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Institutional Trading and Stock Returns*

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Institutional Trading and Stock Returns

ABSTRACT

In this study, we explore the dynamics of the relation between institutional trading and stock returns. We find that stock returns Granger-cause institutional trading (especially purchases) on a quarterly basis, rather than vice versa. This implies that institutions herd on past price behavior instead of being dominant price-setters in the market. The robust and significant causality from equity returns to institutional trading can be largely explained by the time-series variation of *market* returns, that is, institutions buy more popular stocks after market rises. An analysis of the behavior of trading and the returns of the traded stocks reveals strong evidence that stocks with heavy institutional buying (selling) experience positive (negative) momentum over the previous 12 months. The most intriguing finding however is that excess returns disappear immediately after the intense trading (buying/selling) activity by institutions. By examining five subgroups of institutional investors, we find that mutual funds and investment advisors are the main drivers of the inter-temporal relations between equity returns and aggregate institutional trading.

1. Introduction

In this study, we explore the dynamics of the relation between institutional trading and stock returns. Our primary focus is to address the following questions: (1) Is institutional trading related to changes in stock prices? (2) Does institutional trading "cause" stock returns or do institutions follow movements in stock prices? (3) Are there differences in the trading behaviors of different types of institutions? (4) Is it profitable for an uninformed trader to simply mimic the trading behavior of institutions? We are primarily interested in the behavior of stock prices before and after the trading activity of institutions. The motivation for this research is straightforward. It is important to study the dynamic relation between equity returns and institutional trading for at least two reasons. First, institutions account for over 50% of trading in the US stock market. Second, in many theoretical models and empirical papers, institutions are treated differently from individual traders on several dimensions, including their relative advantage(s) at information acquisition, information processing, and trade execution.

We focus on the relationship between institutional trading and stock returns over the medium (three- to 12-month) horizons. Using quarterly Spectrum data, we first establish the existence of a strong contemporaneous relation between the intensity of institutional trading and stock returns. This relation is robust to the inclusion of the Fama and French (1992) factors of size, book-to-market, and the aggregate market. To determine the more interesting issue of the causality between institutional trading and returns, we perform standard Granger-causality tests on each of ten portfolios sorted based on institutional trading. Our results show a distinct causality from returns to institutional trading, but no causality from institutional trading to returns. The returns of portfolios with high levels of institutional trading, especially ones with net institutional purchases (portfolios 8-10), Granger-cause the trading activity, but not vice versa. This suggests that institutional investors follow a positive feedback strategy when they increase their stakes in stocks.

To determine the source(s) of the causality from returns to institutional trading, we conduct Granger-causality tests on the market and excess return (realized returns less the market return) components of the stocks contained in the various portfolios. These

tests show that the causality from returns to trading appears to be a result of institutional traders' positive feedback trading based on movements in the market. The causality from market returns to trading activity dominates the causality from firm-specific components of returns to the trading activity of institutional investors.

To further investigate the dynamics of the relationship between stock returns and institutional trading, we investigate the behavior of both portfolio raw returns and portfolio excess returns around the quarter in which the portfolios are formed. The patterns of returns (raw returns and excess returns) before and after institutional trading are striking. For stocks with the most intensive institutional buying (portfolio 10), positive excess returns exist in all the previous 12 months, and are almost all statistically significant. The positive excess returns exhibit an apparent run-up over the 12 months prior to the portfolio formation quarter, reaching a peak in the first month of the portfolio formation quarter. For stocks with the most intensive institutional selling (portfolio 1), excess returns are almost all negative in the previous 12 months, but not significant until the three months prior to the portfolio formation quarter. The (negative) excess returns decline sharply until reaching a trough in the first month of the portfolio formation quarter.

Surprisingly, however, the excess returns of stocks with intensive institutional buying or selling soon disappear in the quarter immediately following the portfolio formation period. In the following 24 months, the excess returns of the 10 portfolios are almost all statistically close to zero, and the differences between the excess returns of portfolios 10 and 1 become minor and insignificant. This finding suggests that it would not be profitable for an uninformed investor to mimic institutional trading. Finally, stocks that have more balanced institutional purchases and sales, or relatively low aggregate net demand (portfolio 5), seem to show no particular patterns in returns during the entire 36-month period surrounding the portfolio-formation period. We find similar return patterns when we use risk-adjusted returns based on the one-factor, Fama-French (1992) three-factor, and the Carhart (1997) four-factor models. We also observe that the trading activities around the portfolio formation period track the pattern in stock returns.

To examine the potentially different trading behaviors across different institutional investors, we examine the trading activities of each of the five subgroups of institutional investors listed on Spectrum. The tests do not reveal statistical evidence of Granger-causality, either from returns to trading, or vice versa, for any of the subgroups. These findings are probably a result of high levels of noise in return and trading data of each of the subgroups. To mitigate the dependence of our conclusions on standard causality tests, we conduct an analysis of the joint behavior of returns and institutional trading surrounding the portfolio formation period. We find that banks, insurance companies, mutual funds, and investment advisors all follow momentum strategies. Mutual funds seem to look at past returns over shorter time horizons (one to two months), while the others condition on returns over the past twelve months. However, trades by banks and insurance companies are not contemporaneously correlated with stock returns, while trades by mutual funds and investment advisors and contemporaneous returns are highly correlated.

This paper is related to several strands of prior research on the investment behavior of institutional investors. With the dramatic increase in institutional ownership of equities over the past two decades, this general area has deservedly received increasing attention in both academic and popular publications. Most of the research has concentrated on the *investment holdings* of institutions, and specifically on the relationship between the holdings and the cross-sectional characteristics of the firms. Badrinath, Gay, and Kale (1989), Del Guercio (1996), Falkenstein (1996), Gompers and Metrick (2001), and Lakonishok, Shleifer, and Vishny (1994)] find a stable positive relationship between institutional ownership and some "prudent" features such as firm size, past performance, and share turnover. In addition, Badrinath, Kale and Noe (1995) and Sias and Starks (1997) show that institutional ownership relates to some distinct lead-lag patterns in stock returns.

