London School of Economics and Political Science

Essays on Delegated Portfolio Management

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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.

I confirm that Chapter 1 is co-authored with Terence Teo and I contributed in excess of 50% of this work. Chapter 3 is co-authored with Gyuri Venter and I contributed 50% of this work.

Abstract

This thesis contains three essays on delegated portfolio management and deals with issues such as impact of regulations on mutual fund performance, impact of competition on transparency in financial markets and strategic trading behaviour of agents in illiquid markets.

Chapter 1 analyses the impact of more frequent portfolio disclosure on mutual funds performance. Since 2004, SEC requires all U.S. mutual funds to disclose their portfolio holdings on a quarterly basis from semi-annual previously. This change in regulation provides a natural setting to study the impact of disclosure frequency on the performance of mutual funds. Prior to the policy change, it finds that the semi-annual funds with high abnormal returns in the past year outperform the corresponding quarterly funds by 17-20 basis points a month. This difference in performance disappears after 2004. The reduction in performance is higher for semi-annual funds holding illiquid assets than those holding liquid assets. These results support the hypothesis that performance of funds with more disclosure suffers more from activities such as front running.

Chapter 2 analyses the impact of competition in financial markets on incentives to reveal information. It finds that discretionary portfolio disclosure and advertising expenses of mutual funds decrease with competition. This supports the theory that mutual funds use portfolio disclosure and advertising as marketing tools to attract new investments in a financial market, where superior relative performance and greater visibility are rewarded with convex payoffs. With higher competition, the likelihood of landing new investments goes down for each fund while the cost of disclosure goes up. Funds respond by cutting down on costly disclosures and advertising activities. Thus competition seems to have adverse impact on market transparency and search cost.

Chapter 3 develops a model of strategic trading to study forced liquidation. Traders who hold an illiquid risky security have to satisfy minimum capital requirements, or liquidate their position. Therefore, traders with price impact can induce the fire sale of others to benefit from future low prices. It shows that if traders have similar proportions of wealth invested in the risky security, or the market is sufficiently liquid, they behave cooperatively and smooth their orders over several trading periods. However, if the proportions are significantly different across agents, and market liquidity is low, the strong agent, who is less exposed to the risky asset, predates on the weak agent, and forces her to exit the market.

To

Mina,Tuhina and little Tanish

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Chapter 1

The Impact of More Frequent Portfolio Disclosure on Mutual Fund Performance

1.1 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, share holders would be able to better monitor whether, and how, a fund is complying with its stated investment objective. Third, quarterly disclosure would make it easier to track whether

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

funds are engaging in various forms of portfolio manipulation such as window dressing.[2]

However, a section of mutual fund industry and academia [3] were also concerned about the repercussions of more frequent disclosures on fund performance. In a comment letter to the SEC in 2003, Fidelity Investments wrote - "Mutual funds success has its costs, however, in the form of copycats, free-riders and front-runners who can profit from knowledge of fund shareholders holdings. As mutual funds assets have grown, the potential profits to be made by trading against mutual funds at the expense of fund shareholders have grown as well." [4] [5]

Interestingly, it appears that the concerns about holdings disclosure are not new. Way back in 1929, when there were only a few funds around, an author had noted the following[6]-

"...The principal objection voiced by investment trusts to the periodical publication of their investments is that the facts thus broadcasted often subject them to gratuitous criticism on the part of ill-informed investors, while practical use is made of these facts mainly by brokers on behalf of their clients, or by competitive trusts not so well equipped to ferret out investment opportunities for themselves. Moreover, it is felt by many trusts that they would be handicapped in realizing the best price on their holdings if the knowledge of the extent of these holdings were public property..."

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

[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

[3] See Wermers(2001)

[4] See -RE: Shareholder Reports and Quarterly Portfolio Disclosure of Registered Management Investment Companies, Release No. 33-8164; File No. S7-51-02 by Fidelity Investments, 2003

[5] Also in a letter to SEC, ICI (Investment Company Institute) general counsel Craig Tyler wrote " it would be a grave error for the commission to mandate more frequent portfolio holdings disclosure by all funds "

[6] Leland Rex Robinson, Investment Trust Organization and Management. New York: The Ronald Press Company, 1926: 87-89.

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 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. [7]

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 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

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

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 is 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 who 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 1.2 discusses the hypotheses, Section 1.3 discusses the methodology, Section 1.4 describes the data , Section 1.5 presents the results and Section 1.6 concludes.

1.2 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.[8] 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 had 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 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

[8]Funds could chose any frequency higher than semi-annual during this period.

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.

1.3 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 our sample, we have funds which disclosed semi-annually before 2004 and which were subsequently forced to disclose quarterly 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. Hence, 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 $\beta3$, 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.

$$Alpha_{i,t} = Constant + \beta1 * Semi_i + \beta2 * POST2004 + \beta3 * Rank0_{i,t-1} + \gamma1 * Rank0_{i,t-1} *$$

$Semi_i + \gamma 2 * Rank0_{i,t-1} * POST2004 + \gamma 3 * Semi_i * POST2004 + \delta 1 * Semi_i * POST2004 * Rank0_{i,t-1} + \delta 2 * X_{i,t} + \epsilon_{i,t}$

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 $\delta 1$.

1.4 Data and Summary Statistics

Our sample covers the time period between 1990 and 2008. 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 an 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[9] for each of the stocks held by funds.[10] 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 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.

1.4.1 Summary Statistics

Table 1.1 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. Hence, for the most part of the analysis we stick to the 75% threshold.[11] At this level we have around

[9] 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.

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

[11] 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

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 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 1.2 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 which are more likely to incur agency cost are the ones more likely to disclose less frequently. However, 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

beyond 80% we have fewer funds and our statistical tests lack power.

trades, we probably can infer that funds engaged in more information based trades prefer to be semi-annual.[12]

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.

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

1.5 Results

1.5.1 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.It 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

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

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.[13] The intercept of the model, α_i, is Carhart's measure of 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 1.3.

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 1.4. The top quintile semi funds outperform top quintile quarterly funds by 16-19 basis points a month. And there is no significant difference

[13] The factor returns are taken from Kenneth French's Web site: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data Library.

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 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 1.5 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 is 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 1.5 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 1.6 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 1.7 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 1.6. 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.

1.5.2 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 1.4. 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 1.8 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 1.9 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 1.10 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 1.9. 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 1.11 and 1.12. We do not find the results we find for the illiquid funds. In fact in Table 1.12 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 1.13 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.

1.5.3 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 1.14, 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.

1.5.4 Frequency of Disclosure and Return Gap

As a robustness check, 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[14] 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.

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 1.15.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

[14] 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.

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 1.16 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.

1.6 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.

Table 1.1: **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 1.2: **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 1.3: **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 1.4: **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 1.5: **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 1.6: **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 1.7: **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 1.8: **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 1.9: **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 1.10: **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 1.11: **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 1.12: **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 1.13: **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 1.14: **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 1.15: **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 1.16: **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

Chapter 2

Competition and Incentive to reveal Information in Financial Markets

2.1 Introduction

Opinion is divided on the role of competition in bringing about market transparency. Some argue that competition can force the market participants to reveal more information. Others do not agree. In this paper, I study the impact of competition on discretionary disclosure policies and advertising efforts of mutual funds.

Initial works in the disclosure theory suggest that in the absence of disclosure costs or asymmetric information, firms will opt for full disclosure (Grossman and Hart (1980), Grossman (1981), and Milgrom (1981)) and hence there is no need for regulatory interventions. Their arguments were based on the concept of adverse selection: high value firms would like to separate themselves from the low value ones by disclosing their information. Faced with the prospect that market may associate them with low value firms, the remaining firms too disclose their information. So in equilibrium every firm discloses. However, later works proposed that full disclosure may not occur because of various reasons such as cost of disclosure, presence of unsophisticated participants in the market or the possibility that firms may have asymmetric information.[1]

In this debate not much attention seems to have gone towards impact of tournament like competition in the financial market (where superior relative performance is rewarded with convex payoffs) on market transparency[2]. Brown, Harlow, and Starks (1996) were the first to point out the tournament-nature of mutual fund markets and its effects on managerial incentives. Capon, Fitzsimons, and Prince (1996) and Sirri and Tufano (1998) show that investors put a lot of emphasis on past performance while choosing mutual funds. Sirri and Tufano (1998) show that consumers base their fund purchase decisions on prior performance information asymmetrically, investing disproportionately more in funds that performed very well the prior period. Also, they provide evidence that search cost [3] is an important determinant of fund flows. Using different measures of search cost, they find that the performance-flow relationship is most pronounced among funds with higher marketing efforts. They infer that marketing efforts reduce the consumer search costs and facilitate fund flows. There are other recent papers which further establish positive relationship between advertising and fund flows (Gallaher, Kaniel, and Starks (2005), Gualtieri and Petrella (2005), Korkeamaki, and Puttonen, Smythe (2007)).

In addition to advertising, periodic disclosure of fund holdings help lower the search costs

[1]Please see Verrecchia 1983; Fishman and Hagerty 1990, Fishman and Hagerty 2003, Dye, 1985; Jung and Kwon, 1988; Shin, 2003; Acharya, DeMarzo, and Kremer, 2010 for more details.

[2]Please see Carlin, Davis and Iannaccone (2010) for a detailed discussion on this.

[3]They argue that most retail investors are not formally trained in portfolio analysis, nor do they have access to up-to-date information on all potential fund investments. They compare a household's fund purchase decision to buying a large durable good, such as an automobile. In both the cases, consumers must choose from a large number of alternatives, and as in the case of buying a car, brand name, advertising, and distribution ability etc. will matter for investing in mutual funds,in addition to risk adjusted return measures. Thus consumers' purchase decisions-whether for cars or funds-are complicated by the phenomenon of costly search.

too. It serves two important purposes. First, it helps in selling the fund and in building public confidence in the fund. It also facilitates the marketing efforts through third parties in the professional investment businesses, such as investment advisors, plan consultants and fund tracking services, in publicizing fund holdings and strategies. These businesses always demand for additional information on fund investments for their own business purposes and to redistribute the data to their clients. These businesses serve a valuable commercial purpose in advising investors, who find it difficult to make use of the holding information from fund companies directly or who seek an additional third party view.[4] Second, Periodic disclosure help shareholders monitor the fund investment activities and help balance their personal investment portfolios. Investors appears to value periodic portfolio disclosures. Ge and Zheng (2005) show that funds with more frequent disclosure are rewarded with higher investments. [5]

However, periodic portfolio holdings disclosure is also costly for the mutual funds. Fund managers are concerned that frequent disclosure of information on their holdings may expose them to front-running or free-riding activities by other market participants. Front-running refers to a situation where other traders buy (sell) securities in anticipation of buy (sell) trades by the fund. The original fund may therefore be forced to trade at unfavorable prices. Cai(2003), Coval & Stafford(2007), Chen, Hanson, Hong and Stein (2008) et al. give empirical evidence on front running activities in the financial markets. Similarly, free-riding of the funds' proprietary research by copycat funds may result in higher trading cost and less investor flows as the fund faces competition from other copycat funds. Frank, Poterba, Shackelford and Shoven(2004), Wang and Verbeek (2010) et al. give evidence on profit from

[4]See -RE: Shareholder Reports and Quarterly Portfolio Disclosure of Registered Management Investment Companies, Release No. 33-8164; File No. S7-51-02 by Fidelity Investments, 2003 for a detailed discussion. Also, see Sirri and Tufano (1998).

[5]Fund managers seem to be aware of this fact too. Meiera & Schaumburg (2006) show that sometimes fund managers resort to 'window dressing' (sprucing up the holdings just before the report date) to keep the shareholders happy. Also, see 17 CFR Parts 210, 239, et al. Shareholder Reports and Quarterly Portfolio Disclosure of Registered Management Investment Companies; Final Rule, March 9, 2004.

copycat activities. Also, investors may even try to replicate the funds' portfolios instead of investing in the fund directly which may reduce fund flows.

Thus we see that the decision to spend more on advertising and go for more frequent portfolio holding disclosure is a trade off between the desire to receive higher investments next period and the direct cost of advertising as well as the cost coming from activities such as front running and free riding (the later cost increases with more disclosure) against the fund. Hence, rational mutual funds will spend on advertising past performance and resort to discretionary costly portfolio disclosure as long as they expect to profit from it, in terms of receiving a share of the new investments. In this context, it will be interesting to study, how the funds' disclosure policy and advertising efforts will change when competition for the new investment goes up.

This will, of course, depend on how competition is going to modify the benefits and costs of disclosure and advertising activities for a fund. What makes the markets for mutual funds interesting is the convex nature of the payoff. In this set up, it is rather intuitive that with more funds crowding the market, each fund's chance of making to the top will diminish and this will adversely affect its expected payoff(as only the top performing funds can attract new investments). Carlin, Davies and Iannaccone (2010) present this with a theoretical model. They focus on only the benefits of disclosure (not the cost) and predict that performance announcements, advertising and voluntary disclosure will reduce with competition. However, it is reasonable to assume that the cost of disclosure will go up with competition. With more competition and in the absence of enough investment opportunities, funds will try to free ride on others' research ideas and aggressively pursue front running strategies, whenever they spot an opportunity. This will add to the trading costs of the original funds. Thus, we see that competition affects both the expected benefits and disclosure costs adversely - lower expected pay off and higher cost together will force the funds operating in the higher competitive market segments to cut down on discretionary disclosure and advertising related activities.

I test these hypotheses with a sample of mutual fund data. Prior to 2004, the mandatory disclosure frequency for mutual funds was semi-annual.[6] However, during that period a large number of funds had opted to disclose every quarter. This gives me an opportunity to test the impact of competition on the level of discretionary disclosure. Also, I study the impact of competition on funds' advertising expenses. These two constitute my main hypothesis.

I find that semi-annual disclosure goes up with competition as captured by Herfindal index for investment style market segments. A mutual fund operating in the highest competitive segment is between 10 to 13% (13 to 17.5%) more likely to disclose semi-annually than a fund operating in the lowest (middle) competitive segment. I, then, test the impact of competition on advertising efforts. I take the annual 12b1 fees as a proxy for advertising expenses. It is the fee paid by the funds out of fund assets to cover distribution expenses such as paying for advertising, the printing and mailing of prospectuses to new investors, and the printing and mailing of sales literature. I find that 12b1 fees goes down by between 4 and 5 basis points for the funds in the highest competitive sector, compared to the funds in the lowest competitive sector. This is economically very significant as the average 12b1 fees for my sample is 27.5 basis point. Thus I find evidence that competition adversely affects discretionary disclosure as well as advertising efforts of a mutual fund.

Next, I study the section of funds, which are more likely to be affected by higher competition such as funds holding illiquid assets and funds which are relatively more successful.

Cost of disclosure from activities such as front running is not the same across all the funds. It will be more for the funds holding illiquid assets. Trades by illiquid funds will incur larger price impacts and will attract more front runners. With higher competition, the

[6]Mutual funds are required to periodically disclose their portfolio holdings. It was semi-annual between 1985 and 2003.In 2004, the SEC adopted enhanced regulations that increased the frequency of portfolio disclosure from semi-annually to quarterly.

expected pay off of funds will come down and funds holding illiquid assets will be forced more compared to the rest of the funds to cut down on discretionary disclosure (to reduce cost coming from activities such as front running). Also, it is reasonable to assume that the cost of disclosure will go up more for the illiquid funds with competition and this may also reinforce their decision to disclose less often compared to other funds when the competition goes up. [7] Hence, next I test the impact of competition on discretionary portfolio disclosure of illiquid funds vis-a-vis liquid funds. My conjecture is that the the adverse effects of competition on discretionary disclosure will be pronounced for the illiquid funds.

I divide my sample into two, based on the liquidity of their holdings. I find that funds holding illiquid assets (illiquid funds) disclose less frequently with competition. An illiquid fund in the most competitive sector is about 24% more likely to disclose semi-annually than an illiquid fund in the least competitive sector. Liquid funds initially seem to disclose more frequently with competition. A liquid fund in the mid-competitive sector is between 15% and 17% less likely to disclose semi-annually compared to a liquid fund in the lowest competitive sector. However, faced with more competition, their disclosure comes down to the extent that there is no difference between the frequencies of disclosure in the lowest and highest competitive sectors. Also the decrease in the 12b1 fees appears more pronounced, around 8 basis points for the illiquid funds operating in the most competitive sector compared to the illiquid funds operating in the lowest competitive sector. This suggests that illiquid funds follow an integrated cost cutting strategy and disclose less and advertise less when the competition is high. I do not find much difference in the 12b1 fees across various competitive sectors for the liquid funds. Thus, I find strong support for the hypothesis that funds are worried about disclosure costs and are likely to disclose less often and cut down on advertising efforts with higher competition.

[7] Aragon, Hertzel, Shi(2010) find evidence that hedge fund managers seek confidential treatment for their portfolio holdings (i.e. they defer 13f disclosure) to mitigate costs associated with front-running and are more likely to seek confidential treatment of illiquid positions that are more susceptible to front-running.

Next, I examine relatively better performing funds. I would expect the impact of competition on these funds to be higher compared to average performing funds. Because, relatively successful funds are the ones who have a realistic chance to get a part of the convex new investments. Hence, when competition is low, they will spend more on advertising and disclose more often to attract attention of the investors. With higher competition, each fund's chance to make it to the top (only top performing funds can attract new investments) and get a share of the payoff will go down and the funds will respond by cutting down on discretionary disclosure as well as advertising activities. Also, relatively successful funds will attract more copycat funds, especially when the competition is high and investment opportunities are rather scarce. Higher trading costs coming from copycat activities may also contribute to the successful funds' decision to disclose less when competition goes up.

I find evidence that the successful funds disclose the most in the least competitive sector. Successful funds operating in the middle competitive sectors are 24% more likely to disclose semi-annually, compared to successful funds operating in the least competitive sector. So there is a sharp fall in discretionary disclosure with competition. I do not find any variation in the disclosure policy across the competition segments for the average performing funds. Similarly advertising expenses for the successful funds comes down by a higher percentage with competition, compared to the average performing funds.

Overall, I find evidence that competition affects the disclosure and advertising policies of mutual funds adversely. However, it is difficult to identify, if the higher cost of disclosure or the lower expected pay off, brought about by higher competition, is forcing funds to cut down on disclosure and advertising activities. That is why I primarily focus on the overall effects of competition. However, the amplified effects of competition on the illiquid funds, and the findings that advertising expenses are coming down for both the whole sample and the successful funds suggest that both the lower expected pay off and higher disclosure costs force the funds to disclose less and advertise less, when competition goes up.

There are other empirical papers which provide similar results in other settings[8]. Deegan and Carroll (1993) provide evidence that propensity of Australian firms to make voluntarily disclosures and compete for reporting excellence awards decreases with competition in the industry. Wong (1988) and Deegan and Hallam (1991) find that the extent to which firms augment their financial reports with discretionary items is negatively related to industry competition. In a sample of Spanish firms, Gallego-Alvarez et al.(2008) find that the degree to which firms disclose voluntary information on their websites is positively correlated with industry concentration. My paper adds to this literature. To my knowledge, this is the first empirical work to study the effects of competition on market transparency in a tournament-like financial market. It confirms some of the predictions of Carlin, Davis and Iannaccone (2010).

The paper is structured as follows: Section 2.2 formulates the hypotheses, Section 2.3 describes the data and methodology, Section 2.4 provides the summary statistics , Section 2.5 presents the empirical analysis, Section 2.6 carries out the robustness analysis and Section 2.7 concludes.

2.2 Hypotheses

Consumers base their fund purchase decisions on prior performance information asymmetrically, investing disproportionately more in funds that performed very well the prior period. Also, search costs significantly affect the fund flows. The performance-flow relationship is most pronounced among funds with higher marketing efforts.

Mutual funds are mindful about these facts and use discretionary costly portfolio disclosure and advertising as marketing tools to reduce the consumer search cost and attract new

[8]Please see Carlin, Davis and Iannaccone (2010) for a detailed discussion on this.

investments in financial markets. The decision to spend more on advertising and go for more frequent disclosure is a trade off between the desire to receive higher investments next period and the cost of advertising as well as the cost coming from activities such as front running and free riding (the later cost increases with more disclosure) against the fund. Rational funds spend on advertising past performance and resort to discretionary costly portfolio disclosure as long as they expect to profit from it, in terms of receiving a share of the new investments.

With higher competition in the market, each fund's chance of making to the top diminishes, adversely affecting its expected payoff (due to convex nature of the pay offs, only the top performing funds can attract significant new investments) and hence funds respond by cutting down on discretionary disclosure of costly portfolio holding information and advertising related activities.

Also, it is reasonable to assume that the cost of disclosure will go up with competition. With more competitors in the market and in the absence of enough investment opportunities, funds will try to free ride on others' research ideas and aggressively pursue front running strategies, whenever they spot an opportunity. Thus, higher cost of disclosure may also contribute towards funds' decisions to cut down on discretionary disclosure with higher competition. The following hypothesis captures this.

Hypothesis 1: Mutual Funds operating in higher competitive market segments disclose less frequently and spend less on advertising related activities, compared to mutual funds operating in lower competitive segments.

Cost of disclosure from activities such as front running is not the same across all the funds. It will be more for the funds holding illiquid assets. Trades by illiquid funds will incur larger price impacts and will attract more front runners. With higher competition, the expected pay offs of funds will come down and funds holding illiquid assets will be forced more compared to the rest of the funds to cut down on discretionary disclosure (to reduce the cost coming from activities such as front running). Also, it is reasonable to assume that the cost of disclosure will go up more for the illiquid funds with competition and this may also reinforce their decision to disclose less often compared to other funds when the competition goes up. I test this with the following hypothesis.

Hypothesis 2: The effects of competition on disclosure mentioned in Hypothesis 1 will be amplified for funds holding illiquid assets.

Given that in the mutual fund markets superior relative performance is rewarded with convex pay offs, it is the relatively successful funds who are expected to spend more on advertising and disclose more often to attract attention of the investors when the competition is low (or when chances of receiving a part of the convex payoffs are high), compared to the average performing funds. So when the competition goes up, it is again the relatively successful funds, which will respond by cutting down on discretionary disclosure and advertising related activities more than average performing funds. Also, relatively successful funds will attract more copycat funds, especially when the competition is high and investment opportunities are rather scarce. Higher trading costs coming from copycat activities may also contribute to the successful funds' decision to disclose less when competition goes up. The following hypothesis captures this.

