07	-0.03	-0.1**	-0.07
	3	0.95**	0	0.04	-0.02	-0.04
	4	1.2**	0.25*	0.21	0.19**	0.11
Semi Funds	0	0.71*	-0.24*	-0.25*	-0.37***	-0.32**
	1	0.87**	-0.08	-0.06	-0.14*	-0.12
	2	0.89**	-0.06	-0.03	-0.1	-0.1
	3	1**	0.09	0.09	0.03	-0.01
	4	1.4***	0.46**	0.4**	0.39**	0.28**
Semi-Qtly	s-q (0)	-0.03	-0.04	-0.06	-0.09	-0.09
	s-q (1)	0.04	0.04	0.02	0.02	0
	s-q (2)	0.01	0.01	0	0	-0.03
	s-q (3)	0.05	0.09	0.05	0.05	0.03
	s-q (4)	0.2**	0.21**	0.19**	0.2**	0.17**
	s-q	0.054	0.062	0.04	0.036	0.016

Table 3.4: Disclosure Frequency and Fund Performance (1990-2003) Contd.

This table reports mean monthly returns for quintile portfolio of mutual funds sorted on their past 12 month abnormal return during the period 1990-2003. We use the four factor model of Carhart (1997) to determine past 12-month abnormal return. The table reports results for all the funds in the sample and for semi-annual and quarterly funds separately. At the end it reports the difference in performance between semi-annual funds and quarterly funds. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 80% of the time during its whole life span. In the second column we show the mean raw return, in the third, the mean excess return. Fourth, fifth and the last columns show the CAPM alpha, three factor alpha of Fama and French and four factor alpha of Carhart (1997) respectively. The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

	past perf rank	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly Funds	0	0.74**	-0.21*	-0.21*	-0.29**	-0.23**
	1	0.84**	-0.11	-0.08	-0.15**	-0.12*
	2	0.84**	-0.1*	-0.07	-0.14**	-0.11**
	3	0.94**	-0.01	0.02	-0.04	-0.04
	4	1.2**	0.25*	0.21	0.19**	0.12
Semi Funds	0	0.78**	-0.17	-0.17	-0.31**	-0.25**
	1	0.86**	-0.09	-0.05	-0.15*	-0.13
	2	0.93**	-0.02	0.01	-0.06	-0.07
	3	1**	0.09	0.09	0.03	-0.01
	4	1.4***	0.45**	0.4**	0.37**	0.28**
Semi-Qtly	s-q (0)	0.04	0.04	0.04	-0.02	-0.02
	s-q (1)	0.02	0.02	0.03	0	-0.01
	s-q (2)	0.09	0.08	0.08	0.08	0.04
	s-q (3)	0.06	0.1	0.07	0.07	0.03
	s-q (4)	0.2**	0.2**	0.19**	0.18**	0.16*
	s-q	0.082**	0.088**	0.082**	0.062*	0.04

Table 3.5: Disclosure Frequency and Fund Performance (2005-2008)

This table reports mean monthly returns for quintile portfolios of mutual funds sorted on past 12 month abnormal fund return during the period 2005-2008. We use the four factor model of Carhart (1997) to determine past 12-month abnormal return. The table reports results for previously semi-annual and quarterly funds separately. It also reports the difference in performance between previously semi-annual and quarterly funds. We call a fund previously semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its existence prior to 2004. In the second column we show the mean raw return, in the third the mean excess return. Fourth, fifth and the last columns show the CAPM alpha, three factor alpha of Fama and French and four factor alpha of Carhart (1997) respectively. The significance levels are denoted by *, **, *** and indicate whether the results are statistically different from zero at the 10-, 5- and 1-percent significance level

	past perf rank	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly Funds	0	-0.62	-0.27**	-0.21**	-0.21**	-0.2**
	1	-0.54	-0.18**	-0.18**	-0.18**	-0.16**
	2	-0.41	-0.06	-0.06	-0.05	-0.06
	3	-0.4	-0.05	-0.03	-0.01	-0.07
	4	-0.32	0.03	0.07	0.11	-0.03
Semi Funds	0	-0.7	-0.35**	-0.31**	-0.27**	-0.27**
	1	-0.47	-0.12	-0.13	-0.09	-0.08
	2	-0.43	-0.08	-0.04	-0.04	-0.06
	3	-0.4	-0.05	-0.03	-0.01	-0.11**
	4	-0.3	0.05	0.11	0.15	-0.01
Semi-Qtly	s-q (0)	-0.08	-0.08	-0.1	-0.06	-0.07
	s-q (1)	0.07	0.06	0.05	0.09*	0.08
	s-q (2)	-0.02	-0.02	0.02	0.01	0
	s-q (3)	0	0	0	0	-0.04
	s-q (4)	0.02	0.02	0.04	0.04	0.02
	s-q	-0.002	-0.004	0.002	0.016	-0.002