Only recently has the literature turned to the dynamic aspects of the relationship between institutional trading and equity returns. Griffin, Harris and Topaloglu (2001), Grinblatt, Titman and Wermers (1995), Nofsinger and Sias (1999), Sias, Starks and Titman (2001) and Wermers (1999) all document a positive contemporaneous correlation between institutional trading and stock returns. However, the empirical results on the

causal relation between institutional trading and equity returns are still mixed. Kraus and Stoll (1972b) find that institutional trading has a significant price effect. Sias, Starks and Titman (2001) suggest that intra-quarter price impact of institutional trading is primarily responsible for the contemporaneous relation between institutional trading and stock returns. Both theoretical and empirical research has attempted to investigate the existence of institutional investors' herding and feedback trading behaviors.[1] Institutions may herd because they react to the same fundamental information such as changes in dividends. Alternatively, institutional herding may result from agency problems [see, for example, Scharfstein and Stein (1990), Lakonishok, Shleifer, Thaler, and Vishny (1991), and Lakonishok, Shleifer, and Vishny (1994)], and institutions might follow potentially destabilizing short-term strategies such as positive feedback trading [see De Long et al. (1990), Cutler, Poterba, and Summers (1990)]. Grinblatt, Titman, and Wermers (1995) and Wermers (1999) find empirical evidence of positive feedback trading by mutual funds.

The rest of the paper is organized as follows. Section 2 summarizes the data and presents the methodology. Section 3 contains a discussion of the empirical results. Section 4 presents a few possible interpretations of the evidence, and the contribution of our work is discussed in the context of the literature.

2. Data and methodology

A 1978 amendment to the Securities and Exchange Act of 1934 required all institutions with greater than $100 million of securities under discretionary management to report their holdings to the SEC. Holdings are reported quarterly on the SEC's form 13F. All common stock positions greater than 10,000 shares or $200,000 must be disclosed. The institutional holdings data used in this paper include the quarterly reports available on Spectrum from the third quarter of 1981 through the fourth quarter of 1996 (a total of 62 quarters). The common stocks examined in this study are restricted to those listed on both the New York and American Stock Exchanges (NYSE and AMEX) and on

[1] Herding occurs when a group of investors trade the same stock in the same direction over a period of time, while feedback trading occurs when lagged returns act as the common signal that the investors follow.

the monthly tapes of the Center for Research on Security Prices (CRSP). There are a total of 5,891 stocks included over the sample period.

In this paper, *institutional trading* is computed as the change of institutional holdings from last quarter to the current quarter. *Net institutional trading* (also referred as "net institutional demand") for a stock is defined as the sum of changes of holdings across all institutions. Though obvious from the nature of the data, it is important to note that not all institutional trades can be observed in the Spectrum data used in this study.

Each institution that submits a 13F form is assigned a manager type by Spectrum. The five types of managers are (1) banks, (2) insurance companies, (3) investment companies (mutual funds), (4) investment advisors (including most of the large brokerage firms), and (5) others (including pension funds and university endowments). The categorization however is not always precise, especially between type (3) and (4). For example, a brokerage firm with mutual funds will be categorized as type (3) if the mutual funds are deemed to make up more than 50% of the total assets for that manager, and as type (4) otherwise. It is also possible for an institution to be reclassified over time if its main business has changed.

Table 1 presents some sample statistics of the quarterly Spectrum data at the end of each of the fourth quarter from 1981 to 1996. Both number of institutions and number of stocks held by all institutions more than double over the years, although part of the growth might be due to the rising market during the sample period that pushed institutions or stock holdings across the nominal threshold levels. The table however also shows a dramatic increase in the relative importance of institutional investors in financial markets. Institutions' market share increased from 33.97% to 53.68% from 1981 to 1996. The average numbers of stocks held and traded by each institution also display strong upward trends, each increasing by about 80% over the sample period. Finally, an average institution continues to make trades in about 75% of stocks it holds in each quarter, with this frequency remaining surprisingly stable across the sample period.

Table 2 presents data on the relative importance of the five categories of financial institutions listed in the Spectrum database. Panel A contains data on the "size" of each type as measured by the number of institutions representing each category. Panel B contains data on "size" as measured by the average market value of the institutions' holdings (price per share times the number of shares held). For brevity, both panels report data at the end of every fifth year. It is clear from table 2 that the market shares of mutual funds and investment advisers, both in terms of numbers and the market values of their stock holdings, have increased steadily over the sample period. This increase has come largely at the expense of banks, and to a lesser degree at the expense of insurance companies and all other types of financial institutions.

In our data analysis, we sort all sample stocks into ten portfolios at the end of each quarter between the third quarter of 1981 and the fourth quarter of 1996, based on percentage of net institutional trading, which is defined as the ratio of net institutional trading to the number of shares outstanding. The extreme portfolios are the ones with high levels of net institutional trading: portfolio 1 consists of stocks with the highest net institutional sales in that quarter, while portfolio 10 consists of stocks with the highest net institutional demand (purchases) in that quarter. The portfolios in the middle consequently reflect relatively low levels of trading.

3. Institutional trading and stock returns

Before investigating the dynamics of the relation between stock returns and institutional trading, we establish the *contemporaneous* relations between stock returns and both institutional holdings and institutional trading (that is, changes in institutional holdings). For brevity, we do not report the detailed results, but our findings are fairly conclusive. Even after conditioning on the three Fama-French (1992) factors of book-to-market, size, and the market, there is a strong contemporaneous relation between returns and both institutional holdings and institutional trading. In fact, our finding suggests that institutional trading is more closely related to contemporaneous returns than institutional holdings, which makes intuitive sense because institutional trades are more likely to be responses to information updates or short-term goals such as "window dressing" [see Lakonishok et al. (1991)]. The strong contemporaneous relation between institutional

trading and returns is consistent with the recent findings of Gompers and Metrick (2001), Nofsinger and Sias (1999), and Wermers (1999).