Hypothesis 3: The effects of competition on disclosure and advertising mentioned in Hypothesis 1 will be amplified for relatively successful funds.

2.3 Data and Methodology

I 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.

I focus on open-end US domestic equity mutual funds. I select funds with the following Lipper classifications: EIEI, H, LCCE, LCGE, LCVE, MCCE, MCGE, MCVE, MLCE, MLGE, MLVE, RE, SCCE, SCGE, SCVE, TK. The lowest number of unique funds in a segment is 43 (in the lipper class H). I include a report date observation in my analysis only if there are more than 20 fund families present in a market segment on that date.

My sample covers the time period between 1999 and 2006. This is because the Lipper classifications for the mutual funds are available in the database only from 1999. I do not consider data after 2006 to avoid the recent financial crises to influence my results. The mandatory disclosure frequency of mutual funds was changed to quarterly from semi-annual in 2004. So I have included data from 1999 to 2003 for the discretionary disclosure frequency test and the entire sample from 1999 to 2006 for the advertising expenses test.

The reported objectives do not always indicate whether a fund portfolio is balanced or not, and hence I exclude funds that, on average, hold less than 65% or more than 105% in stocks. I 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, I 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, I adopt the following approach. I retrieve detailed holding data for each fund in the sample from the Thompson database and obtain the Gibb's estimate[9] for each of the stocks held by funds. The liquidity measure of the fund is then calculated as the value weighted average liquidity measure of the funds' underlying securities. Every month I divide the funds into two groups based on their fund level liquidity measure and call the top group as illiquid funds and the bottom group as liquid funds. For the sake of robustness analysis, I rerun my tests using Amihud liquidity measure (Section 2.6) and find similar results.

I use Lipper classification for market segmentation and Herfindahl index as a proxy for competition in each of these market segments. The Herfindahl index is a measure of the size of firms in relation to the industry and an indicator of the amount of competition among them.

I recognize the fact that several funds from a single family of funds can coexist within a Lipper classification on any date and hence I aggregate assets by family to calculate this measure. Thus, the value of Herfindahl index for each segment is the sum across families of the square of each family's assets as a proportion of a sector's total assets. i.e.

$h\_index_{jt} = \sum_{i=1}^{n} S_{it}^2$

where h_index_{jt} is the Herfindahl index of Lipper Class j at time t. S_{it} is the TNA share

[9] I 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.

of fund family i in Lipper class j at time t, and n is the number of fund families in lipper class j at time t.

At every report date, I classify a fund as semi-annual if the previous disclosure for that fund was six months earlier and quarterly if the previous disclosure for that fund was three months earlier.

2.4 Summary Statistics

My sample for the Disclosure Frequency Test has 2109 unique funds and 17282 observations, out of which 3270 are semi-annual and 12989 are quarterly.

Table 2.1 displays the mean, the median, the standard deviation, the 25th and the 75th percentile of the Age, Total Net Assets, Expense ratio, 12b1 fees and annual Turnover of all the funds in the sample.

Table 2.2 reports number of funds, the mean fund characteristics and mean Herfindahl index for each Lipper class market segment. As we can see there are a lot of variations in each of these characteristics. Some of the segments are very competitive such as SCVE, which has a Herfindahl index of just 0.038 and some are very concentrated such as H whose Herfindahl index is 0.283. I have excluded observations with Herfindahl index greater than 0.20 in the analysis so that the highly concentrated segments do not affect the results. We also see a lot of variation in the Expenses ratios and 12b1 fees.

Table 2.3 reports the average Age, average Total Net Assets, average Expense ratio, average 12b1 fees and average annual Turnover ratio of semi-annual and quarterly observations and their difference. We can see that there is no significant differences between the semi-annual and quarterly funds in terms of Age or TNA. However, the expense ratio and 12b1 fees of quarterly funds are more than that of the semi-annual funds. This is intuitive in the sense that funds decide to disclose more often as a part of marketing strategy and it comes with higher efforts on marketing and distribution activities which is captured by 12b1 fees and total expenses ratio. The turn over ratios for semi-annual funds are higher than that of the quarterly funds and it may indicate higher information based trades by the semi-annual funds as referred to by Ge and Zheng(2006).

2.5 Empirical Analysis

2.5.1 Hypothesis 1: The Effect of Competition

Competition and Discretionary Disclosure

In this and the next sections, I test the impact of competition on the disclosure and advertising policies of mutual funds. Mutual funds use discretionary portfolio disclosure and advertising as marketing tools to attract new investments in a financial market, which often resemble a tournament (where superior relative performance and greater visibility are rewarded with convex payoffs). With higher competition, the likelihood of landing new investments goes down and funds respond by cutting down on discretionary disclosure of costly portfolio holding information and advertising related activities.

Every month, I divide the funds into three groups based on the level of market competition, as captured by herfindahl index, they operate in and run the following logistic regression to explore the impact of competition on discretionary disclosure decisions of the funds.

$$Prob(Semi\_Disc_{i,t}) = F(\beta_0 + \beta_1 * Rank1\_h_{i,t-1} + \beta_2 * Rank0\_h_{i,t-1} + \beta_3 * PastPerf_{i,t-1} + \beta_4 * Log\_Age_{i,t-1} + \beta_5 * Log\_TNA_{i,t-1} + \beta_6 * Exp\_Ratio_{i,t-1} + \beta_7 * Turn\_Over_{i,t} + \beta_8 * StdDev(Ret)_{i,t} + \epsilon_{i,t})$$

Where Semi_Disc is an indicator variable and takes on the value of one, if the fund provides semi annual disclosure during the past six months and zero otherwise. Rank1_h is an indicator variable, which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the most competitive sector and zero otherwise. I use the dummy variables for competition levels instead of a continuous independent variable, because I expect the competition to affect the disclosure behavior in a non-linear way. Past Perf is the past six month average return of the funds. Log_Age is the natural logarithm of the fund age. Log_TNA is the natural logarithm of total net assets of the fund. Exp_Ratio is the annual expense ratio of a fund. Turn_Over is the turnover ratio of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months.

The results of this regression is reported in the panel A of table 2.4. Here, Rank2_h, the least competitive segment, is the reference category. We see that the coefficient on Rank0_h is positive and statistically significant. That means the funds operating in the most competitive sectors are more likely to disclose semi-annually by 13% compared to funds operating in the least competitive sectors. That is competition has negative impact on fund disclosure. We do not see much difference between the disclosure policy of the funds working in the least competitive sector and the middle competitive sector. However, funds operating in the most competitive sectors are more likely to disclose semi-annually by 17.5% compared to funds operating in the middle competitive sectors.

Looking at the other coefficients, we realize that past performance has a negative coefficient on it. That is, good performing funds tend to disclose more. That supports our reasoning that successful funds use discretionary disclosure as a marketing tool to capture investors' attention. The coefficient on the expense ratio is negative. This is consistent with the difference in the expense ratios between semi and quarterly observations in table 2.3. As marketing expenses are a part of expense ratio, we can conjecture that funds use disclosure and marketing efforts together to obtain a larger share of the next period's investments. Also, we find that bigger funds are quarterly.

It is possible that funds may stick to one disclosure frequency for a period of time owing to various reasons, such as inertia, fund family decision etc. This can create a potential bias in the pooled-logit estimates. I have controlled for this by having the past disclosure decision as an independent variable in the regression and reported the results in panel B. The coefficient on the lagged dependent variable is positive and significant implying a significant correlation between the past and current disclosure policy. The coefficients on the variables becomes smaller in magnitude. But, they are still economically and statistically significant, particularly the coefficient on rank0_h, which is of interest here. The funds operating in the most competitive sectors are more likely to disclose semi-annually by 10% compared to funds operating in the least competitive sectors. This is statistically significant at the 10% level. As before, we do not see much difference between the disclosure policy of the funds working in the least competitive sector and the middle competitive sector. However, funds operating in the most competitive sectors are more likely to disclose semi-annually by 13% compared to funds operating in the middle competitive sectors. This is statistically significant at the 5% level.

Competition and Advertising Efforts

Continuing from the previous section, I test the impact of competition on advertising expenses of the mutual funds. The hypothesis is - advertising expense will go down with competition.

I use annual 12b1 fees as a proxy for the advertising expenses. SEC website defines '12b-1 fees' as fees paid by the fund out of fund assets to cover distribution expenses and sometimes shareholder service expenses. It gets its name from the SEC rule that authorizes a fund to pay them. The rule permits a fund to pay distribution fees out of fund assets only if the fund has adopted a plan (12b-1 plan) authorizing their payment. "Distribution fees" include fees paid for marketing and selling fund shares, such as compensating brokers and others who sell fund shares, and paying for advertising, the printing and mailing of prospectuses to new investors, and the printing and mailing of sales literature.

I run the following OLS regression for the three competition market segment.

$12b1\_Expenses_{i,t} = \beta_0 + \beta_1 * Rank1\_h_{i,t} + \beta_2 * Rank0\_h_{i,t} + \beta_3 * Cash_{i,t} + \beta_4 * PastPerf_{i,t} + \beta_5 * Log\_Age_{i,t} + \beta_6 * Log\_TNA_{i,t} + \beta_7 * StdDev(Ret)_{i,t} + \beta_8 * Flow_{i,t} + \beta_9 * StdDev(Flow)_{i,t} + \beta_{10} * Turn\_Over_{i,t} + \beta_{11} * Log\_Family\_TNA_{i,t} + \epsilon_{i,t}$

Rank2_h is an indicator variable for the reference competition segment, which takes on the value of one, if the fund is operating in the lowest competitive sector and zero otherwise. Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise and so on . Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive sector and zero otherwise. Cash is the percentage of the TNA held in cash. Past Perf is the past six-month holding period return of the funds. Log_Age is the natural logarithm of the fund age. Log_TNA is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow into the fund and calculated over the previous six month period by the following expression:

$flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right),$

where $TNA_{i,t}$ is TNA of fund i on any date t, $TNA_{i,t-1}$ is TNA of fund i six month earlier and $ret_{i,t}$ is the cumulative monthly return over the semi-annual period. Std Dev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn_Over is the turnover ratio of the fund. Log_Family_TNA is the total TNA of the family a funds belongs to.

The results of this regression are reported in Table 2.5. We see that the coefficients on the bottom competitive sector is negative and significant. That is, if a fund is operating in the highest competitive sector, it is likely to spend between 4 and 5 basis points less in advertising related efforts, compared to a fund operating in the lowest competitive sector. This is sizable, given that the average 12b1 fees in the whole sample is 27.5 basis points. Thus mutual funds operating in more competitive sectors seem to spend less in advertising related activities, compared to mutual funds operating in the less competitive sectors.[10]

Coefficient on Cash is positive and significant, which implies that a fund tend to spend more on advertising if they have more cash with them. Coefficient on past performance is negative and significant in most of the specifications. Advertising expenses seems to go up when the past performance goes down. This may appear as efforts to minimize redemptions after adverse performance outcomes. The age of a fund, included as natural logarithm of the age to address non-linearity, has a negative relationship with advertising expenses. It probably implies that as a fund becomes mature, it builds a client base and a reputation for itself and hence the need for advertising goes down. The coefficient on natural logarithm of fund TNA is negative. This means larger funds spend less on advertising. This may be because it is already visible in the market due to its large size. Standard deviation of the past return has a strong positive coefficient. It implies that funds having relatively risky returns tend to spend more on advertising to attract (and keep) investment(Cronqvist(2006) finds that advertisement is effective in attracting funds towards risky investments). Past flow has a negative coefficient on it, which is intuitive - need for advertisement goes down with higher flow. However, the negative coefficient on standard deviation of flow means: risker the flow, lower is the advertising expenses. Turnover does not seem to be significant in explaining variation in advertising expenses. Finally, we see that advertising expenses goes up with fund family size. That is, bigger families have higher budget for marketing and distribution.

[10] I have repeated this regression for 5 competitive market segments and have found similar results (not reported here). A fund operating in the highest competitive sector is likely to spend around 6 basis points less, compared to a fund operating in the lowest competitive sector.

There may be an alternate story for why the fees are coming down with competition. We can think of mutual funds as firms providing various products for a price i.e. fees. Then the lower fees in the higher competitive sectors could be explained by mark-downs by the funds due to competitive pressure from other funds in the market. This argument may be valid for the total fees charged by the funds. In stead, we have considered fees charged for only marketing and distribution.

However, to explore this further, I look at the non-12b1 expenses (i.e. the total expense ratio - 12b1 fees) of the funds. I use this expenses as the dependent variable (instead of 12b1) in the previous regression and report the results for the three competitive market segments in Table 2.6. I see that instead of decreasing, the Non-12b1 expenses is in fact increasing with competition. I also run this exercise for five competition market segments and find similar results(not reported here) - it is just the marketing expenses which goes down with competition.

To sum up the results so far, we have fairly strong results that competition has adverse impact on both discretionary disclosure as well as advertising expenses.

2.5.2 Hypothesis 2: Competition and Illiquid Funds

Competition and Frequency of Disclosure: Illiquid Vs Liquid Funds

In this section, I test the the impact of competition on disclosure policy of funds holding relatively illiquid assets vis-a-vis funds holding relatively liquid assets.

Cost of disclosure from activities such as front running is not the same across all the funds. It will be more for the funds holding illiquid assets. Trades by illiquid funds will incur larger price impacts and will attract more front runners. With higher competition, the expected pay offs of funds will come down and funds holding illiquid assets will be forced more compared to the rest of the funds to cut down on discretionary disclosure (to reduce the cost coming from activities such as front running). Also, it is reasonable to assume that the cost of disclosure will go up more for the illiquid funds with competition and this may also reinforce their decision to disclose less often compared to other funds when the competition goes up.

On every report date, I divide the funds into two categories - illiquid and liquid, according to their fund level liquidity measure(see Section 2.3 for more details). Then I run the logistic regression in the previous section separately for illiquid and liquid funds.

$$Prob(Semi\_Disc_{i,t}) = F(\beta_0 + \beta_1 * Rank2\_h_{i,t-1} + \beta_2 * Rank0\_h_{i,t-1} + \beta_3 * PastPerf_{i,t-1} + \beta_4 * Log\_Age_{i,t-1} + \beta_5 * Log\_TNA_{i,t-1} + \beta_6 * Exp\_Ratio_{i,t-1} + \beta_7 * Turn\_Over_{i,t} + \beta_8 * StdDev(Ret)_{i,t} + \epsilon_{i,t})$$

Panel A in Table 2.7 reports the logistic regression results for the illiquid funds. The coefficient on Rank0_h is much bigger(compared to the regression for the whole sample in the previous section) and it is significant at 5% level. We find that illiquid funds operating in the most competitive sectors are more likely to disclose semi-annually by around 24% (it was 10% for the whole sample), compared to illiquid funds operating in the least competitive sector.

Thus we find support for our hypothesis that with competition, the cost arising from activities such as front running goes up and hence funds holding illiquid assets (with higher price impact) are even more reluctant to disclose portfolio holding information compared to the whole sample of funds. These results are similar to what Aragon, Hertzel, Shi(2010) has found for 13f disclosures of the hedge funds.

In Section 2.6, I use another liquidity measure (Amihud liquidity measure) to define illiquid and liquid funds and have repeated the above regression for illiquid funds. I find similar results.

We also find positive and economically significant coefficient on the middle level competition indicator variable. That is a fund operating in the middle level competition market segment is more likely to disclose semi-annually by 16% ,compared to illiquid funds operating in the least competitive sector. However, it is not statistically significant. The estimates of other coefficients are similar to those for the regression for the whole sample.

Panel B in Table 2.7 reports the logistic regression results for the liquid funds. Liquid funds are not overly worried about the cost of disclosure. So when moving from the least competitive sector to mid-competition sector, they in fact disclose more frequently. Liquid funds operating in the mid-competition sector are 13% less likely to disclose semi-annually. This may be because of the peer pressure coming from the competition - they disclose more frequently because other funds are doing the same. However, when the competitions goes up even more, the disclosure frequency comes down to the extent that there is no statistical difference in the frequency of disclosure between the funds operating in the lowest and the highest competition sectors. This decrease in disclosure frequency from mid-competition sector to the highest competition sector can be explained by the theory that the benefit to disclosure with respect to cost comes down with competition.

Comparing the results of illiquid and liquid funds, we can infer that with competition, disclosure cost goes up more for the illiquid funds compared to the liquid funds and forces them to disclose less often.

Next, I study the impact of competition on advertising efforts of the illiquid funds.

Competition and Advertising: Illiquid Vs Liquid Funds

In this section, I test the impact of competition on advertising policies of Illiquid Vs Liquid funds.

As before, on every report date, I divide the funds into two categories - illiquid and liquid according to their fund level liquidity measure. Then I run the regression for 12b1 fees in the previous section separately for illiquid and liquid funds.

$$12b1\_Expenses_{i,t} = \beta_0 + \beta_1 * Rank1\_h_{i,t} + \beta_2 * Rank0\_h_{i,t} + \beta_3 * Cash_{i,t} + \beta_4 * PastPerf_{i,t} + \beta_5 * Log\_Age_{i,t} + \beta_6 * Log\_TNA_{i,t} + \beta_7 * StdDev(Ret)_{i,t} + \beta_8 * Flow_{i,t} + \beta_9 * StdDev(Flow)_{i,t} + \beta_{10} * Turn\_Over_{i,t} + \beta_{11} * Log\_Family\_TNA_{i,t} + \epsilon_{i,t}$$

Table 2.8 reports the results of the regression for illiquid funds. We see that the coefficients on the highest competitive sector is negative and significant at 1% level and the magnitudes are bigger than those for the whole sample. If a fund is operating in the highest competitive sector, it is likely to spend between 7 and 8 basis points less in advertising efforts(it was between 4 and 5 basis points for the whole sample) compared to a fund operating in the lowest competitive sector.[11]

[11] I repeat the previous regressions with non-12b1 expenses ratio (total expense ratio-12b1 fees) of the illiquid funds as the dependent variable (in the place of the 12b1 expenses). In unreported results, I find that the non-12b1 expense ratios does come down with competition for the last four specifications. However, it does not come down as much as the 12b1 fees . This rules out 'markdown' as the explanation for the lower

It appears that with competition, funds holding illiquid assets (who are concerned about trading costs arising from activities such as front running) are even more reluctant (compared to the whole sample) to advertise and reveal more private information in the process. This may be a part of the integrated strategy to disclose less and advertise less.

The magnitude, statistical significance and interpretation of other coefficients are similar to those for the regression for the whole sample.

Table 2.9 reports the results of the 12b1 fee regression for the Liquid funds. I do not find any difference in advertising expenses across the competition quintiles.

To sum up , we find evidence that funds holding illiquid assets cut down on their discretionary disclosure and advertising activities more than funds holding relatively liquid assets as a response to higher competition.

advertising expense in the highest competition sector for the illiquid funds.

2.5.3 Hypothesis 3: Competition and Successful Funds

Competition and Frequency of Disclosure: Successful Funds

In this and the next sections, I examine the disclosure and advertising policies of relatively better performing funds. I would expect the impact of competition on successful funds to be higher compared to average performing funds. Because, successful funds are the ones who have a realistic chance to receive a part of the new investments. Hence, they are expected to spend more on advertising and disclose more often to attract attention of the investors, when competition is low(or when chances of receiving a part of the convex payoffs are high), compared to the average performing funds. When the competition goes up, it is again the relatively successful funds, which will respond by cutting down on discretionary disclosure and advertising related activities more than average performing funds. Also, relatively successful funds will attract more copycat funds, especially when the competition is high and investment opportunities are rather scarce. Higher trading costs coming from copycat activities may also contribute to the successful funds' decision to disclose less when competition goes up.

First, I divide the funds into three groups based on their past 12 months four factor alpha. I then run the following regression for the top performing and middle performing funds separately

$$Prob(Semi\_Disc_{i,t}) = F(\beta_0 + \beta_1 * Rank1\_h_{i,t-1} + \beta_2 * Rank0\_h_{i,t-1} + \beta_3 * PastPerf_{i,t-1} + \beta_4 * Log\_Age_{i,t-1} + \beta_5 * Log\_TNA_{i,t-1} + \beta_6 * Exp\_Ratio_{i,t-1} + \beta_7 * Turn\_Over_{i,t} + \beta_8 * StdDev(Ret)_{i,t} + \epsilon_{i,t})$$

Table 2.10 lists the results for the top third performing funds. Our variables of interest are Rank1_h and Rank0_h. I see that the coefficient on Rank1_h is both statistically and economically significant. That is successful funds disclose the most in the least competitive sector. A successful fund operating in the middle competitive sector is 24% more likely to disclose semi-annually compared to a fund in the least competitive sector. So we see that there is a sharp fall in discretionary disclosure with competition. A successful fund operating in the top competitive sector is around 12.5% more likely to disclose semi-annually compared to a fund in the least competitive sector. However, it is not statistically significant.

Panel B of the Table 2.10 lists the results for the middle third performing funds. Again our variables of interest are Rank1_h and Rank0_h and we see that coefficients on them are not statistically significant. Thus, I find support for the above hypothesis.

The coefficients on the other variables are similar to what we had seen in the regression for the whole sample.

Competition, Successful Funds and Advertising:

In this section, I test the impact of competition on advertising efforts of successful funds Vs average performing funds. As discussed in the previous section, I would expect the impact of competition to be more for the top performing funds compared to the average performing funds. That is, top performing funds will cut down on their advertising efforts as a response to competition by a higher margin compared to averaging performing funds.