Table 3.6: The Impact of Change in Disclosure Frequency on Mutual Fund Performance: the Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. $Semi_i$ is an indicator variable and takes a value of one if a fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. Expense ratio and Total net assets are control variables and are lagged by a month. Panel A shows the results for the successful funds (funds which are in the top quintiles according to the past 12-month four factor abnormal returns) funds and panel B shows the results for the poorly performing funds (funds which are in the bottom quintiles according to the past 12-month four factor abnormal returns). We include year dummies and use panel corrected standard errors.

Panel A	Coefficient	Std Error	t value	p value
Intercept	0.364	0.13	2.8	0.0053
Semi	0.19	0.079	2.4	0.0168
POST2004	-0.255	0.123	-2.08	0.0379
Semi*POST2004	-0.228	0.104	-2.2	0.028
Expense ratio	-6.988	1.926	-3.63	0.0003
Total net asset	-0.019	0.014	-1.36	0.1744
observations	18190			
R-squared	0.019			
Panel B	Coefficient	Std Error	t value	p value
Intercept	-0.09	0.14	-0.64	0.5222
Semi	0.021	0.086	0.25	0.8049
POST2004	0.213	0.142	1.5	0.1343
Semi*POST2004	-0.061	0.125	-0.49	0.6237
Expense ratio	-15.856	3.005	-5.28	¡.0001
Total net asset	-0.006	0.016	-0.35	0.7298
observations	18530			
R-squared	0.005			

Table 3.7: The Impact of Change in Disclosure Frequency on Mutual Fund Performance: the Diff-in-Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. $rank4$ is an indicator variable and takes a value one if a fund belongs to the top quintiles according to the past 12-month four factor abnormal return and zero otherwise. Similarly $rank0$ is an indicator variable and takes a value one if a fund belongs to the bottom quintile according to the past 12-month four factor abnormal return and zero otherwise. $Perf$ is the percentile rank of the fund according to the past 12-month four factor abnormal return.Expense ratio and Total net assets are control variables and are lagged by a month. We include year dummies and use panel corrected standard errors.The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

	1	2	3	4	5	6
Intercept	0.172**	0.047	0.152**	0.069	0.219**	-0.035
rank4*Semi*POST2004	-0.236**	-0.235**	-0.225*	-0.223*		
rank0*Semi*POST2004	-0.048	-0.049			0.012	0.009
rank4	0.205***	0.105**	0.223***	0.117**		
rank0	-0.073*	0.026			-0.123**	0.088*
rank4*Semi	0.201**	0.201**	0.199**	0.198**		
rank0*Semi	0.01	0.011			-0.043	-0.039
Semi	-0.002	-0.002	0.001	0.001	0.051*	0.047
Semi*POST2004	-0.006	-0.005	-0.018	-0.018	-0.068*	-0.064*
POST2004	-0.054	-0.054	-0.066	-0.064	-0.072	-0.073
rank4*POST2004	-0.033	-0.034	-0.035	-0.036		
rank0*POST2004	0.007	0.008			0.011	0.016
Expense ratio	-14.014***	-13.946***	-14.318***	-13.937***	-13.478***	-13.7***
Total net asset	-0.011**	-0.012**	-0.01*	-0.012**	-0.012**	-0.012**
perf		0.251***		0.215***		0.428***
observations	93123	93123	93123	93123	93123	93123
R-squared	0.0109	0.011	0.0108	0.011	0.01	0.0107

Table 3.8: Disclosure Frequency and Illiquid & Liquid Mutual Fund Performance

This table reports mean monthly returns for tertile portfolio of Illiquid mutual funds in Panel A and Liquid mutual funds in Panel B, sorted on their past 12 month abnormal return during the period 1990-2003. We use the four factor model of Carhart (1997) to determine past 12-month abnormal return. The table reports results for semi-annual and quarterly funds separately and their performance difference. We call a fund illiquid if value weighted average gibb' estimate of its individual holdings on the recent report date is in the top tertile and liquid if it is in the bottom tertile. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its whole life span. In the second column we show the mean raw return, in the third, the mean excess return. Fourth, fifth and the last columns show the CAPM alpha, three factor alpha of Fama and French and four factor alpha of Carhart (1997) respectively. The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