A. Causality tests

To investigate whether institutional investors, as a group, chase past returns or affect subsequent returns through their trading, we perform Granger causality tests on institutional trading and portfolio raw returns. For each of the ten portfolios sorted on net institutional trading percentage, we perform two sets of regressions. The first regression involves the linear projection of net (percentage) institutional trading (or net institutional demand) on its own lagged values and lagged portfolio raw returns, while the second regression involves the projection of portfolio raw returns on lagged raw returns and lagged net institutional trading percentages. Specifically, the regressions are:

$$Dem_t = \alpha + \beta_1 Dem_{t-1} + \beta_2 Dem_{t-2} + \beta_3 Dem_{t-3} + \beta_4 Dem_{t-4} + \gamma_1 Ret_{t-1} + \gamma_2 Ret_{t-2} + \gamma_3 Ret_{t-3} + \gamma_4 Ret_{t-4} + u_t \qquad t = 1, \ldots, T \qquad (1)$$

$$Ret_t = \alpha' + \beta'_1 Ret_{t-1} + \beta'_2 Ret_{t-2} + \beta'_3 Ret_{t-3} + \beta'_4 Ret_{t-4} + \gamma'_1 Dem_{t-1} + \gamma'_2 Dem_{t-2} + \gamma'_3 Dem_{t-3} + \gamma'_4 Dem_{t-4} + u'_t \qquad t = 1, \ldots, T \qquad (2)$$

where Dem_t and Ret_t are the time-series of net institutional trading percentages and portfolio raw returns, respectively, during the portfolio formation period, and Dem_{t-k} and Ret_{t-k} are their respective values with a lag of quarter k. We chose $k = 4$ to capture up to one-year worth of information on returns and the trading activities of institutions.

The causality tests are the standard Granger tests implemented on estimates of regressions (1) and (2). Specifically, we conduct *F*- tests to evaluate the legitimacy of the following null hypotheses:

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = 0 \qquad (3)$$

$$H_0: \gamma'_1 = \gamma'_2 = \gamma'_3 = \gamma'_4 = 0. \qquad (4)$$

Estimates of the above regressions, and the corresponding F-tests, are presented in table 3. In the regression of net institutional demand on lagged institutional demand and lagged raw returns (see panel A), portfolio 5, 8, 9, and 10 exhibit p-values of less than 5%, which means that the null hypothesis (3) is rejected and returns Granger-cause net institutional demand for these four portfolios. Notably, portfolio 8, 9, 10 are the three most highly demanded portfolios, with coefficients on Ret_{t-1} all positive and significant. Moreover, the magnitude of the coefficients on past two quarters' returns increases as net institutional demand increases. This indicates that when institutional investors make purchases, they engage in positive feedback trading, and the stocks with the highest institutional demand exhibit the greatest extent of positive feedback trading. The results also show that institutional investors put more weights on returns of the recent two quarters than on those of more distant quarters, and in general lagged institutional demand does not significantly affect current demand. Interestingly, there is no evidence of positive feedback trading for the portfolios with net institutional selling. This suggests that, when institutional investors sell part of their holdings, poor past performances do not seem to be the dominating reason (though there is the distinct possibility of intra-quarter positive feedback trading that cannot be detected by the causality tests).

The evidence presented in panel B of table 3 suggests that lagged institutional trading does not affect stock returns, or institutional trading does not have significant inter-quarter price impact. Only portfolio 4 has an F-statistics significant at 5% level. For other portfolios, institutional demand does not Granger-cause portfolio returns. However, the relative small p-values for the first four portfolios suggest that institutional trading might have a marginal impact on returns for portfolios with net institutional selling. Therefore, the contemporaneous relation between institutional trading and returns may hide some asymmetric causality for stocks with net institutional purchases and stocks with net institutional sales. For stocks with net institutional purchases, return momentum stimulates the return chasing of institutional investors; for stocks with net institutional selling, the motivation behind the trades is less clear. One possibility is that institutional sales may be destabilizing in that they cause a downward pressure on prices. Moreover, we should note that the lack of inter-quarter price impact by institutions does

not exclude the possibility of intra-quarter price impact as documented by Sias, Starks and Titman (2001).[2]

The reliable evidence of return-chasing by institutional investors when they purchase stocks leads to the following intriguing question. Do institutions chase market movements or do they pick-up on patterns in prices generated by information peculiar to the companies included in their portfolios? In other words, is the causal relationship described above affected by general market conditions? To address this issue, we decompose the time series of raw returns into two components: market returns and portfolio "excess returns." We then re-estimate equations (1) and (2), and conduct the corresponding F-tests, by sequentially replacing raw returns by market and excess returns, respectively.

Table 4 reports the results of the test for net institutional demand and market returns. The striking similarity of table 4 to table 3 suggests that the relation between institutional trading and market returns is the driving force for the causality between institutional trading and raw returns. Panel A again shows that, for stocks with heavy institutional buying, the coefficients of $MktRet_{t-1}$ and $MktRet_{t-2}$ are mostly positive and significant. In addition, the magnitude of the coefficients on lagged market returns increases as net institutional demand increases. These findings suggest that institutional investors follow positive feedback on *market returns* when they make purchases, and stocks with highest institutional demand exhibits the highest extent of positive feedback trading. Similar to panel A of table 3, there is no evidence of positive feedback trading for portfolios with net institutional selling. Finally, panel B shows that past institutional demand does not affect market returns significantly.

Table 5 contains estimates of equations (1) and (2) using portfolio "excess returns," that is raw returns minus market returns. Panel A shows a much less clear pattern of feedback trading: for portfolios 2, 3, and 9, excess returns Granger-cause

[2] We repeat the above tests for institutional trading and returns with one lag and two lags respectively, and get similar results. We also perform the same tests with data of one quarter before and one quarter after portfolio formation period respectively, and find a consistent and even stronger pattern of positive feedback trading, especially for stocks with net institutional demand. In general, institutional trading does not Granger-cause portfolio returns.

institutional demand, but the coefficients on lagged excess returns are mostly negative which suggests negative feedback trading. The apparent pattern of positive feedback trading for portfolios with high net institutional purchases (portfolios 8-10) witnessed in panel A of table 4 does not appear in table 5. Finally, panel B of table 5 shows that lagged institutional trading does not help explain portfolio excess returns.

The evidence in tables 4 and 5, taken together, leads to the conclusion that the positive feedback trading by institutional investors is more closely related to market conditions than to firm-specific information about the stocks.

B. Behavior of returns surrounding institutional trading

The strong correlation between institutional trading and returns, and the apparent tendency of institutional traders to indulge in positive feedback trading (based on signals about the market) while making significant purchases, raises some interesting issues. How intense is the relative trading activity of institutions around the portfolio formation period? How do stocks purchased/sold by institutions perform before the portfolio formation period? How do institutional trades affect stock returns? Is it profitable to buy stocks with heavy institutional purchases and short sell stocks with heavy institutional sales? In essence, our findings motivate a detailed analysis of the trading activity in, and the behavior of, stocks bought/sold by institutions leading up to, and following, the heavy trading period.