I divide the funds into three performance categories according to their past performance. Then I run the regression for 12b1 fees in the previous section separately for top performance quintile funds as well as middle quintile performance funds.

$$12b1\_fees_{i,t} = \beta_0 + \beta_1 * Rank1\_h_{i,t} + \beta_2 * Rank0\_h_{i,t} + \beta_3 * Cash_{i,t} + \beta_4 * PastPerf_{i,t} + \beta_5 * Log\_Age_{i,t} + \beta_6 * Log\_TNA_{i,t} + \beta_7 * StdDev(Ret)_{i,t} + \beta_8 * Flow_{i,t} + \beta_9 * StdDev(Flow)_{i,t} + \beta_{10} * Turn\_Over_{i,t} + \beta_{11} * Log\_Family\_TNA_{i,t} + \epsilon_{i,t}$$

Table 2.11 reports the results of the regression for successful funds. We see that the coefficients on highest competitive sector dummy is negative and significant at 5% level. If a successful fund is operating in the highest competitive sector, it is likely to spend between 4.5 and 5.5 basis points less in advertising efforts compared to a successful fund operating in the lowest competitive sector. [12]

Table 2.12 reports the results of the regression for average performing funds (middle third funds). I see that the coefficient on the highest competition dummy variable is significant only in the last four specifications. And, its magnitude is lower than that for the successful funds. That means, successful funds cut down their advertisement expenses by higher percentage compared to mid-performing fund, when the competition goes up.

I interpret these results as follow: Successful funds strategically spend more money on advertising while operating in a less competitive sector to grab the attention of the investors, so as to gain a slice of the next period's investments. Average performing funds do not have any incentive to spend more on advertising while operating in the lowest competition market segment as it will not lead to higher flow.

Overall, I find evidence that relatively successful funds advertise more and disclose more often when operating in the lowest competition sectors compared to average performing funds. This supports the Hypothesis 3.

Next, I carry out a few robustness analysis.

[12] I repeat the above regression with non-12b1 expenses (total expense ratio-12b1 fees) of the funds as the dependent variable (in the place of the 12b1 expenses) for the successful funds. In unreported results, I find that non-12b1 expense ratios does not come down with competition. This rules out 'markdown' with competition as the explanation for the lower advertising expense in the highest competition sector.

2.6 Robustness Analysis:

2.6.1 Alternative Liquidity Measure (Amihud Measure)

In this section, I rerun the tests in section 2.5.2 to study the the impact of competition on funds holding relatively illiquid assets vis-a-vis liquid assets. However, I use the Amihud measure to calculate the fund level liquidity measure instead of Gibb's estimate to check the robustness of my results.

On every report date, I divide the funds into two categories - illiquid and liquid, according to their fund level liquidity measure. Then I run the following logistic regression separately for illiquid and liquid funds.

$$Prob(Semi\_Disc_{i,t}) = F(\beta_0 + \beta_1 * Rank2\_h_{i,t-1} + \beta_2 * Rank0\_h_{i,t-1} + \beta_3 * PastPerf_{i,t-1} + \beta_4 * Log\_Age_{i,t-1} + \beta_5 * Log\_TNA_{i,t-1} + \beta_6 * Exp\_Ratio_{i,t-1} + \beta_7 * Turn\_Over_{i,t} + \beta_8 * StdDev(Ret)_{i,t} + \epsilon_{i,t})$$

Panel A in Table 2.13 reports the logistic regression results for the illiquid funds. The coefficient on Rank0_h is similar to what I had found in section 2.5.2. That is illiquid funds operating in the most competitive sectors are more likely to disclose semi-annually by around 27% (it was 10% for the whole sample), compared to illiquid funds operating in the least competitive sector.

Thus my results for Illiquid funds are robust to different liquidity specifications.

Panel B in Table 2.13 reports the logistic regression results for the liquid funds. We do not see any difference in their disclosure policy across the competition market segments. Earlier, with the Gibb's estimate, we had first seen improvement with disclosure frequency with higher competition. However, it does not affect my results.

2.6.2 Marketing Expenses including Front-End Load

Some funds collect a front-end load and this often goes towards marketing expenses. I test the impact of competition on advertising expenses of the mutual funds as in section 2.5.1. However, here, I add one seventh of front-end load to 12b1 fees and designate it as marketing expenses. Some earlier works use this proxy.

I run the following OLS regression for the three competition market segment.

$$MarketingExpenses_{i,t} = \beta_0 + \beta_1 * Rank1\_h_{i,t} + \beta_2 * Rank0\_h_{i,t} + \beta_3 * Cash_{i,t} + \beta_4 * PastPerf_{i,t} + \beta_5 * Log\_Age_{i,t} + \beta_6 * Log\_TNA_{i,t} + \beta_7 * StdDev(Ret)_{i,t} + \beta_8 * Flow_{i,t} + \beta_9 * StdDev(Flow)_{i,t} + \beta_{10} * Turn\_Over_{i,t} + \beta_{11} * Log\_Family\_TNA_{i,t} + \epsilon_{i,t}$$

The results of this regression are reported in Table2.14. We see that the coefficients on the highest competitive sector is negative and significant as in section 2.5.1. That is, if a fund is operating in the highest competitive sector, it is likely to spend between 6 and 8 basis points less in marketing and distribution efforts.

The results of this regression for 5 competitive market segments are similar.

We see that our results for advertising expenses are robust to different specifications.

2.6.3 Competition and Family level Marketing Expenses

Often marketing strategy and level of advertising activities are decided at the fund family level. So in this section, I try to find out the impact of competition on average fund family marketing expenses (12b1 plus one seventh of the front-end load) and 12b1 fees for three competition market segments.

Table 2.15 displays results for marketing expenses including the front-end load. We see that the coefficients on the competition dummies are negative and significant. That is a fund family operating in the highest competition segment spends 5 basis points less in marketing related expenses on average, compared to a fund family operating in the lowest competition segment.

Table 2.16 displays the results for 12b1 fees. And as we can see that a fund family operating in the highest competition sector charges around 3.2 basis point less in 12b1 fees on average, compared to a fund family operating in the lowest competition segment.

These results are similar to the results for fund level expenses.

2.7 Conclusion

In this paper I study the impact of competition in financial markets on incentive to reveal private information. The main hypothesis of the paper is that mutual funds use discretionary portfolio disclosure and advertising as marketing tools to attract new investments in a financial market, which often resemble a tournament (where superior relative performance and greater visibility are rewarded with convex payoffs). With higher competition, the likelihood of receiving new investments goes down for every fund and and at the same time the cost of disclosure goes up. Funds respond to it by cutting down on discretionary disclosure of costly portfolio holding information and advertising related activities.

In a sample of mutual funds, I find support for this hypothesis, i.e. discretionary portfolio disclosure and advertising related expenses indeed decrease with competition. And these effects are especially pronounced for funds holding illiquid assets, and for funds, which are relatively more successful.

These results are interesting because, they suggest that competition may actually hinder market transparency in financial markets, and may add to the consumer search cost. These also suggest that competition may not have the same desired effects across all the markets, and one needs to carefully consider market participants' incentives to reveal information and the impact of competition on these incentives.

To my knowledge it is the first empirical paper to study the impact of competition on market transparency in financial markets for the mutual funds.

Table 2.1: **Fund Characteristics**

This table displays the mean, the median, the standard deviation, the 25th and the 75th percentile of the Age, Total Net Assets, Expense Ratio, 12b1 Expenses and Annual Turnover Ratio of all the funds in the sample

Variable	Mean	Median	N	Std Dev	LQuartile	UQuartile
Age	10.788	6.667	17365	12.72	3.75	11.417
Fund TNA	879.657	167.75	16576	3059.6	48	584.2
Expenses Ratio	1.404	1.318	17176	0.944	1.05	1.677
12b1 Expenses	0.346	0.278	11527	0.264	0.099	0.55
Turn Over	117.571	75	17044	210.507	40	132

Table 2.2: **Fund Characteristics and Competition by Lipper Class**

This table reports number of funds, the mean Age, Total Net Assets, Expense Ratio, 12b1 fees , Annual Turnover ratio and Herfindahl index for the lipper class market segments. I calculate the Herfindahl index measure for each lipper class as the sum across families of the square of each family's assets as a proportion of a lipper class's total assets. i.e. $h\_index_{jt} = \sum_{i=1}^{N} S_{it}^2$ where h_index_{jt} is the Herfindahl index of lipper class j at time t. S_{it} is the TNA share of fund family i in lipper class j at time t, and N is the number of fund families in lipper class j at time t.

Lipper Class	No of Funds	Age	Fund TNA	Exp Ratio	12b1 Ratio	Turnover	H_index
EIEI	72	15.02	708.89	1.272	0.276	60.184	0.13296
H	43	5.288	380.32	1.743	0.474	289.613	0.28282
LCCE	368	13.505	990.67	1.252	0.33	77.678	0.134
LCGE	313	12.38	1126.41	1.346	0.342	105.173	0.08834
LCVE	216	16.204	2323.07	1.175	0.332	79.226	0.20999
MCCE	162	8.939	572.92	1.354	0.308	142.227	0.10022
MCGE	239	10.652	589.1	1.487	0.322	168.579	0.05596
MCVE	156	9.03	414.39	1.384	0.31	103.231	0.08327
MLCE	295	11.996	900.08	1.312	0.337	104.204	0.1265
MLGE	297	11.503	1498.75	1.554	0.407	173.192	0.15704
MLVE	309	11.936	924.44	1.273	0.37	68.248	0.07467
RE	56	6.594	195.69	1.457	0.323	96.865	0.0925
SCCE	209	7.687	338.95	1.413	0.29	95.726	0.06845
SCGE	214	7.625	345.86	1.508	0.333	150.692	0.04302
SCVE	173	7.579	377.56	1.527	0.33	72.199	0.03814
TK	110	5.445	900.74	1.945	0.482	291.02	0.1046

Table 2.3: **Semi-annual Vs Quarterly Observations**

This table reports the average Age, average Total Net Assets, average expense ratio, average 12b1 fees and average annual Turnover of semi-annual and quarterly observations and their difference. At every report date, I classify a fund as semi-annual if the previous disclosure for that fund was six months earlier and quarterly if the previous disclosure for that fund was three months earlier.

	Semi	Qtly	Semi-Qtly	t value
Age	10.557	10.946	-0.379	-1.03
Fund TNA	899.782	872.937	28.069	0.24
Expenses Ratio	1.362	1.409	-0.054	-2.67
12b1 Expenses	0.319	0.352	-0.034	-3.26
Turn Over	136.772	112.534	18.553	1.72

Table 2.4: **Competition and Frequency of Mutual Fund Disclosure**

This table displays the results of the logistic regression with Semi_Disc as the dependent variable. It is an indicator variable and takes on the value of one, if the fund provides semi annual disclosure during the past six months and zero otherwise. Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the most competitive sector and zero otherwise. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the fund age. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Expense Ratio is the annual expense ratio of a fund. Turn Over is the turnover ratio of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. All the independent variables in the regression has been lagged by six months. I include the dummy variables for the years.

1999-2003	Parameter Estimate: All the funds			
	A		B	
	Parameter	P Stat	Parameter	P Stat
Intercept	-0.749	< 0.0001	-1.526	< 0.0001
rank1_h	-0.04	0.4394	-0.028	0.6303
rank0_h	0.12	0.0186	0.095	0.0978
Past Perf	-1.206	< 0.0001	-1.266	< 0.0001
Log (Age)	-0.029	0.2981	-0.027	0.3885
Log (Fund TNA)	-0.052	0.0003	-0.038	0.0165
Expense Ratio	-36.904	< .0001	-25.715	< 0.0001
Turn Over	0.021	0.1748	0.003	0.8714
StdDev(Ret)	-0.78	0.2961	-0.577	0.486
semi1			1.976	< 0.0001
No of Obs(16694)	14438		13737	
R squared	0.0227		0.1990	

Table 2.5: **Competition and Advertising**

This table displays the results of the OLS regression with 12b1 fees as the dependent variable. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive quintile sector and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive sector and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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.

	12b1 fees							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	0.312***	0.273***	0.424***	0.41***	0.192***	0.161**	0.237***	0.227***
rank1_h	-0.005	-0.005	-0.006	-0.006	-0.007	-0.006	-0.009	-0.009
rank0_h	-0.038**	-0.037**	-0.036**	-0.036**	-0.048**	-0.045**	-0.047**	-0.047**
Cash					0.003**	0.003**	0.002*	0.002*
Past Perf	-0.012	-0.012	-0.025*	-0.024*	-0.072**	-0.078**	-0.093**	-0.091**
Log (Age)	-0.032***	-0.027**	-0.038***	-0.036***	-0.015*	-0.011	-0.022**	-0.018**
Log (Fund TNA)	-0.013**	-0.012**	0.012**	0.012**	-0.019**	-0.018**	0.003	0.004
StdDev(Ret)	0.818**	0.81**	0.695**	0.682**	0.895**	0.865**	0.803**	0.733**
Flow	0.009	-0.005	-0.006	-0.005	-0.006	-0.014**	-0.015**	-0.015**
StdDev(Flow)	-0.441***				-0.343***			
Turn Over	0.005	-0.005	-0.003		0.003	-0.007**	-0.005	
Log (Family TNA)	0.027***	0.027***			0.023***	0.023***		
No of Obs	23505	23538	23538	23647	13034	13047	13047	13098
R squared	0.084	0.074	0.041	0.04	0.063	0.056	0.029	0.027

Table 2.6: **Competition and Non-12b1 Expenses**

This table displays the results of the OLS regression with Non-12b1 Expenses as the dependent variable. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive quintile sector and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive sector and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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

	Non-12b1 Expenses							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	1.698***	1.669***	1.408***	1.404***	1.551***	1.525***	1.368***	1.32***
rank1_h	0.02	0.02	0.023*	0.023*	0.013	0.015	0.021	0.022
rank0_h	0.063***	0.064***	0.062***	0.06***	0.045**	0.047**	0.051**	0.048**
Cash					0.004**	0.004**	0.005**	0.006**
Past Perf	0.116***	0.117***	0.139***	0.152***	0.113**	0.107**	0.137**	0.154**
Log (Age)	-0.02**	-0.016*	0.005	0.013	-0.011	-0.007	0.016	0.027*
Log (Fund TNA)	-0.066***	-0.065***	-0.105***	-0.11***	-0.064***	-0.063***	-0.106***	-0.11***
StdDev(Ret)	2.999***	2.995***	3.192***	3.748***	6.043***	6.018***	6.145***	6.654***
Flow	-0.009*	-0.019**	-0.018**	-0.015**	-0.02**	-0.027**	-0.024**	-0.023**
StdDev(Flow)	-0.334***				-0.289**			
Turn Over	0.038***	0.032***	0.029***		0.026**	0.019**	0.014**	
Log (Family TNA)	-0.046***	-0.046***			-0.048***	-0.048***		
No of Obs	23505	23538	23538	23647	13034	13047	13047	13098
R squared	0.368	0.366	0.325	0.309	0.379	0.377	0.336	0.331

Table 2.7: **Competition and Frequency of Disclosure: Illiquid Vs Liquid Funds**

This table displays results for the logistic regression with Semi_Disc as the dependent variable for the illiquid funds in panel A and liquid funds in panel B. It is an indicator variable and takes on the value of one, if the fund provides semi annual disclosure during the past six months and zero otherwise. Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the most competitive sector and zero otherwise. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the fund age. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Expense Ratio is the annual expense ratio of a fund. Turn Over is the turnover ratio of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. All the independent variables in the regression has been lagged by six months. I include the dummy variables for the years. 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.

1999-2003	Parameter Estimate	
	A	B
	Illiquid Funds	Liquid Funds
Intercept	-1.823***	-1.03***
rank1_h	0.15	-0.143*
rank0_h	0.212**	0.034
Past Perf	-1.193***	-1.253***
Log (Age)	0.031	-0.073*
Log (Fund TNA)	-0.061**	-0.031
Expense Ratio	-19.174**	-34.31***
Turn Over	0.005	0.028
StdDev(Ret)	-0.401	-2.947
semi1	1.856***	1.759***
No of Obs(7637)	6203	6359
R squared	0.183	0.159

Table 2.8: **Competition, Illiquid Funds and Advertising**

This table displays the results of the OLS regression with 12b1 fees as the dependent variable for the illiquid Funds(on every report date I identify the illiquid Funds according to their fund level liquidity measure). The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive segment and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive segment and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive segment and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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

	12b1 fees: Illiquid funds							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	0.363***	0.322***	0.468***	0.456***	0.197**	0.167**	0.254***	0.248***
rank1_h	-0.016	-0.019	-0.022	-0.021	-0.025	-0.027	-0.03	-0.028
rank0_h	-0.069***	-0.071***	-0.071***	-0.07***	-0.081***	-0.082***	-0.084***	-0.082***
Cash					0.001	0.001	-0.001	-0.001
Past Perf	-0.01	-0.009	-0.025*	-0.026*	-0.051*	-0.053**	-0.067**	-0.067**
Log (Age)	-0.044***	-0.037**	-0.048***	-0.047***	-0.02	-0.014	-0.026**	-0.025**
Log (Fund TNA)	-0.006	-0.005	0.019**	0.019**	-0.011	-0.01	0.01*	0.011*
StdDev(Ret)	0.832**	0.78**	0.634**	0.611**	1.013**	0.9**	0.753*	0.662
Flow	0.012	-0.01	-0.012	-0.011	0.001	-0.02	-0.025*	-0.025*
StdDev(Flow)	-0.53***				-0.403***			
Turn Over	0.005	-0.005	-0.004		0.003	-0.007*	-0.005	
Log (Family TNA)	0.025***	0.025***			0.022***	0.022***		
No of Obs	10975	10994	10994	11034	6119	6126	6126	6138
R squared	0.122	0.107	0.076	0.075	0.09	0.079	0.053	0.053

Table 2.9: **Competition, Liquid Funds and Advertising**

This table displays the results of the OLS regression with 12b1 fees as the dependent variable for the liquid Funds(on every report date I identify the liquid Funds according to their fund level liquidity measure). The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive segment and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive segment and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive segment and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t}-TNA_{i,t-1}*(1+ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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

	12b1 fees: Lliquid funds							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	0.239***	0.209***	0.363***	0.348***	0.22**	0.198**	0.333***	0.312***
rank1_h	-0.004	-0.003	-0.004	-0.004	-0.001	0.002	-0.002	-0.003
rank0_h	0.014	0.015	0.016	0.014	-0.011	-0.009	-0.012	-0.012
					0.005**	0.005**	0.004**	0.004**
Past Perf	-0.003	-0.001	-0.003	0.003	-0.174**	-0.175**	-0.179**	-0.176**
Log (Age)	-0.02*	-0.016	-0.027**	-0.023**	-0.01	-0.007	-0.016	-0.012
Log (Fund TNA)	-0.018**	-0.017**	0.007	0.007	-0.024**	-0.023**	-0.002	-0.002
StdDev(Ret)	1.026**	0.995*	0.906*	0.922*	0.756	0.747	0.868	0.819
Flow	0.012	0.002	0.003	0.004	-0.012**	-0.017**	-0.017**	-0.017**
StdDev(Flow)	-0.365***				-0.259**			
Turn Over	0.008	-0.003	-0.001		0.003	-0.006	-0.004	
Log (Family TNA)	0.028***	0.028***			0.024***	0.024***		
No of Obs	11100	11113	11113	11173	6192	6197	6197	6231
R squared	0.062	0.057	0.022	0.02	0.052	0.049	0.022	0.021

Table 2.10: **Competition and Frequency of Mutual Fund Disclosure: Successful Funds**

This table displays the results of the logistic regressions with Semi_Disc as the dependent variable for the top third funds based on their past 12 months four factor alpha. It is an indicator variable and takes on the value of one, if the fund provides semi annual disclosure during the past six months and zero otherwise. Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive segment and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the most competitive segment and zero otherwise. Log(Age) is the natural logarithm of the fund age. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Expense Ratio is the annual expense ratio of a fund. Turn Over is the turnover ratio of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. All the independent variables in the regression has been lagged by six months. I include the dummy variables for the years.

	Successful Funds			
	A		B	
	top third		middle third	
Parameter	Estimate	P Stat	Estimate	P Stat
Intercept	-2.065	< .0001	-1.501	< .0001
rank1_h	0.213	0.038	-0.147	0.113
rank0_h	0.117	0.231	-0.084	0.408
Log (Age)	0.022	0.698	-0.057	0.281
Log (Fund TNA)	-0.074	0.007	-0.03	0.272
Expense Ratio	-24.891	0.006	-26.536	0.005
Turn Over	-0.032	0.269	0.031	0.357
StdDev(Ret)	1.304	0.273	1.508	0.346
Semi1	1.971	< .0001	1.867	< .0001
No of Obs	5408		5314	
R squared	0.2003		0.1767	

Table 2.11: **Successful Funds and Advertising**

This table displays the results of the OLS regression with 12b1 fees as the dependent variable for top third funds based on their past performance. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive sector and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive sector and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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.

	12b1 Expenses: Successful Funds							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	0.277***	0.236***	0.367***	0.341***	0.23***	0.194**	0.317***	0.299***
rank1_h	-0.02	-0.021	-0.021	-0.02	-0.027*	-0.027*	-0.029*	-0.029*
rank0_h	-0.044**	-0.044**	-0.044**	-0.044**	-0.053**	-0.052**	-0.055**	-0.055**
Cash					0.003*	0.002	0.002	0.002
Past Perf	0.04*	0.043**	0.026	0.026	-0.011	-0.016	-0.029	-0.028
Log (Age)	-0.037***	-0.032***	-0.041***	-0.037***	-0.023**	-0.019**	-0.028**	-0.024**
Log (Fund TNA)	-0.009	-0.008	0.012**	0.012**	-0.013**	-0.012*	0.005	0.005
StdDev(Ret)	1.158***	1.157***	1.062***	0.983***	1.387**	1.377**	1.311**	1.209**
Flow	0.016**	0.006	0.005	0.006	0.002	-0.007	-0.008	-0.008
StdDev(Flow)	-0.397***				-0.32***			
Turn Over	-0.001	-0.009**	-0.008**		0.001	-0.008**	-0.006	
Log (Family TNA)	0.021***	0.022***			0.019***	0.019***		
No of Obs	7558	7567	7567	7599	4344	4349	4349	4365
R squared	.086	.077	.054	.051	.073	.066	.046	.04375

Table 2.12: **Mid-performing Funds and Advertising**

This table displays the results of the OLS regression with 12b1 fees as the dependent variable for middle third funds based on their past performance. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive quintile sector and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive sector and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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.