Panel A			Illiquid Funds			
	past_perf	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly Funds	0	0.81	-0.14	-0.22	-0.31**	-0.3**
	1	0.94*	0	-0.09	-0.18*	-0.22**
	2	1.3**	0.35	0.22	0.22	0.07
Semi Funds	0	0.71	-0.24	-0.37	-0.42**	-0.41**
	1	1*	0.1	-0.06	0.01	-0.15
	2	1.5**	0.55	0.34	0.54**	0.4*
Semi-Qtly	s-q (0)	-0.1	-0.1	-0.15	-0.11	-0.11
	s-q (1)	0.1	0.1	0.03	0.19*	0.07
	s-q (2)	0.2	0.2	0.12	0.32**	0.33**
	s-q	0.05	0.07	0	0.13	0.1
Panel B			Liquid Funds			
	past_perf	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly Funds	0	0.75**	-0.2	-0.08	-0.22***	-0.15**
	1	0.85**	-0.09	0.02	-0.09*	-0.03
	2	0.91***	-0.03	0.1	-0.04	0
Semi Funds	0	0.82**	-0.12	0.02	-0.13	-0.06
	1	0.89**	-0.06	0.05	-0.07	-0.02
	2	0.98***	0.03	0.18	0.01	0.01
Semi-Qtly	s-q (0)	0.07	0.08	0.1**	0.09*	0.09*
	s-q (1)	0.04	0.03	0.03	0.02	0.01
	s-q (2)	0.07	0.06	0.08	0.05	0.01
	s-q	0.06	0.06	0.07*	0.05*	0.04

Table 3.9: The Impact of Change in Disclosure Frequency on Illiquid Mutual Fund Performance: the Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. Here the sample has been restricted to the illiquid funds only. $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. Expense ratio and Total net assets are control variables and are lagged by a month. Panel A shows results for the successful funds only(funds which are in the top quintiles according to the past 12-month four factor abnormal returns) and panel B shows the results for the poorly performing funds only(funds which are in the bottom quintiles according to the past 12-month four factor abnormal returns). We include year dummies and use panel corrected standard errors.

Panel A	Coefficient	Std Error	t value	p value
Intercept	-0.35	0.29	-1.21	0.2252
Semi	0.21*	0.12	1.81	0.0711
POST2004	0.179	0.29	0.62	0.5324
Semi*POST2004	-0.341**	0.16	-2.1	0.0365
Expense ratio	-10.042***	2.11	-4.77	¡.0001
Total net assets	-0.009	0.02	-0.36	0.72
Observations	9050			
R-Square	.017			
Panel B	**Coefficient**	**Std Error**	**t value**	**p value**
Intercept	0.103	0.296	0.35	0.7272
Semi	-0.042	0.147	-0.29	0.7741
POST2004	0.071	0.299	0.24	0.8116
Semi*POST2004	0.038	0.188	0.2	0.8408
Expense ratio	-14.799***	0.93	-15.91	¡.0001
Total net assets	-0.028	0.022	-1.25	0.2115
Observations	9072			
R-Square	0.014			

Table 3.10: The Impact of Change in Disclosure Frequency on Illiquid Mutual Fund performance: the Diff-in-Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. Here the sample has been restricted to the illiquid funds only. $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. $rank2$ is an indicator variable and takes a value one if a fund belongs to the top tertile according to the past 12-month four factor abnormal return and zero otherwise. Similarly $rank0$ is an indicator variable and takes a value one if a fund belongs to the bottom tertile according to the past 12-month four factor abnormal return and zero otherwise. $Perf$ is the percentile rank of the fund according to the past 12-month four factor abnormal return. Expense ratio and Total net assets are control variables and are lagged by a month. We include year dummies and use panel corrected standard errors. The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