Figure 1 shows the aggregate trading activity of all institutions before and after the portfolio formation period/quarter. Recall that the aggregate trading activity of all institutions is defined as the percentage of net institutional trading, which is the net institutional purchase/sale in a stock relative to the total number of shares outstanding. Due to data constraints, only quarterly data are available for the changes of institutional ownership. The time-series averages of the percentages of net institutional trading are calculated for each portfolio for each of the four quarters (quarter t = -4 to -1) before portfolio formation, the quarter (quarter t = 0) of portfolio formation, and the eight quarters (quarter t = 1 to 8) after portfolio formation. For simplicity, we present the aggregate trading activity of institutions for portfolios 1, 5, and 10.

The patterns in figure 1 are obvious. The trading activity, and the net purchasing activity, is quite similar for portfolios 1 and 10 in the three quarters leading up to the portfolio formation quarter. In the quarter just preceding the portfolio formation period, portfolios 10 (1) experience a jump (fall) in net purchases, though the net activity is still positive in the latter. In the portfolio formation quarter, there is a dramatic increase in purchases in portfolio 10 securities, with net purchases increasing from about 4% to about 13%. Conversely, there is a dramatic increase in the sales of portfolio 1 securities, with the percentage of net sales amounting to about 9%. Following the portfolio formation period, the net activities fall close to 0% for both the net purchase and net sale portfolios.

Unlike the constraint imposed by the quarterly trading data, we can analyze the return behavior of the securities traded by institutions at a higher frequency. We consequently examine the monthly raw returns and excess returns of the 10 portfolios one year prior to (month t = -12 to -1) and two years subsequent to (month t = 3 to 26) the portfolio formation quarter (month t = 0 to 2). For each of the 39 months, there are 10 portfolio returns. Again, for simplicity, we present the raw and excess returns of portfolio 1, 5, and 10 in figures 2 and 3, respectively. Before analyzing the behavior of returns (measured on a monthly basis) in figures 2 and 3, and relating it to the behavior of trading (measured on a quarterly basis) depicted in figure 1, we need to emphasize that this analysis will reflect any *intra-quarterly* patterns in returns. Hence, it will be different from the causality tests presented in the previous section because the latter reflect *inter-quarterly* relations between equity returns and institutional trading.

The raw returns in figure 2 show substantial seasonal variation for all portfolios, but there is a clear upward (downward) trend in the returns leading up to the portfolio formation period. This suggests that institutions tend to purchase (sell) stocks that have been appreciating (depreciating) in value. The more surprising pattern is that the upward (downward) trend is reverted following the heaviest trading activity by the institutions. This general pattern mirrors the net trading activity in Figure 1, though the less noisy data on trading makes the patterns more blatant.

The removal of the "market effect" from the raw returns helps reduce the noise in the excess returns displayed in figure 3. The patterns of excess returns before and after institutional trading are striking. First, for stocks with the most intensive institutional buying (portfolio 10), positive excess returns exist in all the previous 12 months, and almost all are statistically significant. The excess returns also exhibit an apparent run-up over time and reach a peak of 1.83% in the first month of the portfolio formation quarter. For stocks with the most intensive institutional selling (portfolio 1), the reverse pattern is witnessed. Excess returns are almost all negative in the previous 12 months, but not significant until the last five months. The excess returns decline sharply until reaching a low of –2.26% in the first month of the portfolio-formation quarter, when the difference in the monthly returns of portfolios 10 and 1 is as large as 4.09%.

Second, the excess returns of stocks with both intensive institutional buying and selling disappear in the quarter immediately following the portfolio formation period. In the following 24 months, the excess returns of all the 10 portfolios are almost all statistically close to zero. Specifically, the differences between the excess returns of portfolio 10 and portfolio 1 become minor and insignificant. This surprising result contrasts with the finding of Nofsinger and Sias (1999) that stocks bought by institutional investors outperform those they sell in the subsequent two years. Third, the returns and excess returns of stocks that have more balanced institutional purchases and sales (portfolio 5) show no obvious patterns around the portfolio-formation quarter. Finally, a comparison of figures 1 and 3 shows a surprising similarity, although figure 1 shows quarterly patterns while figure 3 is based on monthly data. Portfolio 10 experiences high percentage of net institutional purchases in the previous four quarters, a further increase of net purchases over the quarter of portfolio formation, and a drop in the following quarter. The pattern of portfolio 1 is just about the opposite: a sharp decline in net institutional trading over the portfolio formation period is followed by a quick recovery. This evidence shows that institutional trading and returns are highly contemporaneously correlated.[3]

[3] The patterns in excess returns shown in Figure 3 are apparent even in returns adjusted for the Fama-French (1992) three-factor model, or the Carhart (1997) four-factor model. Since these models may not fully account for momentum, it is possible that Figure 3 is simply a reflection of an inadequate model of expected stock returns.

The almost immediate disappearance of excess returns after the trading period suggests that it should not be profitable for individual investors to mimic institutional trading. The return patterns are also the key difference from the evidence of return continuation after institutional trading in Nofsinger and Sias (1999). However, this difference could result from their data constraints: they use annual data on changes in institutional ownership. The data coarseness makes it impossible to know exactly when the changes of holdings occur. Moreover, they use an atypical portfolio formation time at the beginning of October of each year. Institutions and individuals usually rebalance their portfolios late in the year [see Sias and Starks (1997)], and their results may be affected by such seasonal rebalancing. Our results also are subject to a similar criticism because of the use of quarterly data. Though this is an improvement over annual data, there is still room for making the empirical tests more accurate with the availability and use of higher frequency data.[4]

C. Trading behavior of different categories of institutions

To investigate the potentially different trading behavior of each subgroup of institutional investors, we conduct causality tests and examine the trading and return patterns before and after the portfolio-formation quarter for each of the five types of institutional investors. We follow the same methodology within each institution subgroup, and form 10 portfolios based on institutional trading percentages. Probably as a result of noise in the data, the causality tests (not shown for brevity) are inconclusive. An analysis of the trading and return behavior surrounding the portfolio-formation period is informative, however.