	12b1 Expenses: Mid-performing Funds							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	0.192***	0.159**	0.341***	0.335***	0.155**	0.134**	0.291***	0.277***
rank1_h	-0.005	-0.004	-0.007	-0.007	-0.006	-0.004	-0.01	-0.01
rank0_h	-0.025	-0.023	-0.022	-0.023	-0.036**	-0.033*	-0.035**	-0.035**
Cash					0.004**	0.004**	0.003**	0.003**
Past Perf	0.033	0.038	0.022	0.021	-0.04	-0.039	-0.04	-0.04
Log (Age)	-0.017*	-0.014	-0.025**	-0.024**	-0.001	0.004	-0.009	-0.007
Log (Fund TNA)	-0.022**	-0.021**	0.006	0.006	-0.025**	-0.024**	-0.002	-0.001
StdDev(Ret)	0.825**	0.842**	0.751**	0.764**	0.833*	0.795*	0.897*	0.857*
Flow	0.016*	-0.001	-0.002	-0.001	-0.007	-0.015	-0.019*	-0.018*
StdDev(Flow)	-0.425***				-0.315**			
Turn Over	0.008	-0.003	-0.001		0.004	-0.008	-0.005	
Log (Family TNA)	0.03***	0.03***			0.025***	0.026***		
No of Obs	7957	7963	7963	7998	4416	4419	4419	4437
R squared	0.071	0.063	0.023	0.022	0.05	0.045	0.015	0.014

Table 2.13: **Competition and Frequency of Disclosure: Illiquid Vs Liquid Funds: Alternative Liquidity Measure**

This table displays results for the logistic regression with Semi_Disc as the dependent variable for the illiquid funds in panel A and liquid funds in panel B. It is an indicator variable and takes on the value of one, if the fund provides semi annual disclosure during the past six months and zero otherwise. Amihud liquidity measure has been used here to calculate fund level liquidity measures. Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the most competitive sector and zero otherwise. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the fund age. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Expense Ratio is the annual expense ratio of a fund. Turn Over is the turnover ratio of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. All the independent variables in the regression has been lagged by six months. I include the dummy variables for the years. 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.

1999-2003	Parameter Estimate	
	A	B
	Illiquid Funds	Liquid Funds
Intercept	-1.141***	-1.914***
rank1_h	-0.114	0.04
rank0_h	0.238**	0.36
Past Perf	-1.9***	-0.85***
Log (Age)	-0.046	0.015
Log (Fund TNA)	-0.039*	-0.034
Expense Ratio	-31.004**	-19.48**
Turn Over	0.023	-0.007
StdDev(Ret)	-3.573**	1.02
semi1	2.052***	1.902***
No of Obs	6446	6419
R squared	0.214	0.185

Table 2.14: **Marketing Expenses Including Front-End Load**

This table displays the results of the OLS regression with 12b1 fees as the dependent variable. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive sector and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive sector and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive sector and zero otherwise. Cash is the percentage of the fund's total net asset held in cash. Past Perf is the past six-month holding period return of the fund. Log(Age) is the natural logarithm of the age of the fund. Log(Fund TNA) is the natural logarithm of total net assets of the fund. Std Dev(Ret) is the monthly standard deviation of the fund returns calculated over the past 12 months. Flow is the new money flow to the fund and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. StdDev(Flow) is the monthly standard deviation of the fund flows calculated over the past 12 months. Turn Over is the annual turnover ratio of the fund. Log(Family TNA) is the natural logarithm of the total TNA of the fund family. I include the dummy variables for the years and use panel corrected standard errors. 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.

	12b1 with Front-End Load Expenses: All the funds							
1999-2006	Parameter Estimate							
	A	B	C	D	E	F	G	H
Intercept	0.272**	0.214**	0.504***	0.483***	-0.232**	-0.288**	-0.012	-0.033
rank1_h	-0.014	-0.015	-0.016	-0.015	-0.021	-0.019	-0.023	-0.024
rank0_h	-0.068**	-0.067**	-0.062**	-0.062**	-0.08**	-0.077**	-0.075**	-0.076**
Cash					0.005**	0.004**	0.003*	0.003
Past Perf	-0.025	-0.018	-0.043*	-0.042*	-0.119**	-0.115**	-0.155**	-0.141**
Log (Age)	0.032**	0.039**	0.02	0.023*	0.044**	0.051**	0.026	0.031**
Log (Fund TNA)	-0.032***	-0.03**	0.01	0.011	-0.04***	-0.039***	0.007	0.009
StdDev(Ret)	1.836***	1.868***	1.752***	1.666***	1.729**	1.832**	1.856**	1.464**
Flow	0.055***	0.032**	0.032**	0.032**	0.035**	0.018	0.015	0.015
StdDev(Flow)	-0.723***				-0.597***			
Turn Over	-0.003	-0.014*	-0.01		-0.017*	-0.032***	-0.026**	
Log (Family TNA)	0.049***	0.05***			0.054***	0.055***		
No of Obs	17935	17958	17958	18030	9887	9896	9896	9932
R squared	0.08	0.072	0.028	0.028	0.077	0.071	0.025	0.019

Table 2.15: **Competition and Family Marketing Expenses**

This table displays the results of the OLS regression with average 12b1 fees including front-end load of a fund family across all the funds in a market segment as the dependent variable. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive segment and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive segment and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive segment and zero otherwise. Family Cash is the average percentage of the fund's total net asset held in cash across all the funds of a family in a market segment. Similarly Family Past Perf is the average past six-month holding period return of the funds, Log(Avg Family Age) is the natural logarithm of the average age of the funds. Log(Family TNA) is the natural logarithm of total net assets of the funds in the market segment. Avg Family Past Flow is the average new money flow to the funds in a segment and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. Avg Family Turn Over is the average annual turnover ratio of the funds in a segment. I include the dummy variables for the years and use panel corrected standard errors. 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.

Mkting Expenses : All the funds		
Variable	Parameter	t Value
Intercept	0.232	6.94
rank1_h	-0.018	-1.79
rank0_h	-0.051	-4.94
Family Cash	0.004	4.07
Family Past Perf	-0.136	-2.67
Log (Avg Family Age)	0.022	3.88
Avg Family Turn Over	-0.019	-5.19
Log (Family TNA)	0.034	16.3
Avg Family past Flow	0.007	1.01
No of Obs	8266	
R squared	0.0468	

Table 2.16: **Competition and Family 12b1 fees**

This table displays the results of the OLS regression with average 12b1 fees of a fund family across all the funds in a market segment as the dependent variable. The reference indicator variable, Rank2_h, takes on the value of one, if the fund is operating in the lowest competitive segment and zero otherwise Rank1_h is an indicator variable which takes on the value of one, if the fund is operating in the middle competitive segment and zero otherwise. Rank0_h is an indicator variable which takes on the value of one, if the fund is operating in the highest competitive segment and zero otherwise. Family Cash is the average percentage of the fund's total net asset held in cash across all the funds of a family in a market segment. Similarly Family Past Perf is the average past six-month holding period return of the funds, Log(Avg Family Age) is the natural logarithm of the average age of the funds. Log(Family TNA) is the natural logarithm of total net assets of the funds in the market segment. Avg Family Past Flow is the average new money flow to the funds in a segment and calculated over the previous six month period as, $flow_{i,t} = \left(\frac{TNA_{i,t} - TNA_{i,t-1} * (1 + ret_{i,t})}{TNA_{i,t-1}}\right)$. Avg Family Turn Over is the average annual turnover ratio of the funds in a segment. I include the dummy variables for the years and use panel corrected standard errors. 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.

12b1 Expenses : All the funds		
Variable	Parameter	t Value
Intercept	0.216	13.03
rank1_h	-0.004	-0.84
rank0_h	-0.032	-6.08
Family Cash	0.002	4.47
Family Past Perf	-0.07	-2.88
Log (Avg Family Age)	-0.02	-6.97
Avg Family Turn Over	-0.001	-0.46
Log (Family TNA)	0.016	16.27
Avg Family past Flow	-0.012	-3.4
No of Obs	10841	
R squared	0.0402	

Chapter 3

Financial Constraints and Strategic Trading in Illiquid Markets

3.1 Introduction

Often similar trading strategies are pursued by a few large investors in illiquid markets and their trades have significant price impacts. These sophisticated traders are aware of this and take into account the price impacts of their trades not only on their own portfolio choice decisions, but also on the portfolio choice decisions of other traders in the market.

These traders are often exposed to various liquidation constraints, which may depend on the market price. For example, hedge funds with margin accounts may have to liquidate a part or whole of their portfolios in response to margin calls. A variety of risk management practices such as portfolio insurance may trigger liquidation of portfolios. Investors who sale short may have to close their positions and exit the market, if the prices move adversely.

The effects of these endogenous price driven constraints are twofold. On the one hand, it may force the large investors with price impacts to reduce their trading speed in order not to violate the constraints. On the other hand, it may encourage predatory behavior : strong traders may manipulate market price to push other traders into distress and force them to leave the market, so that they can trade at a favorable price next period.

This phenomenon is well documented in the popular press. One recent example is that of Focus Capital.

> "In a letter to investors, the founders of Focus, Tim O'Brien and Philippe Bubb, said it had been hit by "violent short-selling by other market participants", which accelerated when rumors that it was in trouble circulated. Sharp drops in the value of its investments led its two main banks to force it to sell last Tuesday."
> FT 04/03/08.

Another famous example of predatory trading is Goldman Sachs & Co. and other counterparties' trading against LTCM in 1998. The proposal of UBS Warburg, to take over Enron's traders without taking over its trading positions, was opposed on the same ground, i.e. it presented predatory risk. There are also evidence of predatory trading during 1987 stock market crash (Brady et al., 1988).[1]

In this paper we study a multi-period model of strategic trading with large strategic traders and allow for forced liquidations. These large traders invest in an illiquid risky asset and a risk free asset and face liquidation constraints: when their portfolio value becomes negative, they have to unwind their total risky positions immediately and leave the market. In this set up, we show that traders' wealth limits the positions they can take in the risky asset, if they do not want to violate the liquidation constraint. Also, relatively strong strategic traders, who have lower exposures to the risky asset, may take into account this

[1] Please see Brunnermeier and Pendersen(2005) for a detailed discussion on predatory trading.

constraint and trigger insolvency of relatively weak traders.

Our analysis finds that when traders have similar proportions of their wealth invested in the risky asset, they will behave cooperatively and spread their orders over several trading periods. This is similar to what they would do in a benchmark model without the constraint. However, if there is a significant difference in the proportions of the wealth invested in the risky assets among the traders , the strong traders (with low proportion of wealth invested in the risky asset) predate on the weak traders (with high proportion of wealth invested in the risky asset) by manipulating the price and forcing the weak traders to unwind their risky positions immediately. By doing this, the strong traders benefit from the fire sale resulting from the forced liquidation of the weak traders.

Our work contributes to the literature on limits to arbitrage. A large part of this literature, for example works by Shleifer and Vishny(1997), Xiong(2001) , Gromb and Vayanos (2002) and Liu and Longstaff (2004), focuses on potential losses in convergence trading due to institutional frictions or capital constraints. These models share a common element: a mechanism to amplify exogenous shocks. Arbitrageurs have to liquidate part of their positions after an initial shock to prices which creates further adverse price movements and liquidations.

In contrast, we have endogenised the amplification mechanism in our model: arbitrageurs, who are subject to liquidation constraints, are not fully competitive and hence their trades have price impacts. This type of strategic interaction, which is missing in the previous models, makes a fundamentally riskless arbitrage opportunity risky. The existence of the liquidation constraint and presence of other arbitrageurs create a predatory risk, which makes arbitrageurs reluctant to invest in arbitrage opportunities in the first place.

In a related paper Kondor (2009) develops an equilibrium model of convergence trading and its impact on asset prices, where arbitrageurs optimally decide how to allocate their limited capital over time. He shows that prices of identical assets can diverge even if the constraints faced by arbitrageurs are not binding, and that in equilibrium arbitrageurs' activities endogenously generate losses with positive probability, even if the trading opportunity is fundamentally riskless. In his model arbitrageurs are competitive and his focus is on the endogenous determination of the price gap, whereas we study trading behaviour of imperfectly competitive arbitrageurs, who are subject to liquidation constraints.

Our work also adds to the literature on predatory trading (i.e. trading that induces and/or exploits the need of other investors to reduce their positions) and forced liquidation. In an important paper Brunnermeier and Pedersen (2005) show that if one trader needs to sell, others also sell and subsequently buy back the asset. This leads to price overshooting and a reduced liquidation value for the distressed trader. Hence, the market is illiquid when liquidity is needed the most. Carlin, Lobo and Viswanathan (2007) analyze how episodic illiquidity can can arise from a breakdown in cooperation between market participants. They consider a repetition of the predatory stage game and show that while most of the time traders provide apparent liquidity to each other, when the stakes are high, cooperation breaks down, leading to sudden and short-lived illiquidity. Chu, Lehnert, and Passmore (2009) explore the effects of cross-price elasticities on predation, liquidity provision, and the policies in a multi-asset framework. A common element of these papers is again the exogenous nature of liquidation: some arbitrageurs become distressed due to an adverse shock and their need to liquidate is exploited by other solvent traders. In contrast, our model endogenizes the solvency of arbitrageurs as capital requirement is based on observed prices. This encourages arbitrageurs to induce distress of others by manipulating market price.

The closest paper to our analysis on financially constrained arbitrage is Attari and Mello (2006). They analyze trading strategies when arbitrageurs can influence the dynamics of prices on which capital requirements are based. They show that financial constraints are responsible for price volatility and time variation in the correlations of prices across markets. Unlike in their work, we allow heterogeneity among arbitrageurs, which creates opportunity for predatory trading.

This paper proceeds as follows. Section 3.2 presents the general model, Section 3.3 derives the equilibrium for a monopolistic strategic trader, Section 3.4 analyzes the case of identical duopoly, Section 3.5 presents the general model with two strategic traders and Section 3.6 concludes.

3.2 The Model

In this section we describe the setup of the economy, introduce the agents and the financial constraints.

We have two trading periods (0 and 1). In each period, agents trade with each other by submitting orders which clear the market in a Walrasian framework.

3.2.1 Assets

There are two assets. The first is a one-period risk-free asset that pays a constant gross return of R which we normalize to 1. The second is a long-lived risky asset that pays a dividend of d at the end of period 1, where d is normally distributed with mean $\overline{d}$ and variance σ^2. Let p_t denote the market price of the risky asset at time $t = 0$ and 1.

3.2.2 Agents

There are two types of traders: value based long-term traders and strategic traders.

Long-term Traders

We assume a competitive fringe consisting of long-term or 'value-based' traders as follows. Some traders, 0-investors, enter the market at date 0, trade, exit the market and hold their portfolio until the final payoff of the risky asset. Similarly, 1-investors enter the market at date 1, trade and hold their portfolio until the payoff of the risky asset at the end of period 1.

The t-investors, $t = 0, 1$, are competitive, form a continuum of measure 1, and have initial wealth $\overline{w}^t$. They choose holdings of the risky asset, y_t, to maximize the expected utility of final wealth. We model long-term traders to be risk-averse with CARA-coefficient $\overline{\alpha}$. Their optimization problem is

$$\max_{y_t} -E\left[\exp\left(-\overline{\alpha}\overline{w}_1^t\right)\right],$$

subject to the budget constraint $\overline{w}_1^t = \overline{w}^t - p_t y_t + d y_t$.

Long-term traders have CARA-utility on their normally distributed final wealth, hence their optimization problem is equivalent to:

$$\max_{y_t} CE\left(\overline{w}_1^t\right) = \overline{w}^t - p_t y_t + \overline{d} y_t - \frac{\overline{\alpha}}{2}\sigma^2 y_t^2,$$

which yields that the optimal demand of t-investors is

$$y_t(p_t) = \frac{1}{\overline{\alpha}\sigma^2}\left(\overline{d} - p_t\right) = \frac{1}{\lambda}\left(\overline{d} - p_t\right) \tag{3.1}$$

in periods $t = 0$ and 1. As our focus will be on the behaviour of strategic traders, we can introduce the parameter $\lambda \equiv \overline{\alpha}\sigma^2 \geq 0$, and note that from the viewpoint of strategic traders λ represents market illiquidity (or $\frac{1}{\lambda}$ is market depth). Equation 3.1 shows that t-investors will purchase the asset if $p_t < \overline{d}$, since this means that the asset looks cheap and will sell the asset if $p_t > \overline{d}$, since this means that the asset looks dear. Thus value-based traders' demand is driven by the divergence of the price from the intrinsic value.

We define X_t as the aggregate flow of trades coming from strategic traders in period t. The equilibrium market price of the asset is determined by the market clearing condition $X_t + y_t = 0$ and the resulting price is given as

$$p_t = \overline{d} + \lambda X_t. \tag{3.2}$$

Equation 3.2 describes how the demand flow from arbitrageurs affects the market price of the asset. If the arbitrageur is buying the asset ($X_t > 0$), the price, p_t, will be higher than it would be in the absence of an arbitrageur. The reverse will be true if the arbitrageur is selling the asset ($X_t < 0$).

Strategic Traders

Trading by strategic traders affects the market price of the asset. We model strategic traders to be risk-averse with CARA-coefficient α, who maximize their expected final period utility, that is

$$\max -E\left[\exp\left(-\alpha W_1^i\right)\right]$$

We define the wealth (or capital) of strategic trader i, W_1^i, at period 1 as

$$W_1^i = M_1^i + e_1^i d$$

where e_1^i is her position in the risky asset and M_1^i is her position in the riskless asset after trading in period 1. The dynamics of e_t^i and M_t^i are given by the following equations:

$$e_t^i = e_{t-1}^i + x_t^i$$

where e_{t-1}^i is the after-trade position at the end of period $(t-1)$ and x_t^i is the trade order in period t; and

$$M_t^i = M_{t-1}^i - p_t x_t^i$$

which means that the strategic trader's investment in the risk-free asset changes only by the payments for purchases or receipts from the sales of the risky asset. Negative values of M_t^i represent amounts borrowed, negative values of e_t^i represent short position in the the risky asset. For simplicity, we denote their starting positions as $M^i \equiv M_{-1}^i$ and $e^i \equiv e_{-1}^i$.

Traders have CARA-utility on their normally distributed final wealth, hence their optimization problem is equivalent to:

$$\max_{x_0^i, x_1^i} CE\left(W_1^i\right) = M^i - \sum_{t=0}^{1} p_t\left(x_t^i\right) x_t^i + \overline{d}\left(e^i + \sum_{t=0}^{1} x_t^i\right) - \frac{\alpha}{2}\sigma^2\left(e^i + \sum_{t=0}^{1} x_t^i\right)^2 \tag{3.3}$$

After trading in period 0, determination of the strategic trader's solvency is made. If the liquidation constraint is not met, the trader becomes insolvent and is forced to liquidate all its positions and exit the market. if the constraint is met, she remains solvent and can continue to trade in period 1.

We discuss the constraints faced by strategic traders in detail in the next section.

3.2.3 Constraints

Arbitrageurs in financial markets are often required to back their trading positions with some capital, for example margin requirements in futures contracts. Whenever this collateral or margin amount falls below a certain threshold, the arbitrageur gets a margin call and she will be forced either to deposit more money in the account or to sell off some of her assets. We use a simple constraint to capture this in our analysis. However, our model can accommodate different types of financial constraints, as long as these are based on market prices.

We define the constraint in terms of the value of the arbitrageurs' portfolio. Using our previous notations, we require the portfolio value of a strategic trader prior to trading at date t ($t = 0$ or 1) to be nonnegative, i.e.

$$W_{t-1}^i = M_{t-1}^i + p_{t-1}e_{t-1}^i \geq 0$$

where the trader's portfolio wealth consists of her riskless position and risky position evaluated at the current market price. For simplicity, we assume that traders are all solvent at the beginning of the model, evaluated at the unconditional mean price $p_{-1} \equiv \overline{d}$, i.e. $W^i = M^i + p_{-1}e^i = M^i + \overline{d}e^i \geq 0$. For the determination of trader i's solvency prior to the date 1 trade, the constraint to be met is

$$W_0^i = M_0^i + p_0 e_0^i > 0$$

Using the dynamics of the risky and the riskless positions this constraint can be written in the following form:

$$W_0^i = M_0^i + p_0 e_0^i = \left(M^i - p_0 x_0^i\right) + p_0\left(e^i + x_0^i\right) = M^i + p_0 e^i \geq 0 \tag{3.4}$$

This is useful because M^i and e^i are known before date 0 and hence it is only the p_0 term that depends on the trading activity of the traders in period 0. From now on we will use this latest inequality to determine the solvency of strategic traders.

3.3 Trading Strategy of a Constrained Monopoly

In this set up we have just one strategic trader who can trade in both the periods. The optimization problem of this constrained monopolist arbitrageur can be written as

$$\max_{x_0,x_1} CE\left(W_1\right) = M - \sum_{t=0}^{1} p_t\left(x_t\right)x_t + \overline{d}\left(e + \sum_{t=0}^{1} x_t\right) - \frac{\alpha}{2}\sigma^2\left(e + \sum_{t=0}^{1} x_t\right)^2 \tag{3.5}$$

$$\begin{aligned}
\text{s.t. market clears} &: \quad p_t = \overline{d} + \lambda x_t; \\
\text{dynamic budget constraints} &: \quad M_t = M_{t-1} - p_t x_t \\
\text{and } e_t &= \quad e_{t-1} + x_t; \\
\text{final payoff} &: \quad W_1 = M_1 + d e_1; \\
\text{insolvency constraint} &: \quad x_1 = -e_0 \text{ if } W_0 = M_0 + p_0 e_0 \leq 0.
\end{aligned}$$

Proposition 1 *There exist thresholds $\overline{k}^m$ and $\underline{k}^m$ such that we have the following equilibrium: if $W = M + \overline{d}e \geq \lambda \overline{k}^m e^2$ (where $0 \leq \overline{k}^m \leq 1$), the first best is feasible and the trader's optimal trade order is the same as in the absence of the constraint: $x_0^u = x_1^u = -\frac{1}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2}e$ while $p_0^u = p_1^u = \overline{d} - \frac{\lambda}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2}e$;*

if $\lambda\overline{k}^m e^2 > M + \overline{d}e \geq \lambda \max\left\{0, \underline{k}^m\right\} e^2$, the trader reduces its date-0 order to stay solvent. Her trade orders and equilirium prices in both the periods are $x_0^c = -\frac{1}{\lambda}\frac{M+\overline{d}e}{e}$, $p_0^c = -\frac{M}{e}$ and $x_1^c = -\frac{\alpha\sigma^2}{2\lambda+\alpha\sigma^2}e_0^c$, $p_1^c = \overline{d} - \lambda\frac{\alpha\sigma^2}{2\lambda+\alpha\sigma^2}e_0^c$ respectively.

if $\underline{k}^m e^2 > M + \overline{d}e \geq 0$*, the trader liquidates; sells half of her endowment in both periods:* $x_0^l = x_1^l = -\frac{1}{2}e$ *at prices* $p_0^l = p_1^l = \overline{d} - \frac{\lambda}{2}e$*,*

where $\overline{k}^m$ *and* $\underline{k}^m$ *are functions of* $\lambda/\alpha\sigma^2$ *and are given in Appendix 3.A, and* $\underline{k}^m \leq 0$ *if and only if* $\lambda/\alpha\sigma^2 \geq 1/2$ *- in this case the third situation never happens.*

We find that if the proportion of wealth invested in the risky asset is low, i.e. trader is wealthy enough compared to her risky position, the solvency constraint will not bind. In this case she will smooth her trade orders across periods in order to minimize her price impact and hence will trades the same amount in both the periods.