	1	2	3	4
Intercept	-0.141	-0.2	0.014	-0.481***
perf		0.189		0.765***
rank2*Semi*POST2004	-0.368*	-0.366*		
rank0*Semi*POST2004			0.27	0.266
rank2	0.359***	0.266**		
rank0			-0.137*	0.235***
rank2*Semi	0.19	0.187		
rank0*Semi			-0.272*	-0.259*
Semi	0.058	0.058	0.215***	0.203***
Semi*POST2004	-0.01	-0.01	-0.228**	-0.22**
POST2004	0.036	0.039	-0.048	-0.04
rank2*POST2004	-0.168**	-0.169**		
rank0*POST2004			0.076	0.084
Expense ratio	-14.263***	-14.137***	-13.792***	-13.957***
Total net assets	-0.021*	-0.023*	-0.02	-0.024*
Observations	27564	27564	27564	27564
R-Square	0.012	0.013	.011	.012

Table 3.11: The Impact of Change in Disclosure Frequency on Liquid Mutual Fund Performance: the Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. Here the sample has been restricted to the liquid funds only. $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. Expense ratio and Total net assets are control variables and are lagged by a month. Panel A shows the results for the successful funds only(funds which are in the top quintiles according to the past 12-month four factor abnormal returns) and panel B shows the results for the poorly performing funds only(funds which are in the bottom quintiles according to the past 12-month four factor abnormal returns). We include year dummies and use panel corrected standard errors.

Panel A	Coefficient	Std Error	t value	p value
Intercept	-0.061	0.145	-0.42	0.6732
Semi	0.031	0.059	0.52	0.6066
POST2004	-0.029	0.154	-0.19	0.8499
Semi*POST2004	0.111	0.08	1.39	0.1661
Expense ratio	-1.956	4.486	-0.44	0.6631
Total net assets	0	0.009	0.03	0.9733
Observations	8987			
R-Square	0.014			
Panel B	Coefficient	Std Error	t value	p value
Intercept	0.769	0.779	0.99	0.3245
Semi	0.052	0.073	0.72	0.4744
POST2004	-0.252	0.747	-0.34	0.736
Semi*POST2004	-0.12	0.096	-1.25	0.2137
Expense ratio	-19.746***	6.145	-3.21	0.0014
Total net assets	-0.008	0.01	-0.78	0.4362
Observations	8794			
R-Square	0.014			

Table 3.12: The Impact of Change in Disclosure Frequency on Liquid Mutual Fund Performance: the Diff-in-Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. Here the sample has been restricted to the liquid funds only. $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1990 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. $rank2$ is an indicator variable and takes a value one if a fund belongs to the top tertile according to the past 12-month four factor abnormal return and zero otherwise. Similarly $rank0$ is an indicator variable and takes a value one if a fund belongs to the bottom tertile according to the past 12-month four factor abnormal return and zero otherwise. $Perf$ is the percentile rank of the fund according to the past 12-month four factor abnormal return. Expense ratio and Total net assets are control variables and are lagged by a month. We include year dummies and use panel corrected standard errors. The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

	1	2	3	4	5	6
Intercept	0.198	0.181	0.16	0.129	0.196	0.132
perf		0.034		0.078		0.099
rank2*Semi*POST2004	0.103	0.102	0.166*	0.166*		
rank0*Semi*POST2004	-0.133	-0.133			-0.182*	-0.183*
rank2	0.011	0	0.052	0.015		
rank0	-0.087*	-0.076			-0.093	-0.045
rank2*Semi	0.078	0.078	0.026	0.025		
rank0*Semi	0.109	0.109			0.069	0.071
Semi	-0.052	-0.052			-0.012	-0.014
Semi*POST2004	0.012	0.013	-0.051	-0.051	0.061	0.063
POST2004	-0.009	-0.009	0.037	0.038	-0.018	-0.017
rank2*POST2004	-0.015	-0.016	-0.061	-0.063		
rank0*POST2004	0.096*	0.096*			0.104	0.105
Expense ratio	-10.666***	-10.645***	-11.042***	-10.626***	-10.092***	-10.222***
Total net asset	0	0	0	0	0	0
Observations	27210	27210	27210	27210	27210	27210
R-Square	.014	.014	.014	.014	.014	.014

Table 3.13: The Impact of Change in Disclosure Frequency on Small Cap & Large Cap Mutual Fund Performance: the Diff-in-Diff-in-Diff Test

This tables shows the results of the regression with monthly four factor abnormal return as dependent variable. Here the sample has been restricted to the Small Cap funds in column 1 an 2 and to Large Cap funds in column 3 and 4. $Semi_i$ is an indicator variable and takes a value of one if fund i is semi-annual between 1993 and 2003 and zero if it is quarterly. $POST2004$ is an indicator value and takes a value of one if t is later than 2004 and zero otherwise. $rank2$ is an indicator variable and takes a value one if a fund belongs to the top tertile according to the past 12-month four factor abnormal return and zero otherwise. Similarly $rank0$ is an indicator variable and takes a value one if a fund belongs to the bottom tertile according to the past 12-month four factor abnormal return and zero otherwise. $Perf$ is the percentile rank of the fund according to the past 12-month four factor abnormal return. Expense ratio and Total net assets are control variables and are lagged by a month. We include year dummies and use panel corrected standard errors. The significance levels are denoted by *, **, *** and indicate whether the results ate statistically different from zero at the 10-, 5- and 1-percent significance level.