The results are shown in figures 4-8, with each showing trading patterns in the top graph and excess returns in the bottom graph. An analysis of the subgroups leads to the conclusion that mutual funds and investment advisors reflect (and probably cause) the relationship between the aggregate patterns in trading and equity returns. Specifically, each of the subgroups show very similar trading patterns surrounding the portfolio-formation period, with the relative intensity of trading being the highest for the

[4] A reassuring recent development however is that in a recent study based on intra day data for a sample of 100 NASDAQ stocks, Griffin, Harris, and Topaloglu (2001) find strong support for our findings. Both at the intra day and daily intervals, institutions chase returns rather than vice versa.

investment advisors. But it is patterns in excess returns that are clearly apparent for the mutual funds and investment advisors, and these patterns are similar to the trading patterns. This is not surprising given the dominant role of mutual funds and investment advisors in the equity market (see table 2).

Figure 4 presents the trading and excess return patterns for the stocks traded by banks. Stocks that banks buy (sell) most intensively display significantly positive (negative) excess returns in the 12 months before intensive trading, indicating that banks may follow a positive feedback trading strategy. However, the magnitude of the prior-trading excess returns is smaller than in the aggregate case as shown in figure 2. Interestingly, there are no significant excess returns *during* and *after* the portfolio-formation period.

A similar return pattern for insurance company trades is shown in figure 5. Although stocks they trade intensively still show significant excess returns in the 12 months before trading, insurance companies seem to follow a momentum strategy to a lesser extent than banks. We also find that insurance companies, like banks, do not make excess returns in their trading. There is no evidence of market impact by their trades either. Finally, we find that stocks traded by banks and insurance companies tend to be less volatile than those traded by overall institutional investors, indicating that they follow the "prudent man" rule.

In figure 6, we find that stocks with strong purchases (sales) by mutual funds do not show significant positive (negative) excess returns until just one to two months before the portfolio-formation period, and the excess returns disappear immediately after their trading. This interesting result indicates that mutual funds tend to look at stock momentum over a very short time horizon. They respond quickly to past stock returns, and the contemporaneous excess returns on the stocks they trade are the strongest compared with all other types of institutions.

Figure 7 tells a similar story about investment advisors, except that investment advisors look back at a longer horizon (12 months) than mutual funds do (1 or 2 months), and the magnitude of excess returns over the portfolio formation period is smaller. If we

look at the combined behavior of mutual funds and investment advisors, we find stocks they trade display very similar return patterns to the overall patterns shown in figure 2.

Figure 8 presents the results for all other institutions. Since this is the residual group of institutional investors, the evidence may contain some "noisy" information. We find little similarity between the return patterns in figures 3 and 8, which implies that "other institutions" do not contribute significantly to the overall evidence.

4. Interpretation of the evidence

In this paper, we investigate the dynamic relation between the aggregate trading activity of institutions and equity prices. Institutional trading is strongly related to contemporaneous returns. The causality tests however reveal a clear statistical link from past returns to future significant trading (especially buying) activity of institutions on a quarterly basis, but not vice versa. Also, this causality appears to be related to economy-wide factors, and has little to do with the firm-specific component of returns. The excess returns to the portfolios before and after significant trading by institutions however suggest that there is a run-up (down) in returns before and during the major buying (selling) activity by institutions, but any "excess" returns disappear soon after the peak in their trading activity. Finally, most of these results appear to be related to the behavior of mutual funds and investment advisers.

The evidence presented in this paper is consistent with a surprising, yet simple, story about the role of institutional trading in financial markets. Institutions apparently herd and indulge in positive feedback trading based on signals about the aggregate market, but their behavior is not destabilizing in that their trades do not affect stock prices. When one or a few institutions buy some stocks in response to some information (and our evidence suggests upward movements in the market trigger purchases), other institutions may observe these trades and interpret this as good news about these stocks, and therefore follow suit. This is especially likely when the institutions that initiate the buy trend are influential market "leaders", for example, Fidelity or Merrill Lynch. This explanation is in the vein of the informational cascade explanation of fads in Bikhchandani, Hirshleifer and Welch (1992): "conformist behaviors can be fragile and

idiosyncratic because cascades start readily on the basis of even a small amount of information."

One limitation of this paper is that we cannot distinguish institutional herding from big moves by just one or two large institutional investors. Also, given the quarterly nature of the data, our trading measure is "coarse" and, consequently, we cannot determine the existence and extent of intra-quarter positive feedback trading and/or an intra-quarter price impact. Richer data, both higher frequency data and more detailed at the cross-sectional level, can shed light on the many intriguing issues raised by this research. A reassuring development however is that in a recent study based on intra day data for a sample of 100 NASDAQ stocks, Griffin, Harris, and Topaloglu (2001) find strong support for our findings. Both at the intra day and daily intervals, institutions chase returns rather than vice versa.

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Table 1

Summary statistics of spectrum data

The sample consists of all 13F institutions from the 3rd quarter of 1981 through the fourth quarter of 1996. All summary statistics at the end of the fourth quarter of each year are shown below. Percentage of market share is the ratio of total value of institutional holdings to the total market capitalization. Average # of stocks held and average # of stocks traded are the mean values of number of stocks held and number of stocks traded across all institutions respectively. Average trading percentage is the ratio of average # of stock traded to the average # of stocks held.

YearQtr	# of institutions	# of stocks	Percentage of market share	Avg. # of stocks held	Avg. # of stock traded	Avg. trading percentage
814	600	4362	33.97%	171	133	77.91%
824	624	4573	37.09%	178	144	80.89%
834	682	5240	37.69%	192	152	79.21%
844	748	5343	39.67%	189	146	77.06%
854	822	5639	42.04%	203	162	79.84%
864	892	6024	43.89%	208	161	77.42%
874	939	6613	43.48%	215	177	82.00%
884	960	6581	44.10%	223	166	74.29%
894	989	6520	44.40%	228	172	75.43%
904	1030	6549	45.70%	217	159	73.37%
914	1100	6850	47.13%	227	171	75.63%
924	1167	7077	48.39%	239	182	76.43%
934	1205	8337	49.95%	260	191	73.64%
944	1239	9046	50.35%	263	200	75.90%
954	1375	9540	51.36%	262	202	76.87%
964	1441	10571	53.68%	273	203	74.34%

Table 2
Summary statistics of spectrum data

The sample consists of all 13F institutions from the 3rd quarter of 1981 through the fourth quarter of 1996. All summary statistics at the end of the fourth quarter of *every fifth year* are shown below. The whole sample has five categories: banks, insurance companies, mutual funds, investment advisors, and others. For each category, the number of institutions, market value of their holdings, and respective percentage among all institutions are listed.