As the proportion of wealth invested in the risky asset becomes higher (i.e. $\lambda\overline{k}^m e^2 > M + \overline{d}e$ for some $\overline{k}^m$), the trader faces a trade-off between the optimal risk-sharing and her price impact. If the market is relatively illiquid or the trader has low risk-aversion parameter or the asset is not very risky, i.e. $\lambda/\alpha\sigma^2 \geq 1/2$, she does not want to become insolvent and bear the high cost of the fire-sale, hence she reduces her trading speed. The trader will also trade less in the first period if the market is relatively liquid ($\lambda/\alpha\sigma^2 < 1/2$) and her initial wealth is high enough ($M + \overline{d}e \geq \lambda\underline{k}^m e^2$).

Finally, if the market is relatively liquid compared to the trader's risk-bearing capacity and much of her portfolio wealth is invested in the risky asset, she does not mind violating the solvency constraint and the liquidation. In this case she smoothes her trade orders across periods in order to minimize her price impact and hence trades the same amount in both periods, i.e. half of her initial endowment.

3.4 Duopoly with same starting positions in both the assets

In this section we study a model with two identical strategic traders. Both of them start with same position in risky and riskless assets, that is: $M^1 = M^2 = M$ and $e^1 = e^2 = e \neq 0$.

The optimization problem of strategic trader i in this set up is:

$$\max_{x_0^i, x_1^i} CE\left(W_1^i\right) = M - \sum_{t=0}^{1} p_t\left(x_t^i\right) x_t^i + \overline{d}\left(e + \sum_{t=0}^{1} x_t^i\right) - \frac{\alpha}{2}\sigma^2\left(e + \sum_{t=0}^{1} x_t^i\right)^2 \tag{3.6}$$

$$\begin{aligned}
\text{s.t. market clears} &: \quad p_t = \overline{d} + \lambda\left(\sum_{i=1}^{2} x_t^i\right); \\
\text{dynamic budget constraints} &: \quad M_t^i = M_{t-1}^i - p_t x_t^i \\
\text{and } e_t^i &= \quad e_{t-1}^i + x_t^i; \\
\text{final payoff} &: \quad W_1^i = M_1^i + d e_1^i; \\
\text{insolvency constraint} &: \quad x_1^i = -e_0^i \text{ if } W_0^i = M_0^i + p_0 e_0^i < 0;
\end{aligned}$$

We ignore the case when $e = 0$, because a risk-averse trader with no position in the risky asset, will not trade with the value-traders. This is because she will have to offer a price $p_t > \overline{d}$, if she wants to buy, and accept a price $p_t < \overline{d}$, if she wants to go short.

These restrictions on the starting positions yield: $W_0^1 = M_0^1 + p_0 e_0^1 = M^1 + p_0 e^1 = M^2 + p_0 e^2 = M_0^2 + p_0 e_0^2 = W_0^2$. This implies that insolvency constraints will bind on both the traders at the same time. Therefore in equilibrium they need to have same certainty equivalent and must pursue identical trading strategies. If not, one of them will deviate.

Proposition 2 *There exist thresholds $\overline{k}^d$ and $\underline{k}^d$ such that we have the following equilibrium:*

if $W = M + \overline{d}e \geq \lambda \overline{k}^d e^2$ (where $0 \leq \overline{k}^d \leq 1$), the first best is feasible and the traders' optimal trade orders are the same as in the absence of the constraint: $x_0^{1u} = x_0^{2u} = -a_0^{ss}e$ and $x_1^s = x_1^w = -a_1^{ss}e_0$ with $p_0^u = \overline{d} - 2\lambda a_0^{ss}e$ and $p_1^u = \overline{d} + \lambda\left(2b_1^{ss} - a_1^{ss}\right)e_0$;

if $\lambda \overline{k}^d e^2 > M + \overline{d}e \geq \lambda \max\left\{0, \underline{k}^d\right\} e^2$, both traders reduce their date-0 sell orders to stay solvent, that is $x_0^{1c} = x_0^{2c} = -\frac{1}{2\lambda}\frac{M+\overline{d}e}{e}$ and $p_0^c = -\frac{M}{e}$, then proceed with $x_1^{1c} = x_1^{2c} = -a_1^{ss}e_0^c$ and $p_1^c = \overline{d} - 2\lambda a_1^{ss}e_0^c$;

if $\lambda \underline{k}^d e^2 > M + \overline{d}e \geq 0$, the traders liquidate; sell half of their endowment in both periods: $x_0^{1l} = x_0^{1l} = x_1^{1l} = x_1^{1l} = -\frac{1}{2}e$ at prices $p_0^l = p_1^l = \overline{d} - \lambda e$,

where $\overline{k}^d$ and $\underline{k}^d$ are functions of $\lambda/\alpha\sigma^2$ given in Appendix 3.B and $\underline{k}^d \leq 0$ if and only if $\lambda/\alpha\sigma^2 \geq \overline{l}^d$ constant - in this case the third situation never happens.

The intuition is similar to the case of monopolist arbitrageur. We find that as long as traders have a low proportion of wealth invested in the risky asset, the solvency constraint will not bind. In this case they will smooth their trade orders across periods in order to minimize their price impact and hence trade the same amount in both the periods.

As the proportion of wealth invested in the risky asset becomes higher, i.e. $\lambda \overline{k}^d e^2 \geq M + \overline{d}e$, traders face a trade-off between the optimal risk-sharing and the trading speed. If the market is very illiquid or the traders have low risk-aversion parameters or the asset is not very risky, that is $\lambda/\alpha\sigma^2 \geq \overline{l}^d$ for a given constant $\overline{l}^d$, they do not want to become insolvent and hence reduce their trade speed. They will also want to avoid insolvency (and subsequent fire-sale), and will reduce their trade speed, if the market is relatively liquid or they are significantly risk-averse ($\lambda/\alpha\sigma^2$ is close to zero), and they are relatively not poor, i.e. $M + \overline{d}e \geq \lambda \underline{k}^d e^2$.

Finally, if the market is relatively liquid compared to the traders' risk-bearing capacity or the payoff risk is high ($\lambda/\alpha\sigma^2 < \bar{l}^d$) and most of their capital is invested in the risky asset, they will decide to violate the constraint and hence liquidate. In this case they will smooth their trade orders across periods in order to minimize their price impact and hence will trade the same amounts in both periods: half of their initial endowments.

The only changes compared to the monopolistic model are related to the thresholds, and it is because of the fact that there are two identical traders now. When one decides on a particular trade order, she has to take into account that altogether they will have a price impact double of that in the single trader case. Comparing trade orders, prices, and the wealth thresholds (the $\underline{k}$s and the $\overline{k}$s) in the monopoly and the duopoly case we find that the unconstrained trade order is less per se and the equilibrium price is lower; the constrained price is the same as in the monopolistic case and trades are half of the original; while when being liquidated, trades are the same in both cases and the market-clearing price in case of multiple traders is lower.

3.5 Duopoly with different starting positions in risk free asset but same position in risky asset

In this section we study the optimal trading strategies of two strategic traders who start with the same positions in the risky asset but with different positions in the riskless asset. As described in Section 3.2.3, the solvency constraint can be written as

$$M^i + p_0 e \geq 0$$

for $i = 1, 2$. Hence by making M^1 and M^2 different we can ensure that the constraint will not bind on both the traders at the same time and therefore it is possible to obtain an equilibrium price p_0 under which one trader remains solvent while the other is forced to go for a fire-sale in the subsequent period. If, for example, $M^1 > M^2$, that is, trader one is wealthier than trader two, the solvency of trader two ($W_0^2 = M^2 + p_0 e \geq 0$) will also imply the solvency of trader one, as $W_0^1 = M^1 + p_0 e > M^2 + p_0 e = W_0^2 \geq 0$. Therefore, from now on we will call the two traders strong and weak, where $M^s > M^w$.

The optimization problem of trader i is the following:

$$\max_{x_0^i, x_1^i} CE\left(W_1^i\right) = M^i - \sum_{t=0}^{1} p_t\left(x_t^i\right) x_t^i + \overline{d}\left(e + \sum_{t=0}^{1} x_t^i\right) - \frac{\alpha}{2}\sigma^2\left(e + \sum_{t=0}^{1} x_t^i\right)^2 \qquad (3.7)$$

$$\begin{aligned} \text{s.t. market clears} \quad &: \quad p_t = \overline{d} + \lambda\left(\sum_{i=1}^{2} x_t^i\right); \\ \text{dynamic budget constraints} \quad &: \quad M_t^i = M_{t-1}^i - p_t x_t^i \\ \text{and } e_t^i \quad &= \quad e_{t-1}^i + x_t^i; \\ \text{final payoff} \quad &: \quad W_1^i = M_1^i + d e_1^i; \\ \text{and insolvency constrain} \quad &: \quad x_1^i = -e_0^i \text{ if } W_0^i = M^i + p_0 e < 0. \end{aligned}$$

For the definition of the equilibrium we first define the value function.

Definition 3 *We define the following conditional value functions for period t:*

$$V_t^{jk}\left(M_t^i, e_t^i, M_t^{-i}, e_t^{-i}\right) = M_t^i + \overline{d} e_t^i - \frac{1}{2}\left(e_t^i, e_t^{-i}\right) Q_t^{jk}\left(e_t^i, e_t^{-i}\right)'$$

for $i \in \{s, w\}$ and $t = 0, 1$, conditional on state $\{jk\}$, where

$j \in \{s, l\}$ denotes the state of trader i, that is if she is solvent or being liquidated;

$k \in \{s, l\}$ denotes the state of trader $-i$;

M_t^i and e_t^i are the after-trade portfolio holdings of trader i;

M_t^{-i} and e_t^{-i} are the after-trade portfolio holdings of trader $-i$;

Q_t^{jk} is a 2×2 symmetric matrix.

Definition 4 *The value function of trader i at date t is the merger of (up to) four different conditional value functions in different regions given as*

$$V_t^i\left(M_t^i, e_t^i, M_t^{-i}, e_t^{-i}\right) = \begin{cases} V_t^{ss}\left(M_t^i, e_t^i, M_t^{-i}, e_t^{-i}\right) & \text{if} \quad W_t^i, W_t^{-i} \geq 0, \\ V_t^{sl}\left(M_t^i, e_t^i, M_t^{-i}, e_t^{-i}\right) & \text{if} \quad W_t^i \geq 0 > W_t^{-i}, \\ V_t^{ls}\left(M_t^i, e_t^i, M_t^{-i}, e_t^{-i}\right) & \text{if} \quad W_t^{-i} \geq 0 > W_t^i, \\ V_t^{ll}\left(M_t^i, e_t^i, M_t^{-i}, e_t^{-i}\right) & \text{if} \quad 0 \geq W_t^i, W_t^{-i}. \end{cases}$$

Definition 5 *A Nash-equilibrium of the above trading game is a vector of demands $\{x_t^i\}_{i=s,w;t=0,1}$ such that x_1^i solves the program*

$$\begin{aligned} & \max_x V_1^i\left(M_1^i, e_1^i, M_1^{-i}, e_1^{-i} | x_1^{-i}, M_0^i, e_0^i, M_0^{-i}, e_0^{-i}\right) \\ = & \max_x V_1^i\left(M_0^i - P_{(x)} x\left(P_{(x)}\right), e_0^i + x\left(P_{(x)}\right), M_0^{-i} - P_{(x)} x_1^{-i}, e_1^{-i}\right) \end{aligned}$$

and x_0^i solves the program

$$\begin{aligned} & \max_x V_0^i\left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i} | x_0^{-i}, M^i, M^{-i}, e\right) \\ = & \max_x V_0^i\left(M^i - P_{(x)} x\left(P_{(x)}\right), e + x\left(P_{(x)}\right), M^{-i} - P_{(x)} x_0^{-i}, e_0^{-i}\right) \end{aligned}$$

with

$$V_0^i(.) = \max\left\{V_0^{ss}(.), V_0^{sl}(.), V_0^{ls}(.), V_0^{ll}(.)\right\},$$

and $P_{(x)}$ *is the market-clearing price in period* t *when trader* i *submits the demand* x*, and trader* $-i$ *submits her equilibrium demand* x_t^{-i} *and* p_t *clears the market at date* t*.*

3.5.1 Equilibrium Trades

In this section we study the date 0 and 1 trades in equilibrium for the above problem. We solve it backwards. First, we solve for the optimal trades at date 1, given the state the traders are in (that is whether they are solvent or insolvent), then we obtain value functions representing the continuation utilities, and solve for the optimal trades of period 0 for a conjectured state of the world. Finally, we check whether it is optimal for any trader to deviate in such a way that it would change the state of the world (the change of the state would imply a change in the value function as well).

Depending on if the solvency constraint is binding or not, we have to distinguish between three states of the world in the begining of period 1: first, both traders are solvent, that is $W_0^s, W_0^w \geq 0$; second, the strong trader is solvent while the weak is insolvent, that is $W_0^s \geq 0 > W_0^w$; and third, both traders are insolvent, that is $0 > W_0^s, W_0^w$.

Equilibrium of Type 1: Both traders remain solvent

If both traders remain solvent for period 1, their optimal trades are

$$x_1^i = -a_1^{ss} e_0^i + b_1^{ss} e_0 = -\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2} e_0^i + \frac{2\alpha\sigma^2}{\lambda + \alpha\sigma^2} \frac{\lambda}{3\lambda + \alpha\sigma^2} e_0,$$

with the market-clearing price

$$p_1 = \overline{d} - \lambda \frac{2\alpha\sigma^2}{3\lambda + \alpha\sigma^2} e_0,$$

where $e_0 = \frac{1}{2}\left(e_0^s + e_0^w\right)$. Their value functions become

$$\begin{aligned} V_0^{ss}\left(M_0^i, M_0^{-i}, e_0^i, e_0^{-i}\right) &\equiv \max_{x_1^i} M_0^i - p_1\left(x_1^i\right)x_1^i + \overline{d}\left(e_0^i + x_1^i\right) - \frac{\alpha}{2}\sigma^2\left(e_0^i + x_1^i\right)^2 \\ &= M_0^i + \overline{d}e_0^i - \frac{\alpha}{2}\sigma^2\left(e_0^i\right)^2 + \frac{1}{2}\left(e_0^i, e_0^{-i}\right)Q_0^{ss}\left(e_0^i, e_0^{-i}\right)' \end{aligned}$$

where Q_0^{ss} is a 2×2 symmetric, positive definite matrix:

$$\begin{aligned} Q_0^{ss} &= \frac{1}{2\lambda + \alpha\sigma^2}\left(\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}\right)^2\left(\frac{2\lambda + \alpha\sigma^2}{3\lambda + \alpha\sigma^2}\right)^2\begin{pmatrix} \left(2\lambda + \alpha\sigma^2\right)^2 & -\lambda\left(2\lambda + \alpha\sigma^2\right) \\ -\lambda\left(2\lambda + \alpha\sigma^2\right) & \lambda^2 \end{pmatrix} \\ &= \frac{1}{2\lambda + \alpha\sigma^2} a \begin{pmatrix} \left(2\lambda + \alpha\sigma^2\right)^2 & -\lambda\left(2\lambda + \alpha\sigma^2\right) \\ -\lambda\left(2\lambda + \alpha\sigma^2\right) & \lambda^2 \end{pmatrix}. \end{aligned}$$

Therefore the optimal first-period trades satisfy the following optimization problems:

$$\begin{aligned} \max_{x_0^i} V_0^{ss}\left(M_0^i, M_0^{-i}, e_0^i, e_0^{-i}\right) &= M_0^i + \overline{d}e_0^i - \frac{\alpha}{2}\sigma^2\left(e_0^i\right)^2 + \frac{1}{2}\left(e_0^i, e_0^{-i}\right)Q_0^{ss}\left(e_0^i, e_0^{-i}\right)' \\ &= M^i + \overline{d}e + \left(\overline{d} - p_0\right)x_0^i - \frac{\alpha}{2}\sigma^2\left(e + x_0^i\right)^2 \\ &\quad + \frac{1}{2}\left(e + x_0^s, e + x_0^w\right)Q_0^{ss}\left(e + x_0^s, e + x_0^w\right)'. \end{aligned}$$

After solving for the optimal trades, conditional on both traders satisfying the solvency constraint, we obtain the following result:

Proposition 6 *There exists a linear equilibrium in which both traders remain solvent with trades and market-clearing prices*

$$\begin{aligned} x_0^i &= -a_0^{ss}e \text{ and } x_1^i = -a_1^{ss}e_0^i + b_1^{ss}e_0 \text{ for } i = s, w \text{ and} \\ p_0 &= \overline{d} - 2\lambda a_0^{ss}e \text{ and } p_1 = \overline{d} + \lambda\left(2b_1^{ss} - a_1^{ss}\right)e_0, \end{aligned}$$

with the necessary and sufficient condition

$$0 \leq \lambda \max\left\{\underline{k}^{ss,sl}, 2a_0^{ss}\right\}e^2 \leq M^w + \overline{d}e \leq M^s + \overline{d}e.$$

The coefficients a_0^{ss}, a_1^{ss} and b_1^{ss} and function $\underline{k}^{ss,sl}\left(\lambda/\alpha\sigma^2\right)$ is given in Appendix 3.D.1.

Given the state of the world in which both traders remain solvent, the above trades and prices must be consistent with satisfying the solvency constraint, that is

$$M^s + p_0 e \geq M^w + p_0 e \geq 0,$$

which is equivalent to

$$M^s + \overline{d}e \geq M^w + \overline{d}e \geq 2\lambda a_0^{ss}e^2.$$

For the existence of a Nash equilibrium, though, we need another constraint on the starting wealth:

$$\lambda\underline{k}^{ss,sl}e^2 \leq M^w + \overline{d}e.$$

where $\underline{k}^{ss,sl}$ is a function of the relative market depth, $\lambda/\alpha\sigma^2$. The reason for this is rather simple. Being aware of the solvency constraint, traders can engage in the costly manipulation of date 0 prices if they are able to extract higher payoffs in the next trading round. That is the strong trader might want to force the weak trader to liquidation and benefit from lower purchase price in the next period. The cost of making the weak trader distressed is increasing in her starting wealth, $M^w + \overline{d}e$, hence there exists a threshold $\underline{k}^{ss,sl}$ such that the strong trader will engage in this type of price-manipulation if and only if $M^w + \overline{d}e < \lambda\underline{k}^{ss,sl}e^2$.