	Small Cap Funds		Large Cap Funds	
	1	2	3	4
Intercept	-0.151	-0.347	-0.468**	-0.426**
perf	0.34***	0.746**	0.205***	0.18**
rank2*Semi*POST2004	-0.366**		0.023	
rank0*Semi*POST2004		0.151		-0.036
rank2	0.164**		0.029	
rank0		0.158*		-0.044
rank2*Semi	0.328**		-0.018	
rank0*Semi		-0.163		0.074
Semi	-0.165**	-0.012	-0.037	-0.067**
Semi*POST2004	0.166*	0.002	0.015	0.034
POST2004	0.041	-0.033	0.42**	0.348*
rank2*POST2004	-0.152**		-0.134***	
rank0*POST2004		0.072		0.082
Total net asset	-0.014	-0.015	-0.008*	-0.009*
Expense ratio	-6.91**	-6.829**	-2.057	-2.259
Observation	25457	25457	33050	33050
R squared	.01	.01	.01	.01

Table 3.14: The Impact of Fund Size on Successful Fund Performance

This table reports results for the test to examine if the asset under management (TNA) has implications for the trading costs of a fund. Our sample covers 1998-2003 for this test. We rank both the semi-annual and quarterly funds based on their past 12 months four factor abnormal return and choose only the top quintile semi-annual and quarterly funds from the sample. Then we rank these top quintile funds based on their recent total net assets into three groups (funds with rank 2 are the largest) and hold equally weighted portfolio of funds in each group for the next one month. In Panel A, the second column reports mean raw return, third column, the mean excess return. Fourth, fifth and the last columns report the CAPM alpha, three factor alpha of Fama and French and four factor alpha of Carhart (1997) respectively. It also reports the relative performance of semi-annual funds over the quarterly funds. Next we rank these top quintile funds based on their recent total net assets into two groups (funds with rank 1 are larger) and hold equally weighted portfolio of funds in each group for the next one month. The mean and abnormal return of these two portfolios for the semi-annual funds and quarterly funds are reported in Panel B. The significance levels are denoted by *, **, *** and indicate whether the results are statistically different from zero at the 10-, 5- and 1-percent significance level.

Successful Semi-annual Vs Successful Quarterly Funds

Panel A	past size rank	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly funds	0	0.94	0.46	0.44	0.29	0.21
	1	1.1	0.61**	0.59*	0.4**	0.3
	2	0.85	0.36	0.34	0.22	0.09
Semi funds	0	1	0.54**	0.53**	0.36*	0.36
	1	1.2	0.75**	0.74**	0.58**	0.4
	2	1.1	0.65	0.6	0.59*	0.38
Semi-Qtly	s-q (0)	0.06	0.08	0.09	0.07	0.15
	s-q (1)	0.1	0.14	0.15	0.18	0.1
	s-q (2)	0.25	0.29	0.26	0.37*	0.29

Panel B	past size rank	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly funds	0	1	0.54*	0.53*	0.37*	0.28
	1	0.89	0.41	0.39	0.24	0.12
Semi funds	0	1.1	0.61**	0.6**	0.46**	0.39*
	1	1.2	0.68	0.65	0.56**	0.36
Semi-Qtly	s-q (0)	0.1	0.07	0.07	0.09	0.11
	s-q (1)	0.31	0.27	0.26	0.32**	0.24*

Table 3.15: The Persistence in Difference of Return Gap

The table below reports mean monthly return gaps for quintile portfolios sorted by their average lagged return gaps during the previous 12 months in Panel A, 18 months in Panel B and 24 months in Panel C over the period 1990-2003. First column reports the return gap for all the funds in the sample, second column for the semi-annual funds, third column for the quarterly funds and the last column reports the difference in monthly return gaps between semi-annual and quarterly funds. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its whole life span. The return gap is defined as the difference between the reported fund return and the return on a portfolio that invests in previously disclosed fund holdings. The returns are reported in percentage per month. The significance levels are denoted by *, **, *** and indicate whether the results are statistically different from zero at the 10-, 5- and 1-percent significance level.