PANEL A: Number of institutions and their percentage by type

	Banks		Insurance companies		Mutual funds		Investment advisors		Others	
YYQ	# of Insts	Percentage	# of Insts	Percentage	# of Insts	Percentage	# of Insts	Percentage	# of Insts	Percentage
814	232	38.67%	67	11.17%	54	9.00%	162	27.00%	85	14.17%
864	227	25.45%	70	7.85%	72	8.07%	415	46.52%	108	12.11%
914	230	20.91%	76	6.91%	61	5.55%	638	58.00%	95	8.64%
964	197	13.67%	76	5.27%	94	6.52%	988	68.56%	86	5.97%

Panel B: Market value of institution holdings and their percentage by type

	Banks		Insurance companies		Mutual funds		Investment advisors		Others	
YYQ	Mkt Value (in billions)	Percentage	Mkt Value (in billions)	Percentage	Mkt Value (in billions)	Percentage	Mkt Value (in billions)	Percentage	Mkt Value (in billions)	Percentage
814	178.98	40.91%	53.93	12.33%	36.96	8.45%	113.31	25.90%	54.31	12.41%
864	377.78	34.88%	91.02	8.41%	67.97	6.28%	407.99	37.67%	138.18	12.76%
914	528.22	28.14%	140.27	7.47%	180.39	9.61%	800.00	42.63%	227.91	12.14%
964	918.41	20.77%	414.84	9.38%	1092.65	24.71%	1658.05	37.50%	337.95	7.64%

Table 3
Causality test of the relation between institutional trading and raw returns

At the end of each quarter (3rd quarter of 1981 - 4th quarter of 1996), stocks are sorted into ten portfolios based on the percentage of net institutional trading. Portfolio 1 consists of stocks with the most negative institutional purchases (or the highest institutional sales) in that quarter, while portfolio 10 consists of stocks with the highest institutional demand in that quarter. Panel A presents results of a regression of net institutional trading (or net institutional demand) percentage on its own lagged values and lagged portfolio raw returns: $Dem_t = \alpha + \beta_1 Dem_{t-1} + \beta_2 Dem_{t-2} + \beta_3 Dem_{t-3} + \beta_4 Dem_{t-4} + \gamma_1 Ret_{t-1} + \gamma_2 Ret_{t-2} + \gamma_3 Ret_{t-3} + \gamma_4 Ret_{t-4} + u_t$, $t = 1, \ldots, T$. Panel B presents results of a regression of portfolio raw return on its own lagged values and lagged net institutional trading (or net institutional demand): $Ret_t = \alpha' + \beta'_1 Ret_{t-1} + \beta'_2 Ret_{t-2} + \beta'_3 Ret_{t-3} + \beta'_4 Ret_{t-4} + \gamma'_1 Dem_{t-1} + \gamma'_2 Dem_{t-2} + \gamma'_3 Dem_{t-3} + \gamma'_4 Dem_{t-4} + u'_t$, $t = 1, \ldots, T$, where Dem_t and Ret_t are the time-series of net institutional trading percentage and portfolio returns respectively during the portfolio formation period; Dem_{t-1} and Ret_{t-1} are their values with a lag of one quarter, Dem_{t-2} and Ret_{t-2} are their values with a lag of two quarters, and so on. The t-statistics are in parentheses, and the R-squares, F-statistics, and p-values are presented in the last three columns.

Panel A: Regression of net institutional demand on lagged institutional demand and lagged raw returns

Portfolio	Alpha	Dem-1 (β_1)	Dem-2 (β_2)	Dem-3 (β_3)	Dem-4 (β_4)	Ret-1 (γ_1)	Ret-2 (γ_2)	Ret-3 (γ_3)	Ret-4 (γ_4)	R-square	F-stat	p-value
Port. 1	-0.0886	-0.4719	-0.3218	0.3130	0.0018	-0.0484	0.1717	-0.1074	0.0219	0.2735	0.7693	0.5505
	(-13.84)	(-2.89)	(-3.28)	(1.27)	(0.01)	(-0.45)	(1.38)	(-1.00)	(0.20)			
Port. 2	-0.0160	-0.0235	-0.0099	-0.0530	0.0432	0.0248	0.0040	0.0156	-0.0205	0.0920	0.5161	0.7242
	(-11.94)	(-0.24)	(-0.12)	(-0.59)	(1.03)	(0.96)	(0.18)	(0.67)	(-0.90)			
Port. 3	-0.0050	-0.0863	-0.0022	-0.0048	-0.0512	0.0243	0.0168	0.0041	0.0023	0.1557	0.7024	0.5942
	(-5.07)	(-1.36)	(-0.04)	(-0.08)	(-0.88)	(1.48)	(0.92)	(0.22)	(0.14)			
Port. 4	-0.0005	-0.1108	-0.0534	-0.0152	-0.0202	0.0086	0.0142	0.0091	-0.0018	0.3498	1.0617	0.3857
	(-1.14)	(-3.05)	(-1.26)	(-1.19)	(-1.70)	(1.03)	(1.43)	(1.02)	(-0.22)			
Port. 5	-0.0007	0.0115	0.0246	0.0532	0.1321	0.0192	0.0287	-0.0003	-0.0071	0.3984	3.5751	0.0125
	(-1.96)	(0.28)	(0.54)	(1.49)	(2.56)	(2.22)	(3.01)	(-0.03)	(-0.83)			
Port. 6	0.0004	0.0336	0.2072	0.1178	-0.0054	0.0272	0.0163	-0.0164	-0.0020	0.4504	1.6548	0.1760
	(0.64)	(0.58)	(3.36)	(1.67)	(-0.08)	(1.98)	(0.97)	(-1.09)	(-0.14)			
Port. 7	0.0035	0.1094	0.1258	0.0322	0.0621	0.0529	0.0257	0.0011	0.0001	0.2253	1.3777	0.2557
	(2.08)	(1.02)	(1.44)	(0.37)	(0.75)	(2.20)	(1.04)	(0.05)	(0.01)			
Port. 8	0.0103	-0.0252	0.0793	0.2546	-0.0441	0.1021	0.0561	-0.0138	0.0062	0.3151	3.1676	0.0217
	(4.14)	(-0.22)	(1.50)	(2.21)	(-0.51)	(3.30)	(1.75)	(-0.44)	(0.21)			
Port. 9	0.0251	0.1167	-0.0273	-0.0863	0.1169	0.1154	0.0889	0.0356	0.0408	0.3132	2.8437	0.0340
	(7.52)	(1.02)	(-0.25)	(-0.82)	(0.93)	(2.94)	(2.15)	(0.83)	(1.11)			
Port. 10	0.0722	0.1535	0.5382	0.0075	0.5734	0.4988	0.3079	-0.0298	0.0395	0.4147	4.0880	0.0062
	(5.75)	(0.85)	(1.60)	(0.03)	(1.68)	(3.23)	(1.80)	(-0.18)	(0.24)			