Equilibrium of Type 2: The strong trader remains solvent, the weak trader is liquidated

If one trader is liquidated while the other survives with after-trade positions of e_0^s and e_0^w the second-period (optimal) trades are

$$x_1^w = -e_0^w$$

and

$$x_1^s = \frac{\lambda}{2\lambda + \alpha\sigma^2} e_0^w - \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^s$$

with market-clearing price

$$p_1 = \overline{d} - \lambda \frac{\lambda + \alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^w - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^s$$

and the continuation value functions are

$$V_0^{sl}\left(M_0^s, e_0^s, M_0^l, e_0^l\right) = M_0^s + \overline{d}e_0^s - \frac{\alpha}{2}\sigma^2 \left(e_0^s\right)^2 + \frac{1}{2}\left(e_0^s, e_0^w\right) Q_0^{sl} \left(e_0^s, e_0^w\right)',$$

where Q_0^{sl} is a 2×2 positive semidefinite matrix:

$$Q_0^{sl} = \frac{1}{2\lambda + \alpha\sigma^2} \begin{pmatrix} \left(\alpha\sigma^2\right)^2 & -\lambda\alpha\sigma^2 \\ -\lambda\alpha\sigma^2 & \lambda^2 \end{pmatrix}$$

and

$$V_0^{ls}\left(M_0^w, e_0^w, M_0^s, e_0^s\right) = M_0^w + \overline{d}e_0^w - \frac{1}{2}\left(e_0^w, e_0^s\right) Q_0^{ls}\left(e_0^w, e_0^s\right)',$$

where Q_0^{ls} is

$$Q_0^{ls} = \frac{\lambda}{2\lambda + \alpha\sigma^2}\begin{pmatrix} 2\left(\lambda + \alpha\sigma^2\right) & \alpha\sigma^2 \\ \alpha\sigma^2 & 0 \end{pmatrix}.$$

Therefore the optimal first-period trades satisfy the following optimization problems:

$$\begin{aligned} \max_{x_0^s} V_0^{sl}\left(M_0^s, e_0^s, M_0^l, e_0^l\right) &= M_0^s + \overline{d}e_0^s - \frac{\alpha}{2}\sigma^2\left(e_0^s\right)^2 + \frac{1}{2}\left(e_0^s, e_0^w\right) Q_0^{sl}\left(e_0^s, e_0^w\right)' \\ &= M^s + \overline{d}e + \left(\overline{d} - p_0\right)x_0^s - \frac{\alpha}{2}\sigma^2\left(e + x_0^s\right)^2 \\ &\quad + \frac{1}{2}\left(e + x_0^s, e + x_0^w\right) Q_0^{sl}\left(e + x_0^s, e + x_0^w\right)' \end{aligned}$$

for the strong trader, while for the weak trader we have

$$\begin{aligned} \max_{x_0^w} V_0^{ls}\left(M_0^w, e_0^w, M_0^s, e_0^s\right) &= M_0^w + \overline{d}e_0^w - \frac{1}{2}\left(e_0^w, e_0^s\right) Q_0^{ls}\left(e_0^w, e_0^s\right)' \\ &= M^w + \overline{d}e + \left(\overline{d} - p_0\right)x_0^w - \frac{1}{2}\left(e_0^w, e_0^s\right) Q_0^{ls}\left(e_0^w, e_0^s\right)'. \end{aligned}$$

After solving for the optimal trades conditional on the strong trader surviving and the weak trader liquidating, we obtain the following result:

Proposition 7 *There exists a linear equilibrium in which the strong trader remains solvent and the weak trader is liquidated with trades and market-claring prices in the following form:*

$$\begin{aligned} x_0^s &= -a_0^{sl}e \text{ and } x_0^w = -a_0^{ls}e \text{ and } p_0 = \overline{d} - \lambda\left(a_0^{sl} + a_0^{ls}\right)e \text{ and} \\ x_1^s &= \left[\frac{\lambda}{2\lambda + \alpha\sigma^2}\left(1 - a_0^{ls}\right) - \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}\left(1 - a_0^{sl}\right)\right]e \text{ and } x_1^w = -\left(1 - a_0^{ls}\right)e \text{ and} \\ p_1 &= \overline{d} - \lambda\left[\frac{\lambda + \alpha\sigma^2}{2\lambda + \alpha\sigma^2}\left(1 - a_0^{ls}\right) + \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}\left(1 - a_0^{sl}\right)\right]e \end{aligned}$$

with the constants a^{sl} and a^{ls} (as functions of $\lambda/\alpha\sigma^2$) given in Appendix 3.D.2. A necessary condition for this type of equilibrium to happen is the existence of function $\overline{k}^{ls,ss}(\lambda/\alpha\sigma^2)$ (given in Appendix 3.D.2) such that

$$0 < M^w + \overline{d}e \leq \lambda\overline{k}^{ls,ss}e^2 < \lambda\left(a_0^{sl} + a_0^{ls}\right)e^2 \leq M^s + \overline{d}e.$$

Given the state of the world in which the strong trader remains solvent and the other is liquidated, the above trades and prices must be consistent with only the weak trader violating the solvency constraint, that is

$$M^s + p_0e \geq 0 > M^w + p_0e,$$

which is equivalent to

$$M^s + \overline{d}e \geq \lambda\left(a_0^{sl} + a_0^{ls}\right)e^2 > M^w + \overline{d}e.$$

For the existence of a Nash equilibrium, though, we need another constraints on the starting wealth:

$$\lambda\overline{k}^{ls,ss}e^2 > M^w + \overline{d}e,$$

where $\overline{k}^{ls,ss}$ is a functions of the relative market depth, $\lambda/\alpha\sigma^2$. The reason for this is rather simple. Being aware of the solvency constraint, traders can engage in costly manipulation of date 0 prices, if they are able to extract higher payoffs in the next trading round. In this equilibrium the strong trader remains solvent while the weak trader is forced to liquidate. Therefore there is no possible benefit for the strong trader either to push herself to liquidation by bearing extra cost in period 0 and then face a reduced action space (the forced fire-sale) in the next period or to rescue the other trader, again by bearing a cost and face costly risk-sharing in the next period (the weak trader will trade in the same direction).

The weak trader, however, might benefit from price manipulation by rescuing herself. She can reduce her trade speed in period 0, so that she remains solvent and hence is able to trade optimally for risk-sharing in the next period. The cost of this price manipulation is decreasing in her own wealth, $M^w + \overline{d}e$, hence there exists a threshold $\overline{k}^{ls,ss}$ such that the weak trader will engage in this type of price-manipulation if $M^w + \overline{d}e \geq \lambda \overline{k}^{ls,ss} e^2$.

The above constraints yield that we have a price constraint for the strong trader; and a price and a deviation constraint for the weak trader. For the existence of an equilibrium we need the portfolio wealth of the strong trader to satisfy the following

$$M^s + \overline{d}e \geq \lambda \left(a_0^{sl} + a_0^{ls}\right) e^2,$$

and that of weak to statisfy the following

$$\lambda \min \left\{\overline{k}^{ls,ss}, a_0^{sl} + a_0^{ls}\right\} e^2 > M^w + \overline{d}e \geq 0.$$

It is easy to show that $\lambda \left(a_0^{sl} + a_0^{ls}\right) > \overline{k}^{ls,ss} > 0$, hence the above constraints can be summed up as

$$0 \leq M^w + \overline{d}e \leq \lambda \overline{k}^{ls,ss} e^2 < \lambda \left(a_0^{sl} + a_0^{ls}\right) e^2 \leq M^s + \overline{d}e.$$

That is, for the strong trader, the price constraint is always tighter than the deviation constraint and for the weak trader the opposite is true.

We see that the coefficient of the strong trader's trade in period 0 is negative, while in period 1, it is positive, i.e. she first sells and then buys, whereas without the constraint he would always sell, as he is risk-averse. So, it can be interpreted as the strong trader predating against the weak trader, i.e. part of his first period strategy is to push the price down.

Equilibrium of Type 3: Both the traders are liquidated

The date 1 trades when both traders liquidate are

$$x_1^s = -e_0^s \text{ and } x_1^w = -e_0^w$$

hence

$$p_1 = \overline{d} - \lambda \left(e_0^s + e_0^w \right)$$

and the optimal first-round trades have to satisfy

$$\begin{aligned}\max_{x_0^i} V_0^{ll} \left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i} \right) &= M_0^i + \overline{d} e_0^i - \frac{1}{2} \left(e_0^i, e_0^{-i} \right) Q_0^{ll} \left(e_0^i, e_0^{-i} \right)' \\ &= M^i + \overline{d} e + \left(\overline{d} - p_0 \right) x_0^i - \frac{1}{2} \left(e + x_0^i, e + x_0^{-i} \right) Q_0^{ll} \left(e + x_0^i, e + x_0^{-i} \right)'.\end{aligned}$$

Proposition 8 *The optimal trades and the market-clearing prices when both traders are liquidated are given by*

$$x_0^s = x_0^w = x_1^s = x_1^w = -\frac{1}{2} e$$

and

$$p_0 = p_1 = \overline{d} - \lambda e.$$

Both the traders get liquidated in equilibrium if and only if

$$\begin{aligned} 0 &\leq M^s + \overline{d} e < \lambda \overline{k}^{ll,sl} e^2 \text{ and} \\ 0 &\leq M^w + \overline{d} e < \lambda \overline{k}^{ll,ss} e^2. \end{aligned}$$

where $\overline{k}^{ll,sl}, \overline{k}^{ll,ss}$ are functions of $\lambda / \alpha \sigma^2$ given in Appendix 3.D.3.

The above trades and prices must be consistent with violating the solvency constraint.

$$M^i + p_0 e = M^i + \left(\overline{d} - \lambda e\right) e < 0,$$

which is equivalent to

$$0 \leq M^i + \overline{d}e < \lambda e^2 \text{ for } i = s, w,$$

For the existence of a Nash equilibrium we also need that $M^s + \overline{d}e \leq \lambda \overline{k}^{ll,sl} e^2$, and $M^w + \overline{d}e \leq \lambda \overline{k}^{ll,ss} e^2$, where $\overline{k}^{ll,sl}$ and $\overline{k}^{ll,ss}$ are functions of $\lambda/\alpha\sigma^2$. Being aware of the solvency constraint, traders with price impact can manipulate date 0 prices with a cost, if they are able to extract higher payoffs in the next trading round. In this scenario these higher payoffs are obvious. An unconstrained risk-averse trader never sells all her risky holdings. Hence forced liquidation is clearly suboptimal. Therefore, if it is not too costly to increase the price in period 0 to secure solvency, the strong trader is willing to bear this cost. The price-manipulation cost is decreasing in the trader's initial wealth, hence there exists a threshold, $\overline{k}^{ll,sl}$, such that the strong trader will engage in price-manipulation if and only if $M^s + \overline{d}e \geq \lambda \overline{k}^{ll,sl} e^2$.

As both traders have price impacts, the forced liquidation and the resulting selling pressure of the strong trader hurts the weak trader too. Therefore it might be in her interest to manipulate the date 0 price and rescue the strong trader. As before the cost is again a decreasing in the wealth of the strong trader and therefore, there exists a threshold, $\overline{k}^{ll,ls}$, such that the weak trader prefers to make the strong trader solvent if and only if $M^s + \overline{d}e \geq \lambda \overline{k}^{ll,ls} e^2$. If this price manipulation is not too costly, the weak trader might also want to increase the date-0 price high enough to secure her solvency (and implicitly the strong trader's solvency too). This cost will be a decreasing function of her own wealth and therefore there exists a threshold, $\overline{k}^{ll,ss}$, such that the weak trader prefers to make both traders solvent if and only if $M^w + \overline{d}e \geq \lambda \overline{k}^{ll,ss} e^2$.

As discussed above, we have a price constraint and two deviation constraints on the wealth of the strong trader, and a price and a deviation constraint on the wealth of the weak trader. For the existence of an equilibrium we need the portfolio wealth of the strong trader to satisfy

$$0 \leq M^s + \overline{d}e < \lambda \min \left\{ 1, \overline{k}^{ll,ls}, \overline{k}^{ll,sl} \right\} e^2,$$

while for the weak trader we must have

$$0 \leq M^w + \overline{d}e < \lambda \min \left\{ 1, \overline{k}^{ll,ss} \right\} e^2.$$

It is easy to show that $\overline{k}^{ll,ls}, \overline{k}^{ll,sl}, \overline{k}^{ll,ss} \leq 1$, which means that the deviation constraint is always tighter than the price requirement. In fact, when traders liquidate, they smooth it through two periods to minimize their price impact and hence sell the same amount, i.e. half of their endowments in each period. Also, we can show that

$$\overline{k}^{ll,sl} < \overline{k}^{ll,ls},$$

which is equivalent to saying that it is always cheaper for the strong trader to reduce her trading speed in order to stay solvent than for the weak trader to rescue her. Given these inequalities we can sum up the above constraints as

$$0 \leq M^s + \overline{d}e < \lambda \overline{k}^{ll,sl} e^2 \text{ and } 0 \leq M^w + \overline{d}e < \lambda \overline{k}^{ll,ss} e^2. \tag{3.8}$$

3.5.2 Existence of Equilibria

The k thresholds mentioned in the previous sections are functions of $\lambda/\alpha\sigma^2$. However, they are too complicated to be solved analytically. We solve them numerically instead.

As mentioned in appendix 3.D.4, we fix the relative market depth ratio, i.e $\lambda/\alpha\sigma^2$ and examine the existence of equilibria as a function of the initial portfolio wealths of the strong and the weak traders. We find three different scenarios with two positive constants l and u.

- If $\lambda/\alpha\sigma^2 \leq l$, there exist all three types of equilibrium.

  We plot this case on Figure 3.1. On the x axis we have the initial wealth of the strong trader, $M^s + \overline{d}e$, on the y axis we have the starting wealth of the weak trader, $M^w + \overline{d}e$. As we have assumed $M^w + \overline{d}e \leq M^s + \overline{d}e$, we only plot the three types of equilibrium as a function of the initial portfolio wealths in the bottom right triangle. The area highlighted with medium grey represents equilibrium when both traders remain solvent, i.e., $M^i + \overline{d}e \geq 2\lambda a_0^{ss} e^2$ for $i = s, w$. The area highlighted by dark grey stands for equilibrium with the weak trader's fire-sale, i.e. when $M^s + \overline{d}e \geq \lambda \underline{k}^{ls,ll} e^2 > \lambda \left(a_0^{sl} + a_0^{ls}\right) e^2 > M^w + \overline{d}e \geq 0$. Finally the light grey area represents equilibria with double liquidation; this happens when $0 \leq M^i + \overline{d}e < \lambda e^2$ for $i = s, w$.

- If $l < \lambda/\alpha\sigma^2 \leq u$, there exist only ss and sl equilibria.

  We plot this case on Figure 3.2. On the x axis we have the initial wealth of the strong trader, $M^s + \overline{d}e$, on the y axis we have the starting wealth of the weak trader, $M^w + \overline{d}e$. As we assumed $M^w + \overline{d}e \leq M^s + \overline{d}e$, we only plot the three types of equilibria as a function of the initial portfolio wealths in the bottom right triangle. The area highlighted medium grey represents equilibria when both traders remain solvent, i.e., $M^i + \overline{d}e \geq 2\lambda a_0^{ss} e^2$ for $i = s, w$. The area highlighted by dark grey stands for equilibria with the weak trader's fire-sale, i.e. when $M^s + \overline{d}e \geq \lambda \underline{k}^{ls,ll} e^2 > \lambda \left(a_0^{sl} + a_0^{ls}\right) e^2 >$

$M^w + \overline{d}e \geq 0$.

- If $u < \lambda/\alpha\sigma^2$, there exist only the ss equilibria.

We plot this case on Figure 3.3. On the x axis we have the initial wealth of the strong trader, $M^s + \overline{d}e$, on the y axis we have the starting wealth of the weak trader, $M^w + \overline{d}e$. As we assumed $M^w + \overline{d}e \leq M^s + \overline{d}e$, we only plot the three types of equilibria as a function of the initial portfolio wealths in the bottom right triangle. The area highlighted with grey represents the only equilibria, that is when both traders remain solvent, i.e., $M^i + \overline{d}e \geq 2\lambda a_0^{ss} e^2$ for $i = s, w$.

3.6 Conclusion

This paper presents an equilibrium model of endogenous predation with strategic traders, who are subject to liquidation constraints: when the portfolio value of a trader becomes negative, she has to unwind her total risky position immediately and leave the market. In this set up we find that relatively strong traders may trigger the liquidation of relatively weak trader.

The behaviour of traders depends on their relative proportion of wealth invested in the risky asset. When these proportions are similar across the traders , they behave cooperatively and spread their orders over several trading periods, as they would do in a setting without the constraint. However, if there is a significant difference in the proportion of wealth invested in the risky asset among the traders, the relatively strong trader (with lower proportion of wealth invested in the risky asset) predates on the relatively weak trader (with higher proportion of wealth invested in the asset) by manipulating the price in the first period, and forcing her to unwind her risky position immediately. By doing this, the strong trader benefits from the fire sale resulting from the forced liquidation of the weak trader.

One obvious question is whether a strategic trader will be willing to invest in a portfolio of illiquid assets, if it makes her prone to predation and hence large losses. The answer coming from our model is in negative. Our rational arbitrageurs won't be willing to buy an asset if they will have to liquidate for sure in the subsequent period. This result is due to the fact that there is no informational asymmetry in our model and prices and positions are always deterministic. Therefore, the optimal strategy is to refrain from investing in the market if other potential strategic traders are present. An extension of the framework including some information asymmetry is left for future work.

Figure 3.1: The three types of equilibria plotted as a function of initial wealths for $\lambda/\alpha\sigma^2 = 0.5$.The x axis stands for $M^s + \overline{d}e$, the y axis represents $M^w + \overline{d}e$. The top right area represents equilibria when both traders remain solvent, the bottom right grey area stands for equilibria with the weak trader's fire-sale, and the bottom left area shows equilibria with double liquidation.

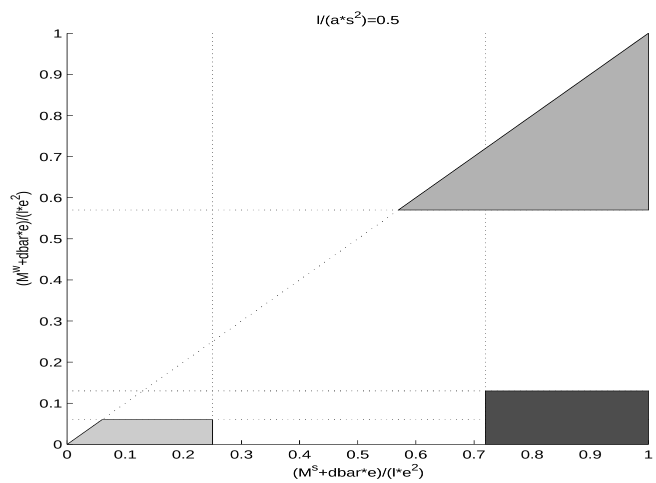


Figure 3.2: The ss and sl equilibria plotted as a function of initial wealths for $\lambda/\alpha\sigma^2 = .7$. The x axis stands for $M^s + \overline{d}e$, the y axis represents $M^w + \overline{d}e$. The top right area represents equilibria when both traders remain solvent, the bottom right are stands for equilibria with the weak trader's fire-sale.

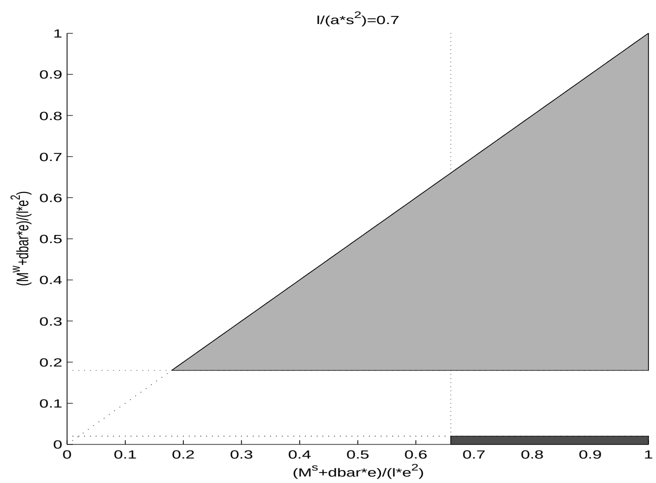
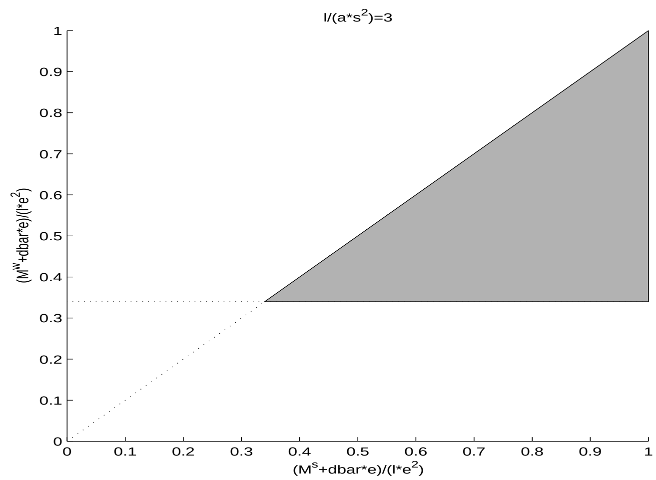


Figure 3.3: The ss equilibrium plotted as a function of initial wealths for $\lambda/\alpha\sigma^2 = 3$. The x axis stands for $M^s + \overline{d}e$, the y axis represents $M^w + \overline{d}e$. The top right area represents equilibria when both traders remain solvent.



Appendix 3.A Trading Strategy of a Constrained Monopoly

Proof of Proposition 1. First we have the following proposition:

Proposition 9 *In period* 1*, conditional on being solvent and having endowment* e_0 *in the risky asset, the first-best trade size and market-clearing price are given by*

$$x_1 = -\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0 \text{ and } p_1 = \overline{d} - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0. \tag{3.9}$$

Proof. As the market clearing price is determined by Equation 3.2 with $X_t = x_t$, we have $p_1 = \overline{d} + \lambda x_1$, hence we can rewrite the optimization problem conditional on being solvent at date 0 with positions M_0 and e_0 in the risk less and the risky assets, respectively, as

$$\max_{x_1} M_0 - \left(\overline{d} + \lambda x_1\right) x_1 + \overline{d}\left(e_0 + x_1\right) - \frac{\alpha}{2}\sigma^2\left(e_0 + x_1\right)^2.$$

The FOC is

$$0 = -\left(\overline{d} + 2\lambda x_1\right) + \overline{d} - \alpha\sigma^2\left(e_0 + x_1\right),$$

which yields

$$\begin{aligned} x_1 &= -\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0 \text{ and} \\ p_1 &= \overline{d} - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0. \end{aligned}$$

It also gives a continuation value function of

$$V\left(M_0, e_0\right) = M_0 - \left(\overline{d} + \lambda x_1\right) x_1 + \overline{d}\left(e_0 + x_1\right) - \frac{\alpha}{2}\sigma^2\left(e_0 + x_1\right)^2 \tag{3.10}$$

$$= M_0 + \overline{d} e_0 - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^2. \tag{3.11}$$

■

Proof of Proposition 1. The solution of the constrained case is presented in two steps. First we solve the optimization problem given that (i) the strategic trader remains solvent and (ii) she becomes insolvent, and check in which regions of the parameters it can happen. Then we compare the certainty equivalents of surviving and liquidating in the overlapping domain of parameters (when multiple equilibria exist) to see what the optimal strategy is when both are possible.