	All	Semi	Qtly	Semi-Qtly
Panel A(12)				
0	-0.161***	-0.132***	-0.158***	0.026
1	-0.066***	-0.037*	-0.067***	0.03
2	-0.047***	-0.04**	-0.054***	0.014
3	-0.023**	-0.013	-0.033**	0.019
4	0.098***	0.171***	0.065***	0.106**
Panel B(18)				
0	-0.165***	-0.175***	-0.157***	-0.018
1	-0.072***	-0.045**	-0.082***	0.037
2	-0.041***	-0.033*	-0.054***	0.021
3	-0.023**	0.046*	-0.032**	0.077
4	0.094***	0.178***	0.081***	0.097**
Panel C (24)				
0	-0.15***	-0.143***	-0.157***	0.015
1	-0.069***	-0.055**	-0.06***	0.005
2	-0.042***	-0.029	-0.057***	0.028
3	-0.017*	0.018	-0.02	0.037
4	0.071***	0.153***	0.066**	0.087*

Table 3.16: Return Gap Predicts Performance

This table reports the mean monthly returns for decile portfolios of semi-annual and quarterly funds sorted according to their lagged 12-month return gaps over the period 1990-2003. It also reports the difference in performance of semi-annual and quarterly funds. Here we have allowed for a two month lag for the disclosed portfolios to be made public so that this trading strategy can be implemented in practice. The return gap is defined as the difference between the reported return and the holding returns of the portfolio disclosed in the previous period. We call a fund semi-annual (or quarterly) if it discloses every six months (or every three months) at least 75% of the time during its whole life span. In the second column we show the mean raw return, in the third the mean excess return. Fourth, fifth and the last columns show the CAPM alpha, three factor alpha of Fama and French and four factor alpha of Carhart (1997) respectively. The returns are reported in percentage per month. The significance levels are denoted by *, **, *** and indicate whether the results are statistically different from zero at the 10-, 5- and 1-percent significance level

lag3	past rg rank	Raw Ret	Ex Ret	CAPM	3F	4F
Qtly Funds	0	0.73**	-0.21*	-0.21*	-0.19*	-0.25**
	1	0.85**	-0.1	-0.08	-0.11	-0.12*
	2	0.94**	-0.01	0.03	-0.03	-0.05
	3	0.87**	-0.07	-0.04	-0.13**	-0.1*
	4	0.91**	-0.04	0	-0.11	-0.06
	5	0.94**	0	0.04	-0.04	-0.01
	6	0.93**	-0.02	0.02	-0.09	-0.05
	7	1**	0.06	0.08	-0.03	-0.01
	8	1**	0.07	0.07	0.01	0
	9	0.99**	0.04	0	-0.04	-0.07
Semi Funds	0	0.68*	-0.26	-0.26	-0.25**	-0.3**
	1	0.85**	-0.09	-0.1	-0.12	-0.19**
	2	0.95**	0	0.01	-0.04	-0.08
	3	1**	0.05	0.05	-0.07	-0.08
	4	0.97**	0.03	0.05	-0.05	-0.03
	5	1**	0.08	0.1	0	0.01
	6	1.1**	0.13	0.15	0.04	0.06
	7	0.97**	0.02	0.03	-0.11	-0.09
	8	1.1**	0.12	0.11	0.01	-0.01
	9	1.3**	0.35	0.24	0.3*	0.17
Semi-Qtly	semi-qly(0)	-0.05	-0.05	-0.05	-0.06	-0.05
	semi-qly(1)	0	0.01	-0.02	-0.01	-0.07
	semi-qly(2)	0.01	0.01	-0.02	-0.01	-0.03
	semi-qly(3)	0.13	0.12	0.09	0.06	0.02
	semi-qly(4)	0.06	0.07	0.05	0.06	0.03
	semi-qly(5)	0.06	0.08	0.06	0.04	0.02
	semi-qly(6)	0.17*	0.15*	0.13	0.13	0.11
	semi-qly(7)	-0.03	-0.04	-0.05	-0.08	-0.08
	semi-qly(8)	0.1	0.05	0.04	0	-0.01
	semi-qly(9)	0.31*	0.31*	0.24	0.34**	0.24
	semi-qly	0.07*	0.07*	0.05	0.05	0.02