Table 3 (cont.)
Causality test of the relation between institutional trading and raw returns

At the end of each quarter (3rd quarter of 1981 - 4th quarter of 1996), stocks are sorted into ten portfolios based on the percentage of net institutional trading. Portfolio 1 consists of stocks with the most negative institutional purchases (or the highest institutional sales) in that quarter, while portfolio 10 consists of stocks with the highest institutional demand in that quarter. Panel A presents results of a regression of net institutional trading (or net institutional demand) percentage on its own lagged values and lagged portfolio raw returns: $Dem_t = \alpha + \beta_1 Dem_{t-1} + \beta_2 Dem_{t-2} + \beta_3 Dem_{t-3} + \beta_4 Dem_{t-4} + \gamma_1 Ret_{t-1} + \gamma_2 Ret_{t-2} + \gamma_3 Ret_{t-3} + \gamma_4 Ret_{t-4} + u_t$, $t = 1, \ldots, T$. Panel B presents results of a regression of portfolio raw return on its own lagged values and lagged net institutional trading (or net institutional demand): $Ret_t = \alpha' + \beta'_1 Ret_{t-1} + \beta'_2 Ret_{t-2} + \beta'_3 Ret_{t-3} + \beta'_4 Ret_{t-4} + \gamma'_1 Dem_{t-1} + \gamma'_2 Dem_{t-2} + \gamma'_3 Dem_{t-3} + \gamma'_4 Dem_{t-4} + u'_t$, $t = 1, \ldots, T$, where Dem_t and Ret_t are the time-series of net institutional trading percentage and portfolio returns respectively during the portfolio formation period; Dem_{t-1} and Ret_{t-1} are their values with a lag of one quarter, Dem_{t-2} and Ret_{t-2} are their values with a lag of two quarters, and so on. The t-statistics are in parentheses, and the R-squares, F-statistics, and p-values are presented in the last three columns.

Panel B: **Regression of raw returns on lagged raw returns and lagged institutional demand**

Portfolio	Alpha	Ret-1 (β'_1)	Ret-2 (β'_2)	Ret-3 (β'_3)	Ret-4 (β'_4)	Dem-1 (γ'_1)	Dem-2 (γ'_2)	Dem-3 (γ'_3)	Dem-4 (γ'_4)	R-square	F-stat	p-value
Port. 1	0.0167	-0.0469	-0.2957	-0.1477	-0.0929	0.0703	0.0937	-0.0766	-0.5320	0.1932	2.0939	0.0962
	(1.97)	(-0.33)	(-1.79)	(-1.03)	(-0.65)	(0.32)	(0.72)	(-0.23)	(-2.75)			
Port. 2	-0.0019	0.0649	-0.0786	-0.0743	-0.1415	-0.2927	0.0102	0.0149	0.6456	0.1575	1.6801	0.1700
	(-0.23)	(0.40)	(-0.55)	(-0.51)	(-1.00)	(-0.48)	(0.02)	(0.03)	(2.48)			
Port. 3	0.0167	0.1722	0.0228	0.0571	-0.1052	-1.1634	-0.4208	0.2252	-0.0927	0.1827	1.9785	0.1128
	(2.00)	(1.26)	(0.15)	(0.37)	(-0.77)	(-2.19)	(-0.91)	(0.44)	(-0.19)			
Port. 4	0.0255	0.0838	-0.2030	-0.0751	-0.1161	-1.4627	-0.0689	-0.3927	-0.1639	0.2679	3.3840	0.0162
	(4.00)	(0.68)	(-1.38)	(-0.56)	(-0.95)	(-2.70)	(-0.11)	(-2.06)	(-0.92)			
Port. 5	0.0171	0.0164	-0.0763	0.1005	-0.0840	-0.4478	-0.7959	-0.1795	0.4451	0.1105	1.1050	0.3651
	(2.59)	(0.11)	(-0.46)	(0.62)	(-0.56)	(-0.63)	(-1.00)	(-0.29)	(0.49)			
Port. 6	0.0285	0.0309	0.0526	-0.1555	-0.0846	-1.4740	0.3157	0.1740	-0.2880	0.1543	1.4994	0.2173
	(3.72)	(0.20)	(0.28)	(-0.94)	(-0.55)	(-2.30)	(0.47)	(0.23)	(-0.37)			
Port. 7	0.0208	-0.1211	-0.1077	-0.2315	-0.1832	0.9442	-0.5323	0.0250	-0.1404	0.1169	0.6115	0.6564
	(1.86)	(-0.76)	(-0.66)	(-1.62)	(-1.21)	(1.32)	(-0.92)	(0.04)	(-0.26)			
Port. 8	0.0334	-0.0426	-0.1720	-0.3841	-0.0635	-0.0664	0.2669	0.3207	-0.8767	0.1769	1.4457	0.2335
	(2.74)	(-0.28)	(-1.09)	(-2.48)	(-0.44)	(-0.12)	(1.02)	(0.57)	(-2.08)			
Port. 9	0.0354	-0.0182	-0.2126	-0.1985	-0.0472	0.2979	-0.2441	-0.1046	-0.2886	0.0918	0.3417	0.8484
	(2.69)	(-0.12)	(-1.30)	(-1.17)	(-0.32)	(0.66)	(-0.580	(-0.25)	(-0.58)			
Port. 10	0.0389	0.1453	-0.2697	-0.2382	-0.1217	-0.1515	0.3031	0.1330	-0.3702	0.1199	0.4766	0.7527
	(3.29)	(1.00)	(-1.67)	(-1.51)	(-0.79)	(-0.89)	(0.95)	(0.54)	(-1.15)			