Conditional on the strategic trader remaining solvent, she proceeds with the unconstrained optimal trades given in Proposition 9 and the date-0 optimization problem becomes equivalent to the following one:

$$\begin{aligned}\max_{x_0} V(M_0, e_0) &= M_0 + \overline{d}e_0 - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^2 \\ &= M + \overline{d}e + \left(\overline{d} - p_0\right) x_0 - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} (e + x_0)^2 \\ \text{s.t. } M + p_0(x_0)\, e &\geq 0.\end{aligned}$$

The Lagrangian is

$$L = M + \overline{d}e + \left(\overline{d} - p_0\right) x_0 - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} (e + x_0)^2 - \mu \left[M + \left(\overline{d} + \lambda x_0\right) e\right],$$

where μ denotes the Lagrange multiplier of the constraint; hence the FOC w.r.t. x_0 is:

$$0 = -\lambda x_0 - \left(\overline{d} + \lambda x_0\right) + \overline{d} - 2\lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} (x_0 + e) - \mu\lambda e$$

and

$$-\left(M + p_0(x_0)\, e\right) \begin{cases} \leq 0 & \text{if } \mu = 0 \\ = 0 & \text{if } \mu > 0. \end{cases} \quad \text{w.r.t. } \mu.$$

Now either $\mu = 0$ which gives

$$x_0^u = -\frac{1}{2}\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}e$$

and the market clearing price

$$p_0^u = \overline{d} - \frac{\lambda}{2}\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}e,$$

or $\mu > 0$, thus $M + p_0 e = 0$ and we get

$$\begin{aligned} p_0^c &= -\frac{M}{e} = \overline{d} + \lambda x_0 \text{ and} \\ x_0^c &= -\frac{1}{\lambda}\frac{M + \overline{d}e}{e} = -\frac{1}{\lambda}\frac{M + \overline{d}e}{e^2}e, \end{aligned}$$

which also yield a value function of

$$\begin{aligned} V^c(M, e) &= M + \overline{d}e + \left(\overline{d} - p_0^c\right)x_0^c - \lambda\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}\left(e + x_0^c\right)^2 \\ &= M + \overline{d}e - \frac{1}{\lambda}\left(\frac{M + \overline{d}e}{e}\right)^2 - \lambda\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}\left(e - \frac{1}{\lambda}\frac{M + \overline{d}e}{e}\right)^2. \end{aligned}$$

Now turning to the insolvent case, full liquidation means $x_1 = -e_0 = -(x_0 + e)$, hence the optimization program becomes

$$\begin{aligned} \max_{x_0} M - p_0(x_0)x_0 - p_1(x_1)x_1 &= M + \overline{d}e - \lambda\left[x_0^2 + (x_0 + e)^2\right] \\ \text{s.t. } M + p_0(x_0)e &< 0, \end{aligned}$$

hence the FOC gives

$$\begin{aligned} 0 &= -2\lambda x_0 - 2\lambda(x_0 + e)\text{, that is} \\ x_0^l &= x_1^l = -\frac{1}{2}e \end{aligned}$$

and

$$p_0^l = p_1^l = \overline{d} - \frac{\lambda}{2}e,$$

which also yield a value function of

$$V^l(M,e) = M + \overline{d}e - \lambda\left[\left(x_0^l\right)^2 + \left(x_0^l + e\right)^2\right] = M + \overline{d}e - \frac{\lambda}{2}e^2$$

and the insolvency constraint becomes

$$\begin{aligned} M + p_0 e &= M + \left(\overline{d} - \frac{\lambda}{2}e\right)e < 0, \text{ i.e.} \\ M + \overline{d}e &< \frac{\lambda}{2}e^2. \end{aligned}$$

Thus we have the following results: if $M + \overline{d}e \geq \lambda\overline{k}^m e^2 = \frac{\lambda}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2}e^2$, the first best trade (that is the optimal trade in absence of the constraint) is feasible and the trade will proceed with it; if $M + \overline{d}e < \lambda\overline{k}^m e^2 \leq \frac{\lambda}{2}e^2$, there are multiple equilibria and the trader can choose between the second-best survival and the optimal liquidation. She is better off by reducing her trading speed and hence remaining solvent if and only if

$$V^c(M,e) \geq V^l(M,e),$$

that is

$$M + \overline{d}e - \frac{1}{\lambda}\left(\frac{M + \overline{d}e}{e}\right)^2 - \lambda\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}\left(e - \frac{1}{\lambda}\frac{M + \overline{d}e}{e}\right)^2 \geq M + \overline{d}e - \frac{\lambda}{2}e^2,$$

which is equivalent to

$$\frac{1}{2}\left(\frac{M + \overline{d}e}{e}, e\right)\begin{pmatrix} \frac{2}{\lambda} + 2\lambda\frac{\alpha\sigma^2}{2\lambda+\alpha\sigma^2}\frac{1}{\lambda}\frac{1}{\lambda} & -2\lambda\frac{\alpha\sigma^2}{2\lambda+\alpha\sigma^2}\frac{1}{\lambda} \\ -2\lambda\frac{\alpha\sigma^2}{2\lambda+\alpha\sigma^2}\frac{1}{\lambda} & -\lambda + 2\lambda\frac{\alpha\sigma^2}{2\lambda+\alpha\sigma^2} \end{pmatrix}\left(\frac{M + \overline{d}e}{e}, e\right)' \leq 0,$$

$$\frac{1}{2}\left(\frac{M+\overline{d}e}{e},e\right)Q^m\left(\frac{M+\overline{d}e}{e},e\right)' \leq 0$$

with

$$Q^m = \frac{1}{\lambda\left(2\lambda+\alpha\sigma^2\right)}\left(\begin{array}{ll} 4\left(\lambda+\alpha\sigma^2\right) & -2\lambda\alpha\sigma^2 \\ -2\lambda\alpha\sigma^2 & \lambda^2\left(\alpha\sigma^2-2\lambda\right) \end{array}\right)$$

hence, given that $0 \leq M+\overline{d}e < \frac{\lambda}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2}e^2$, is satisfied if and only if

$$\lambda\underline{k}^m e^2 \leq M+\overline{d}e$$

with

$$\underline{k}^m = \frac{\alpha\sigma^2-\sqrt{\lambda\left(2\lambda+\alpha\sigma^2\right)}}{2\left(\lambda+\alpha\sigma^2\right)}.$$

Since $\underline{k}^m > 0$ if $\lambda/\alpha\sigma^2 < \frac{1}{2}$, the proof of Proposition **1** is complete. ■

Appendix 3.B Trading Strategy of the Duopoly with same starting positions in both the assets

Proof of Proposition 2. As the general model is solved in Appendices 3.C and 3.D, we apply those results to the special case and extend it where needed. As noted in Section 3.4, the identical starting positions imply that either both traders remain solvent or both of the violate the constraint and get liquidated. Therefore we need to consider two continuation value functions only.

From Appendix 3.C.1 we know that the optimal trades at date 1 given that both traders remain solvent are

$$x_1^i = -\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2} e_0^i + \frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2} \frac{\lambda}{3\lambda + \alpha\sigma^2} e_0,$$

with the value function

$$V_0^{ss}\left(M_0^i, M_0^{-i}, e_0^i, e_0^{-i}\right) = M_0^i + \overline{d} e_0^i - \frac{\alpha}{2}\sigma^2\left(e_0^i\right)^2 + \frac{1}{2}\left(e_0^i, e_0^{-i}\right) Q_0^{ss}\left(e_0^i, e_0^{-i}\right)',$$

where Q_0^{ss} is a 2×2 symmetric, positive definite matrix:

$$Q_0^{ss} = \frac{1}{2\lambda + \alpha\sigma^2}\left(\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}\right)^2\left(\frac{2\lambda + \alpha\sigma^2}{3\lambda + \alpha\sigma^2}\right)^2\begin{pmatrix} \left(2\lambda + \alpha\sigma^2\right)^2 & -\lambda\left(2\lambda + \alpha\sigma^2\right) \\ -\lambda\left(2\lambda + \alpha\sigma^2\right) & \lambda^2 \end{pmatrix}.$$

Therefore going back to date 0 trader i has the following optimization problem:

$$\max_{x_0^i} CE\left(W_1^i\right) = M + \overline{d}e + \left(\overline{d} - p_0\left(x_0^i\right)\right)x_0^i - \frac{\alpha}{2}\sigma^2\left(e + x_0^i\right)^2 + \frac{1}{2}\left(e + x_0^i, e_0^{-i}\right) Q_0^{ss}\left(e + x_0^i, e_0^{-i}\right)'$$

$$\begin{aligned}
\text{s.t. market clears} &: \quad p_t = \overline{d} + \lambda \left(\sum_{i=1}^{2} x_t^i \right); \\
\text{dynamic budget constraints} &: \quad M_t^i = M_{t-1}^i - p_1 x_1^i \\
\text{and } e_t^i &= \quad e_{t-1}^i + x_t^i; \\
\text{final payoff} &: \quad W_1^i = M_1^i + d e_1^i; \\
\text{insolvency constraint} &: \quad x_1^i = -e_0^i \text{ if } W_0^i = M + p_0 e < 0.
\end{aligned}$$

The Lagrangian becomes

$$\begin{aligned}
L &= M + \overline{d}e + \left(\overline{d} - p_0\right) x_0^i - \frac{\alpha}{2}\sigma^2 \left(e + x_0^i\right)^2 + \frac{1}{2}\left(e + x_0^i, e_0^{-i}\right) Q_0^{ss} \left(e + x_0^i, e_0^{-i}\right)' \\
&\quad -\mu^i \left(M + p_0 e\right),
\end{aligned}$$

where μ^i denotes the Lagrange multiplier of the constraint for trader i; hence the FOC w.r.t. x_0^i is

$$\begin{aligned}
0 &= \left(\overline{d} - p_0\right) - \lambda x_0^i - \alpha\sigma^2 \left(e + x_0^i\right) \\
&\quad + (1,0)\, Q_0^{ss} \left(e + x_0^i, e_0^{-i}\right)' - \mu^i \lambda e,
\end{aligned}$$

and

$$-\left(M + p_0\left(x_0\right) e\right) \begin{cases} \leq 0 & \text{if} \quad \mu^i = 0 \\ = 0 & \text{if} \quad \mu^i > 0. \end{cases} \quad \text{w.r.t. } \mu^i.$$

Given that the two traders get distressed at the same time they must have identical Lagrange multipliers as well, $\mu^1 = \mu^2 = \mu$. If $\mu = 0$, we get the unconstrained solution of

Appendix 3.D.1, hence

$$\begin{aligned} x_0^{1u} &= x_0^{2u} = -\frac{\alpha\sigma^2}{3\lambda + 2\alpha\sigma^2} e \text{ with} \\ p_0^u &= \overline{d} - 2\lambda \frac{\alpha\sigma^2}{3\lambda + 2\alpha\sigma^2} e; \end{aligned}$$

thus, as long as the unconstrained strategies are feasible:

$$M + p_0^u e \geq 0, \text{ i.e. } M + \overline{d}e \geq \lambda \overline{k}^d e^2 = 2\lambda \frac{\alpha\sigma^2}{3\lambda + 2\alpha\sigma^2} e^2,$$

the two identical traders will proceed with these optimal trades.

If $\mu > 0$, the constraints must bind and hence

$$p_0^c = -\frac{M}{e} = \overline{d} + \lambda \left(x_0^1 + x_0^2 \right).$$

If $x_0^1 \neq x_0^2$, the two identical traders will end up with different positions for period 1 and after the second round as well, in which case one is better off than the other, which cannot happen in equilibrium, and hence we must have

$$x_0^{1c} = x_0^{2c} = -\frac{1}{2\lambda} \frac{M + \overline{d}e}{e}.$$

It also implies that the value functions become

$$V^c(M, e) = M + \overline{d}e - \frac{1}{2\lambda} \left(\frac{M + \overline{d}e}{e} \right)^2 - \frac{\lambda}{2} \frac{\alpha\sigma^2 (9\lambda + 4\alpha\sigma^2)}{(3\lambda + \alpha\sigma^2)^2} \left(e - \frac{1}{2\lambda} \frac{M + \overline{d}e}{e} \right)^2.$$

From Appendices 3.C.3 and 3.D.3 we know that the optimal trading trades given that both traders become insolvent are

$$x_0^1 = x_0^2 = x_1^1 = x_1^2 = -\frac{1}{2}e$$

which yields

$$p_0 = p_1 = \overline{d} - \lambda e,$$

and the value of this strategy for trader i is

$$V^l\left(M, e\right) = M + \overline{d}e - \lambda e^2.$$

Therefore, as long as the unconstrained strategies are not feasible, i.e.

$$0 \leq M + \overline{d}e < 2\lambda \frac{\alpha\sigma^2}{3\lambda + 2\alpha\sigma^2} e^2,$$

the two identical traders either reduce their trading speed or liquidate. Remaining solvent is preferred if and only if

$$V^c\left(M, e\right) \geq V^l\left(M, e\right),$$

that is

$$\begin{aligned} & M + \overline{d}e - \frac{1}{2\lambda}\left(\frac{M + \overline{d}e}{e}\right)^2 - \frac{\lambda}{2}\frac{\alpha\sigma^2\left(9\lambda + 4\alpha\sigma^2\right)}{\left(3\lambda + \alpha\sigma^2\right)^2}\left(e - \frac{1}{2\lambda}\frac{M + \overline{d}e}{e}\right)^2 \\ \geq \; & M + \overline{d}e - \lambda e^2, \end{aligned}$$

which is equivalent to

$$0 \geq \frac{1}{2}\left(\frac{M + \overline{d}e}{e}, e\right) Q^d \left(\frac{M + \overline{d}e}{e}, e\right),$$

where

$$Q^d = \begin{pmatrix} \frac{1}{\lambda}\left(1+\frac{\alpha\sigma^2\left(9\lambda+4\alpha\sigma^2\right)}{4(3\lambda+\alpha\sigma^2)^2}\right) & -\frac{1}{2}\frac{\alpha\sigma^2\left(9\lambda+4\alpha\sigma^2\right)}{(3\lambda+\alpha\sigma^2)^2} \\ -\frac{1}{2}\frac{\alpha\sigma^2\left(9\lambda+4\alpha\sigma^2\right)}{(3\lambda+\alpha\sigma^2)^2} & \lambda\left[-2+\frac{\alpha\sigma^2\left(9\lambda+4\alpha\sigma^2\right)}{(3\lambda+\alpha\sigma^2)^2}\right] \end{pmatrix},$$

hence, given that $0 \leq M + \overline{d}e < 2\lambda\frac{\alpha\sigma^2}{3\lambda+2\alpha\sigma^2}e^2$, is satisfied if and only if

$$\lambda\underline{k}^d e^2 \leq M + \overline{d}e$$

with

$$\underline{k}^d = \frac{-Q_{12}^d - \sqrt{\left(Q_{12}^d\right)^2 - Q_{11}^d Q_{22}^d}}{Q_{11}^d}.$$

Since $\underline{k}^d < 0$ if and only if $\lambda/\alpha\sigma^2$ is low enough, i.e. there exists an $\overline{l}^d > 0$ such that $\lambda/\alpha\sigma^2 < \overline{l}^d$, the proof of Proposition **2** is complete. ■

Appendix 3.C Trading Strategy of the Duopoly with different starting positions in risk free asset but same position in risky asset - date 1

3.C.1 Date 1 trades when both traders are solvent

The optimization problem of the strategic trader in period 1 is

$$V_0^{ss}\left(M_0^i, M_0^{-i}, e_0^i, e_0^{-i}\right) \equiv \max_{x_1^i} M_0^i - p_1\left(x_1^i\right) x_1^i + \overline{d}\left(e_0^i + x_1^i\right) - \frac{\alpha}{2}\sigma^2\left(e_0^i + x_1^i\right)^2,$$

hence the FOC becomes

$$0 \;=\; -2\lambda x_1^i - \lambda x_1^{-i} - \alpha\sigma^2\left(e_0^i + x_1^i\right).$$

Assuming the symmetric form $x_1^i = -a_1^{ss} e_0^i + b_1^{ss} e_0$ where a_1^{ss} and b_1^{ss} are constants and $e_0 = \frac{1}{2}\left(e_0^s + e_0^w\right)$ we have

$$x_1^{-i} = -a_1^{ss} e_0^{-i} + b_1^{ss} e_0 = a_1^{ss} e_0^i + \left(b_1^{ss} - 2a_1^{ss}\right) e_0,$$

which yields that

$$x_1^i = -\frac{\left(\lambda a_1^{ss} + \alpha\sigma^2\right)}{\left(2\lambda + \alpha\sigma^2\right)} e_0^i + \frac{\lambda\left(2a_1^{ss} - b_1^{ss}\right)}{\left(2\lambda + \alpha\sigma^2\right)} e_0,$$

therefore

$$a_1^{ss} = \frac{\left(\lambda a_1^{ss} + \alpha\sigma^2\right)}{\left(2\lambda + \alpha\sigma^2\right)} \text{ and } b_1^{ss} = \frac{\lambda\left(2a_1^{ss} - b_1^{ss}\right)}{\left(2\lambda + \alpha\sigma^2\right)},$$

which implies

$$a_1^{ss} = \frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2} \text{ and } b_1^{ss} = \frac{2\lambda}{3\lambda + \alpha\sigma^2}\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}.$$

Hence the optimal period 1 trades when both traders remain solvent are

$$\begin{aligned} x_1^i &= -a_1^{ss} e_0^i + b_1^{ss} e_0 \\ &= -\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2} e_0^i + \frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}\frac{2\lambda}{3\lambda + \alpha\sigma^2} e_0, \end{aligned}$$

and the market-clearing price is

$$p_1 = \overline{d} - 2\lambda \frac{\alpha\sigma^2}{3\lambda + \alpha\sigma^2} e_0.$$

It also gives that

$$\begin{aligned} V_0^{ss}\left(M_0^i, M_0^{-i}, e_0^i, e_0^{-i}\right) &\equiv \max_{x_1^i} M_0^i - p_1\left(x_1^i\right) x_1^i + \overline{d}\left(e_0^i + x_1^i\right) - \frac{\alpha}{2}\sigma^2\left(e_0^i + x_1^i\right)^2 \\ &= M_0^i + \overline{d} e_0^i - \frac{\alpha}{2}\sigma^2\left(e_0^i\right)^2 + \frac{1}{2}\left(e_0^i, e_0^{-i}\right) Q_0^{ss}\left(e_0^i, e_0^{-i}\right)' \end{aligned}$$

where Q_0^{ss} is a 2×2 positive semidefinite matrix:

$$Q_0^{ss} = \frac{1}{2\lambda + \alpha\sigma^2} a \begin{pmatrix} \left(2\lambda + \alpha\sigma^2\right)^2 & -\lambda\left(2\lambda + \alpha\sigma^2\right) \\ -\lambda\left(2\lambda + \alpha\sigma^2\right) & \lambda^2 \end{pmatrix}.$$

with

$$a = \left(\frac{\alpha\sigma^2}{\lambda + \alpha\sigma^2}\right)^2 \left(\frac{2\lambda + \alpha\sigma^2}{3\lambda + \alpha\sigma^2}\right)^2$$

3.C.2 Date 1 Trades when one trader is liquidated

Suppose trader w is forced to fire-sell, hence

$$x_1^w = -e_0^w.$$

At the same time trader i is solvent thus her optimization problem is

$$V_0^{sl}\left(M_0^s, M_0^w, e_0^s, e_0^w\right) \equiv \max_{x_1^s} M_0^s - p_1\left(x_1^s\right)x_1^s + \overline{d}\left(e_0^s + x_1^s\right) - \frac{\alpha}{2}\sigma^2\left(e_0^s + x_1^s\right)^2,$$

therefore her FOC is

$$0 = -p_1 - \frac{dp_1}{dx_1^s}x_1^s + \overline{d} - \alpha\sigma^2\left(e_0^s + x_1^s\right),$$

which yields

$$x_1^s = -\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}e_0^s - \frac{\lambda}{2\lambda + \alpha\sigma^2}x_1^w = -\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}e_0^s + \frac{\lambda}{2\lambda + \alpha\sigma^2}e_0^w$$

and hence the market-clearing price is

$$p_1 = \overline{d} - \lambda\frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2}e_0^s - \lambda\frac{\lambda + \alpha\sigma^2}{2\lambda + \alpha\sigma^2}e_0^w.$$

The continuation values become

$$\begin{aligned} V_0^{sl}\left(M_0^s, M_0^w, e_0^s, e_0^w\right) &\equiv \max_{x_1^s} M_0^s - p_1\left(x_1^s\right)x_1^s + \overline{d}\left(e_0^s + x_1^s\right) - \frac{\alpha}{2}\sigma^2\left(e_0^s + x_1^s\right)^2 \\ &= M_0^s + \overline{d}e_0^s - \frac{\alpha}{2}\sigma^2\left(e_0^s\right)^2 + \frac{1}{2}\left(e_0^s, e_0^w\right)Q_0^{sl}\left(e_0^s, e_0^w\right)', \end{aligned}$$

where Q_0^{sl} is a 2×2 positive semidefinite matrix:

$$Q_0^{sl} = \frac{1}{2\lambda + \alpha\sigma^2} \begin{pmatrix} \left(\alpha\sigma^2\right)^2 & -\lambda\alpha\sigma^2 \\ -\lambda\alpha\sigma^2 & \lambda^2 \end{pmatrix};$$

and

$$\begin{aligned} V_0^{ls}\left(M_0^w, e_0^w, M_0^s, e_0^s\right) &= M_0^w - p_1 x_1^w \\ &= M_0^w + \overline{d} e_0^w - \frac{1}{2}\left(e_0^w, e_0^s\right) Q_0^{ls} \left(e_0^w, e_0^s\right)', \end{aligned}$$

where Q_0^{ls} is a 2×2 matrix:

$$Q_0^{ls} = \frac{\lambda}{2\lambda + \alpha\sigma^2} \begin{pmatrix} 2\left(\lambda + \alpha\sigma^2\right) & \alpha\sigma^2 \\ \alpha\sigma^2 & 0 \end{pmatrix}.$$

3.C.3 Date 1 Trades when both traders liquidate

The constraint yields that there is not much strategic activity going on here, as

$$x_1^s = -e_0^s \text{ and } x_1^w = -e_0^w,$$

which implies

$$p_1 = \overline{d} - \lambda\left(e_0^s + e_0^w\right).$$

Also, the continuation value functions are

$$V_0^{ll}\left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i}\right) = M_0^i - p_1 x_1^i = M_0^i + \overline{d} e_0^i - \frac{1}{2}\left(e_0^i, e_0^{-i}\right) Q_0^{ll} \left(e_0^i, e_0^{-i}\right)'$$

where

$$Q_0^{ll} = \begin{pmatrix} 2\lambda & \lambda \\ \lambda & 0 \end{pmatrix}.$$

Appendix 3.D Trading Strategy of the Duopoly with different starting positions in risk free asset but same position in risky asset - date 0

For date 0, we solve for the optimal trades given (after period 0 trading) both traders remain solvent; one remains solvent, the other liquidates; both liquidate. Then we consider possible deviations that may change the state of the world, for example the stronger trader deviates from an ss (both solvent after period 0 trading) equilibrium and pushes the other trader into distress. There can be an equilibrium only if there is no potential profitable deviations. But, since the value functions are quadratic, it will always give us intervals as conditions on $M^s + \overline{d}e$ or $M^w + \overline{d}e$, so that the equilibrium exists.

3.D.1 Equilibrium of Type 1: Both traders remain solvent

When both traders remain solvent they both satisfy the solvency constraints

$$M^i + p_0 e \geq 0 \text{ for } i = s, w.$$

Let us analyze the case when the constraints are not binding. We will show later that in equilibrium the constraint cannot bind for any traders as it would be optimal for at least one of them to deviate.

From Appendix 3.C.1 we know that the optimal date 1 trades in case both traders stay solvent are

$$x_1^i = -a_1^{ss} e_0^i + b_1^{ss} e_0 = -\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2} e_0^i + \frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2} \frac{2\lambda}{3\lambda+\alpha\sigma^2} e_0 \text{ for } i = s, w, \tag{3.12}$$

and the market-clearing price is

$$p_1 = \overline{d} - 2\lambda \frac{\alpha\sigma^2}{3\lambda+\alpha\sigma^2} e_0$$

where $e_0 = \frac{1}{2}(e_0^s + e_0^w)$, and the value functions are

$$V_0^{ss}\left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i}\right) = M_0^i + \overline{d} e_0^i - \frac{\alpha}{2}\sigma^2 \left(e_0^i\right)^2 + \frac{1}{2}\left(e_0^i, e_0^{-i}\right) Q_0^{ss} \left(e_0^i, e_0^{-i}\right)'.$$

where Q_0^{ss} is a 2×2 symmetric, positive definite matrix:

$$Q_0^{ss} = \frac{1}{2\lambda+\alpha\sigma^2} a \begin{pmatrix} \left(2\lambda+\alpha\sigma^2\right)^2 & -\lambda\left(2\lambda+\alpha\sigma^2\right) \\ -\lambda\left(2\lambda+\alpha\sigma^2\right) & \lambda^2 \end{pmatrix}.$$

where

$$a = \left(\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2}\right)^2 \left(\frac{2\lambda+\alpha\sigma^2}{3\lambda+\alpha\sigma^2}\right)^2.$$

Going back to date 0 trader i has the following optimization problem

$$\begin{aligned} \max_{x_0^i} V_0^{ss}\left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i}\right) &= M_0^i + \overline{d} e_0^i - \frac{\alpha}{2}\sigma^2\left(e_0^i\right)^2 + \frac{1}{2}\left(e_0^i, e_0^{-i}\right) Q_0^{ss}\left(e_0^i, e_0^{-i}\right)' \\ &= M^i + \overline{d} e + \left(\overline{d} - p_0\right) x_0^i - \frac{\alpha}{2}\sigma^2\left(e + x_0^i\right)^2 + \\ &\quad \frac{1}{2}\left(e + x_0^i, e + x_0^{-i}\right) Q_0^{ss}\left(e + x_0^i, e + x_0^{-i}\right)' \end{aligned}$$

which gives the FOC

$$\begin{aligned} 0 &= -2\lambda x_0^i - \lambda x_0^{-i} - \alpha\sigma^2 \left(e + x_0^i\right) \\ &\quad + \left(2\lambda + \alpha\sigma^2\right) a \left(e + x_0^i\right) - \lambda a \left(e + x_0^{-i}\right), \end{aligned}$$

hence

$$\begin{aligned} x_0^i &= -\frac{a\left(\lambda + \alpha\sigma^2\right) - \alpha\sigma^2}{a\left(\lambda + \alpha\sigma^2\right) - \left(\alpha\sigma^2 + 3\lambda\right)} e \\ &= -a_0^{ss} e \end{aligned}$$

which implies that the equilibrium price takes the form

$$p_0 = \overline{d} - 2\lambda a_0^{ss} e$$

and the expected utility of trader i is

$$\begin{aligned} V^{ss}\left(M^i, M^{-i}, e\right) &= M^i + \overline{d}e + \left(\overline{d} - p_0\right) x_0^i - \frac{\alpha}{2}\sigma^2 \left(e + x_0^i\right)^2 + \\ &\quad \frac{1}{2}\left(e + x_0^i, e + x_0^{-i}\right) Q_0^{ss} \left(e + x_0^i, e + x_0^{-i}\right)' \end{aligned}$$

and imply that a necessary condition for the existence of an equilibrium with two solvent traders is

$$\begin{aligned} M^i + p_0 e &= M^i + \left[\overline{d} - 2\lambda a_0^{ss} e\right] e \geq 0, \text{ that is} \\ M^i + \overline{d}e &\geq 2\lambda a_0^{ss} e^2 \end{aligned}$$

In case $M^w + \overline{d}e \leq 2\lambda a_0^{ss} e^2$, the first-best trades are not feasible, hence in order to stay solvent the FOC of the weak trader is replaced by

$$M^w + p_0 e = 0,$$

that is

$$\begin{aligned} p_0 &= -\frac{M^w}{e} \text{ or} \\ x_0^w &= -\frac{1}{\lambda}\frac{M^w + \overline{d}e}{e} - x_0^s, \end{aligned}$$

and therefore the equilibrium trades are given by

$$\begin{aligned} x_0^s &= \frac{\lambda(1+a)}{[(2\lambda+\alpha\sigma^2)(1-a)-\lambda(1+a)]}\frac{1}{\lambda}\frac{M^w+\overline{d}e^w}{e^w} - \frac{\alpha\sigma^2-(3\lambda+\alpha\sigma^2)a}{[(2\lambda+\alpha\sigma^2)(1-a)-\lambda(1+a)]}e \\ &= -a_0^{ssC}e + b_0^{ssC}\frac{1}{\lambda}\frac{M^w+\overline{d}e^w}{e^w}, \end{aligned}$$

and

$$x_0^w = -\frac{1}{\lambda}\frac{M^w+\overline{d}e}{e} - x_0^s = a_0^{ssC}e - \left(1+b_0^{ssC}\right)\frac{1}{\lambda}\frac{M^w+\overline{d}e^w}{e^w},$$

We can compute the optimal value function by pluging in these optimal trades in V_0^{ss} .

Deviations

Strong Trader attacks the Weak Trader For the weak trader to be liquidated we need that

$$M^s + p_0 e \geq 0 > M^w + p_0 e$$

while the weak trader does not change her optimal trade of period 0:

$$x_0^w = -a_0^{ss} e$$

The strong trader is therefore better off by forcing the weak trader to liquidation if and only if

$$V^{sl}\left(M^s, M^l, e, x_0^s\right) \geq V^{ss}\left(M^s, M^l, e\right)$$

Weak Trader decides to liquidate instead of reducing trading speed The strong trader has trade order

$$x_0^s = -a_0^{ssC} e + b_0^{ssC} \frac{1}{\lambda} \frac{M^w + \overline{d} e^w}{e^w}$$

hence for the weak to be liquidated she needs $M^w + p_0 e < 0 \leq M^s + p_0 e$

She prefers being liquidated iff

$$V^{ls}\left(M^w, M^s, e, x_0^w\right) \geq V^{ssC}\left(M^w, M^s, e\right)$$

We solve the above two inequalities in value functions, which are quadratic in nature. After several steps of tedious algebra, we find the following constraint on $M^w + \overline{d}e$, which ensures that there are no profitable deviations from the equilibrium.

$$\lambda \underline{k}^{ss,sl} e^2 \leq M^w + \overline{d} e.$$

However, the threshold $\underline{k}^{ss,sl}$ is a functions of $\lambda/\alpha\sigma^2$ and it is too complicated to be solved analytically, so we find existence of equilibriums numerically in Section 3.5.2.

3.D.2 Equilibrium of Type 2: The Strong Trader remains solvent, the Weak Trader is liquidated

If one trader is liquidated while the other survives with after-trade positions of e_0^s and e_0^w, the second-period optimal trades are

$$x_1^w = -e_0^w$$

and

$$x_1^s = \frac{\lambda}{2\lambda + \alpha\sigma^2} e_0^w - \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^s$$

while

$$p_1 = \overline{d} - \lambda \frac{\lambda + \alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^w - \lambda \frac{\alpha\sigma^2}{2\lambda + \alpha\sigma^2} e_0^s$$

and the continuation value functions are

$$V_0^{sl}\left(M_0^s, e_0^s, M_0^l, e_0^l\right) = M_0^s + \overline{d} e_0^s - \frac{\alpha}{2}\sigma^2 \left(e_0^s\right)^2 + \frac{1}{2}\left(e_0^s, e_0^w\right) Q_0^{sl} \left(e_0^s, e_0^w\right)',$$

where Q_0^{sl} is a 2×2 positive semidefinite matrix:

$$Q_0^{sl} = \frac{1}{2\lambda + \alpha\sigma^2} \begin{pmatrix} \left(\alpha\sigma^2\right)^2 & -\lambda\alpha\sigma^2 \\ -\lambda\alpha\sigma^2 & \lambda^2 \end{pmatrix}$$

and

$$V_0^{ls}\left(M_0^w,e_0^w,M_0^s,e_0^s\right)=M_0^w+\overline{d}e_0^w-\frac{1}{2}\left(e_0^w,e_0^s\right)Q_0^{ls}\left(e_0^w,e_0^s\right)',$$

where Q_0^{ls} is

$$Q_0^{ls}=\frac{\lambda}{2\lambda+\alpha\sigma^2}\left(\begin{array}{cc}2\left(\lambda+\alpha\sigma^2\right) & \alpha\sigma^2\\ \alpha\sigma^2 & 0\end{array}\right).$$

The optimal first-period trades are obtained from the first-order conditions of the two traders, that is

$$\begin{aligned}\max_{x_0^s}V_0^{sl}\left(M_0^s,e_0^s,M_0^l,e_0^l\right) &= M_0^s+\overline{d}e_0^s-\frac{\alpha}{2}\sigma^2\left(e_0^s\right)^2+\frac{1}{2}\left(e_0^s,e_0^w\right)Q_0^{sl}\left(e_0^s,e_0^w\right)'\\ &= M^s+\overline{d}e+\left(\overline{d}-p_0\right)x_0^s-\frac{\alpha}{2}\sigma^2\left(e+x_0^s\right)^2+\\ &\quad \frac{1}{2}\left(e+x_0^s,e+x_0^w\right)Q_0^{sl}\left(e+x_0^s,e+x_0^w\right)'\end{aligned}$$

hence the FOC is

$$0=-4\lambda\frac{\lambda+\alpha\sigma^2}{2\lambda+\alpha\sigma^2}x_0^s-2\lambda\frac{\lambda+\alpha\sigma^2}{2\lambda+\alpha\sigma^2}x_0^w-\frac{3\lambda}{2\lambda+\alpha\sigma^2}\alpha\sigma^2e$$

while for the weak trader we have

$$\max_{x_0^w}V_0^{ls}\left(M_0^w,e_0^w,M_0^s,e_0^s\right)=M^w+\overline{d}e+\left(\overline{d}-p_0\right)x_0^w-\frac{1}{2}\left(e_0^w,e_0^s\right)Q_0^{ls}\left(e_0^w,e_0^s\right)'$$

hence the FOC is

$$0=-2\lambda\frac{3\lambda+2\alpha\sigma^2}{2\lambda+\alpha\sigma^2}x_0^w-2\lambda\frac{\lambda+\alpha\sigma^2}{2\lambda+\alpha\sigma^2}x_0^s-\lambda\frac{2\lambda+3\alpha\sigma^2}{2\lambda+\alpha\sigma^2}e$$

that is

$$x_0^w=-\frac{\lambda+\alpha\sigma^2}{3\lambda+2\alpha\sigma^2}x_0^s-\frac{1}{2}\frac{2\lambda+3\alpha\sigma^2}{3\lambda+2\alpha\sigma^2}e$$

combining the FOCs gives

$$x_0^s = \frac{1}{2}\left[\frac{\lambda}{\lambda+\alpha\sigma^2}\frac{2\lambda+\alpha\sigma^2}{5\lambda+3\alpha\sigma^2} - \frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2}\right] e = -a_0^{sl} e$$

and

$$x_0^w = -\frac{1}{2}\frac{4\lambda+3\alpha\sigma^2}{5\lambda+3\alpha\sigma^2} e = -a_0^{ls} e > -\frac{1}{2} e$$

and

$$x_1^s = \left[-\frac{1}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2} + \frac{1}{2}\frac{\lambda}{\lambda+\alpha\sigma^2}\frac{3\lambda+2\alpha\sigma^2}{5\lambda+3\alpha\sigma^2}\right] e > x_0^s$$

and $x_1^w = -\left[\frac{1}{2}\frac{6\lambda+3\alpha\sigma^2}{5\lambda+3\alpha\sigma^2} + \frac{3\lambda+3\alpha\sigma^2}{5\lambda+3\alpha\sigma^2}\right] e < -\frac{1}{2} e$

which yields a market-clearing price of

$$p_0 = \overline{d} - \lambda\left[a_0^{sl} + a_0^{ls}\right] e$$

$$p_0 = \overline{d} + \lambda\left[-\frac{1}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2} e + \frac{1}{2}\left(\frac{\lambda}{\lambda+\alpha\sigma^2}\frac{2\lambda+\alpha\sigma^2}{5\lambda+3\alpha\sigma^2} - \frac{4\lambda+3\alpha\sigma^2}{5\lambda+3\alpha\sigma^2}\right) e\right]$$

and

$$p_1 = \overline{d} + \lambda\left[-\frac{1}{2}\frac{\alpha\sigma^2}{\lambda+\alpha\sigma^2} e + \frac{1}{2}\left(\frac{\lambda}{\lambda+\alpha\sigma^2}\frac{2\lambda+\alpha\sigma^2}{5\lambda+3\alpha\sigma^2} - \frac{5\lambda+3\alpha\sigma^2}{5\lambda+3\alpha\sigma^2}\right) e\right] < p_0$$

We can plug in the values of trade and price the value functions $V^{sl}\left(M^s, M^l, e\right)$ and $V^{ls}\left(M^w, M^s, e\right)$

For the existence of an equilibrium of this type we also need

$$M^s + p_0 e \geq 0 > M^w + p_0 e$$

In case this does not hold, the constraint will bind for the strong trader and hence instead of her FOC we have

$$-\frac{M^s}{e} = p_0 = \overline{d} + \lambda\left[x_0^s + x_0^w\right]$$

that is

$$-\frac{1}{\lambda}\frac{M^s + \overline{d}e}{e} = x_0^s + x_0^w,$$

which together with the weak trader's FOC yields

$$\begin{aligned} x_0^w &= -\frac{1}{2}\frac{2\lambda + 3\alpha\sigma^2}{2\lambda + \alpha\sigma^2}e + \frac{\lambda + \alpha\sigma^2}{2\lambda + \alpha\sigma^2}\frac{1}{\lambda}\frac{M^s + \overline{d}e}{e} \\ &= -a_0^C e + b_0^C \frac{1}{\lambda}\frac{M^s + \overline{d}e}{e} \text{ and} \\ x_0^s &= a_0^C e - \left(1 + b_0^C\right)\frac{1}{\lambda}\frac{M^s + \overline{d}e^s}{e^s}, \end{aligned}$$

which satisfies

$$M^s + p_0 e = 0 > M^w + p_0 e$$

Again we can plug in the values in the expected utilities $V^{sl}\left(M^s, M^l, e\right)$ and $V^{ls}\left(M^w, M^s, e\right)$

Deviations

There are three realistic deviations from this setup. In two of them it is the weak trader who might want to change the state of the world. In the other case, the strong trader might not want to reduce her trading speed in the constrained case in order to stay alive and decides to liquidate instead.

Weak Trader forces the Strong to liquidate She can decrease the first period price by excessive selling hence forcing the strong trader to liquidate.

However this strategy is probably suboptimal: the weak trader has to bear an extra cost for selling with the price drop and in the second period too she liquidates at a lower price as now the strong trader is not able to drive the price up by buying part of the weak's endowment. Let us check this.

The weak trader needs to make sure

$$0 > M^s + p_0 e$$

and she will do it iff

$$V^{ll}\left(M^w, M^s, e, x_0^w\right) \geq V^{ls}\left(M^w, M^s, e\right),$$

Weak Trader rescues itself The other possible deviation is when the weak trader is willing to bear some cost in the first period by buying and hence increasing the price in order to meet solvency and be unconstrained in the next trading round.

While the strong trader sticks to her original trade, she needs to make sure

$$M^w + p_0 e \geq 0,$$

ans she will do it iff

$$V^{ss}\left(M^w, M^s, e, x_0^w\right) \geq V^{ls}\left(M^w, M^s, e\right),$$

Strong Trader decides to liquidate In case the strong trader just barely survives, which includes reducing her trade speed at date 0 and thus bearing a cost coming from insufficient price-impact reduction, she may want to violate the constraint and hence liquidate everything in period 1.

While the date 0 trade of the weak trader does not change, she needs to make

$$0 > M^s + p_0 e^s > M^w + p_0 e^w$$

and she will do it iff

$$V^{ll}\left(M^s, e^s, M^w, e^w, x_0^s\right) \geq V^{sl}\left(M^s, e^s, M^w, e^w\right),$$

We solve the above three inequalities in value functions, which are quadratic in nature. After several steps of tedious algebra, we find the following constraint, which ensures that there are no profitable deviations from the equilibrium.

$$\lambda \overline{k}^{ls,ss} e^2 > M^w + \overline{d}e,$$

However, the threshold $\overline{k}^{ls,ss}$ is a function of $\lambda/\alpha\sigma^2$ and is too complicated to be solved analytically, so we find existence of equilibriums numerically in Section 3.5.2.

3.D.3 Equilibrium of Type 3: Both Traders liquidate

As derieved in appendix 3.C.3, the date 1 trades when both traders liquidate are

$$x_1^s = -e_0^s \text{ and } x_1^w = -e_0^w$$

hence

$$p_1 = \overline{d} - \lambda\left(e_0^s + e_0^w\right)$$

and therefore

$$\begin{aligned} V_0^{ll}\left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i}\right) &= \; = M^i + \overline{d}e^i + \left(\overline{d} - p_0\right) x_0^i \\ & \quad -\lambda \left(e^i + x_0^i\right)^2 - \lambda \left(e^i + x_0^i\right)\left(e^{-i} + x_0^{-i}\right) \end{aligned}$$

the optimal first-period trades hence satisfy

$$\max_{x_0^i} V_0^{ll}\left(M_0^i, e_0^i, M_0^{-i}, e_0^{-i}\right) = M^i + \overline{d}e + \left(\overline{d} - p_0\right) x_0^i - \frac{1}{2}\left(e + x_0^i, e + x_0^{-i}\right) Q_0^{ll} \left(e + x_0^i, e + x_0^{-i}\right)'$$

which gives the FOC of

$$0 = -4\lambda x_0^i - 2\lambda x_0^{-i} - 3\lambda e$$

for $i = s, w$, therefore

$$x_0^i = -\frac{1}{2}e$$

which yields

$$x_1^i = x_0^i = -\frac{1}{2}e$$

and

$$p_0 = p_1 = \overline{d} - \lambda e$$

The value of this strategy for trader i is

$$V^{ll}\left(M^i, M^{-i}, e\right) == M^i + \overline{d}e - \lambda e^2$$

It also has to satisfy that both trader violate the constraint, that is

$$M^i + p_0 e = M^i + \left(\overline{d} - \lambda e\right) e < 0$$

which is equivalent to

$$0 \le M^i + \overline{d}e < \lambda e^2 \text{ for } i = s, w,$$

Deviations

Strong Trader rescues itself It means that she wants to increase the price to make sure

$$M^s + p_0 e \ge 0 > M^w + p_0 e$$

while

$$x_0^w = -\frac{1}{2}e$$

The strong trader is better off by rescuing itself iff

$$V^{sl}\left(M^s, M^w, e, x_0^s\right) \ge V^{ll}\left(M^s, M^w, e\right)$$

Weak Trader rescues Strong Trader It might be optimal to rescue the strong trader (even if she would not rescue itself) as the second period price might be higher in case the strong trader remains solvent and therefore the liquidation payoff of the weak trader is higher.

In this scenario the strong trader proceeds with

$$x_0^s = -\frac{1}{2}e$$

while the weak trader wants to increase the price to make sure

$$M^s + p_0 e \ge 0 > M^w + p_0 e$$

The weak trader is better off rescuing the strong iff

$$V^{ls}\left(M^w, M^s, e, x_0^w\right) \geq V^{ll}\left(M^s, M^w, e\right)$$

Weak Trader rescues both: itself and the strong trader It might be optimal to rescue itself (and at the same time the strong trader as well) since she could perform the first-best trade in period 1.

In this scenario the strong trader proceeds with

$$x_0^s = -\frac{1}{2}e$$

while the weak trader wants to increase the price to make sure

$$M^s + p_0 e \geq M^w + p_0 e \geq 0$$

The weak trader is better off rescuing both of them iff

$$V^{ss}\left(M^w, M^s, e, x_0^w\right) \geq V^{ll}\left(M^s, M^w, e\right)$$

We solve the above three inequalities in value functions, which are quadratic in nature. After several steps of tedious algebra, we find the following constraints, which ensures that there are no profitable deviations from the equilibrium.

$$\begin{aligned} 0 &\leq M^s + \overline{d}e < \lambda \overline{k}^{ll,sl} e^2 \text{ and} \\ 0 &\leq M^w + \overline{d}e < \lambda \overline{k}^{ll,ss} e^2. \end{aligned}$$

However, the threshold $\overline{k}^{ll,sl}, \overline{k}^{ll,ss}$ are functions of $\lambda/\alpha\sigma^2$ is too complicated to be solved analytically, so we find existence of equilibriums numerically in Section 3.5.2.

3.D.4 Existence of Equilibria

As mentioned before, it is easy to see that the k thresholds are functions of $\lambda/\alpha\sigma^2$, however, it is too difficult to solve for them analytically. We have instead tried to solve them numerically. We fix α and σ^2 and vary λ. Given these values, we compute the optimal trades for each of the equilibriums. Then we check for the deviations. We find the following. When the relative market depth ratio, $\lambda/\alpha\sigma^2$, is lower than a threshold l, which is approximately equal to 0.65, there exists all three types of equilibriums; when $\lambda/\alpha\sigma^2$ is between the lower and a upper threshold, u, which is approximately equal to 0.71, i.e. when $0.65 = l < \lambda/\alpha\sigma^2 \leq u = 0.71$, there exists only the ss and sl equilibria; when relative market depth ratio, $\lambda/\alpha\sigma^2$, is higher than the upper threshold i.e. $\lambda/\alpha\sigma^2 > 0.71$, there exists only the ss equilibrium.

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