Table 4
Causality test of the relation between institutional trading and market returns

At the end of each quarter (3rd quarter of 1981 - 4th quarter of 1996), stocks are sorted into ten portfolios based on the percentage of net institutional trading. Portfolio 1 consists of stocks with the most negative institutional purchases (or the highest institutional sales) in that quarter, while portfolio 10 consists of stocks with the highest institutional demand in that quarter. Panel A presents the R-squares, F-statistics, and p-values of a regression of net institutional trading (or net institutional demand) percentage on its own lagged values and lagged market returns: $Dem_t = \alpha + \beta_1 Dem_{t-1} + \beta_2 Dem_{t-2} + \beta_3 Dem_{t-3} + \beta_4 Dem_{t-4} + \gamma_1 MktRet_{t-1} + \gamma_2 MktRet_{t-2} + \gamma_3 MktRet_{t-3} + \gamma_4 MktRet_{t-4} + u_t$, $t = 1, \ldots, T$. Panel B presents the R-squares, F-statistics, and p-values of a regression of market return on its own lagged values and lagged net institutional trading (or net institutional demand): $MktRet_t = \alpha' + \beta'_1 MktRet_{t-1} + \beta'_2 MktRet_{t-2} + \beta'_3 MktRet_{t-3} + \beta'_4 MktRet_{t-4} + \gamma'_1 Dem_{t-1} + \gamma'_2 Dem_{t-2} + \gamma'_3 Dem_{t-3} + \gamma'_4 Dem_{t-4} + u'_t$, $t = 1, \ldots, T$, where Dem_t and $MktRet_t$ are the time-series of net institutional trading percentage and market returns respectively during the portfolio formation period; Dem_{t-1} and $MktRet_{t-1}$ are their values with a lag of one quarter, Dem_{t-2} and $MktRet_{t-2}$ are their values with a lag of two quarters, and so on.

Panel A:

Portfolio	R-square	F-stat	p-value
Port. 1	0.2932	1.1253	0.3557
Port. 2	0.1718	1.7227	0.1604
Port. 3	0.2176	1.7073	0.1638
Port. 4	0.4040	2.2497	0.0775
Port. 5	0.3504	2.4244	0.0608
Port. 6	0.4230	1.0054	0.4140
Port. 7	0.2303	1.4646	0.2277
Port. 8	0.2907	2.6446	0.0448
Port. 9	0.3567	3.8484	0.0086
Port. 10	0.4254	4.3864	0.0042

Panel B:

Portfolio	R-square	F-stat	p-value
Port. 1	0.1411	1.2839	0.2895
Port. 2	0.1178	0.9335	0.4526
Port. 3	0.2070	2.3872	0.0640
Port. 4	0.2870	4.0027	0.0070
Port. 5	0.1738	1.8093	0.1425
Port. 6	0.1507	1.4344	0.2371
Port. 7	0.1229	1.0081	0.4126
Port. 8	0.1387	1.2473	0.3037
Port. 9	0.0995	0.6695	0.6163
Port. 10	0.0974	0.6402	0.6364

Table 5
Causality test of the relation between institutional trading and excess returns

At the end of each quarter (3rd quarter of 1981 - 4th quarter of 1996), stocks are sorted into ten portfolios based on the percentage of net institutional trading. Portfolio 1 consists of stocks with the most negative institutional purchases (or the highest institutional sales) in that quarter, while portfolio 10 consists of stocks with the highest institutional demand in that quarter. Panel A presents the R-squares, F-statistics, and p-values of a regression of net institutional trading (or net institutional demand) percentage on its own lagged values and lagged portfolio excess returns: $Dem_t = \alpha + \beta_1 Dem_{t-1} + \beta_2 Dem_{t-2} + \beta_3 Dem_{t-3} + \beta_4 Dem_{t-4} + \gamma_1 ExcRet_{t-1} + \gamma_2 ExcRet_{t-2} + \gamma_3 ExcRet_{t-3} + \gamma_4 ExcRet_{t-4} + u_t$, $t = 1, \ldots, T$. Panel B presents the R-squares, F-statistics, and p-values of a regression of portfolio excess return on its own lagged values and lagged net institutional trading (or net institutional demand): $ExcRet_t = \alpha' + \beta'_1 ExcRet_{t-1} + \beta'_2 ExcRet_{t-2} + \beta'_3 ExcRet_{t-3} + \beta'_4 ExcRet_{t-4} + \gamma'_1 Dem_{t-1} + \gamma'_2 Dem_{t-2} + \gamma'_3 Dem_{t-3} + \gamma'_4 Dem_{t-4} + u'_t$, $t = 1, \ldots, T$, where Dem_t and $ExcRet_t$ are the time-series of net institutional trading percentage and portfolio excess returns respectively during the portfolio formation period; Dem_{t-1} and $ExcRet_{t-1}$ are their values with a lag of one quarter, Dem_{t-2} and $ExcRet_{t-2}$ are their values with a lag of two quarters, and so on.

Panel A:

Portfolio	R-square	F-stat	p-value
Port. 1	0.3084	1.4147	0.2434
Port. 2	0.2561	3.2773	0.0187
Port. 3	0.3337	4.0965	0.0062
Port. 4	0.3581	1.2318	0.3099
Port. 5	0.2660	0.7657	0.5528
Port. 6	0.4264	1.0839	0.3750
Port. 7	0.2338	1.5270	0.2093
Port. 8	0.1973	0.9415	0.4482
Port. 9	0.4077	5.2118	0.0014
Port. 10	0.2723	0.9396	0.4492

Panel B:

Portfolio	R-square	F-stat	p-value
Port. 1	0.3480	0.1670	0.9541
Port. 2	0.3102	1.2652	0.2967
Port. 3	0.2712	2.0606	0.1007
Port. 4	0.1186	1.2943	0.2856
Port. 5	0.2390	2.0239	0.1060
Port. 6	0.1208	0.2538	0.9059
Port. 7	0.2688	0.6658	0.6188
Port. 8	0.1596	1.2835	0.2896
Port. 9	0.2323	2.5566	0.0506
Port. 10	0.1507	1.0691	0.3821

Figure 1

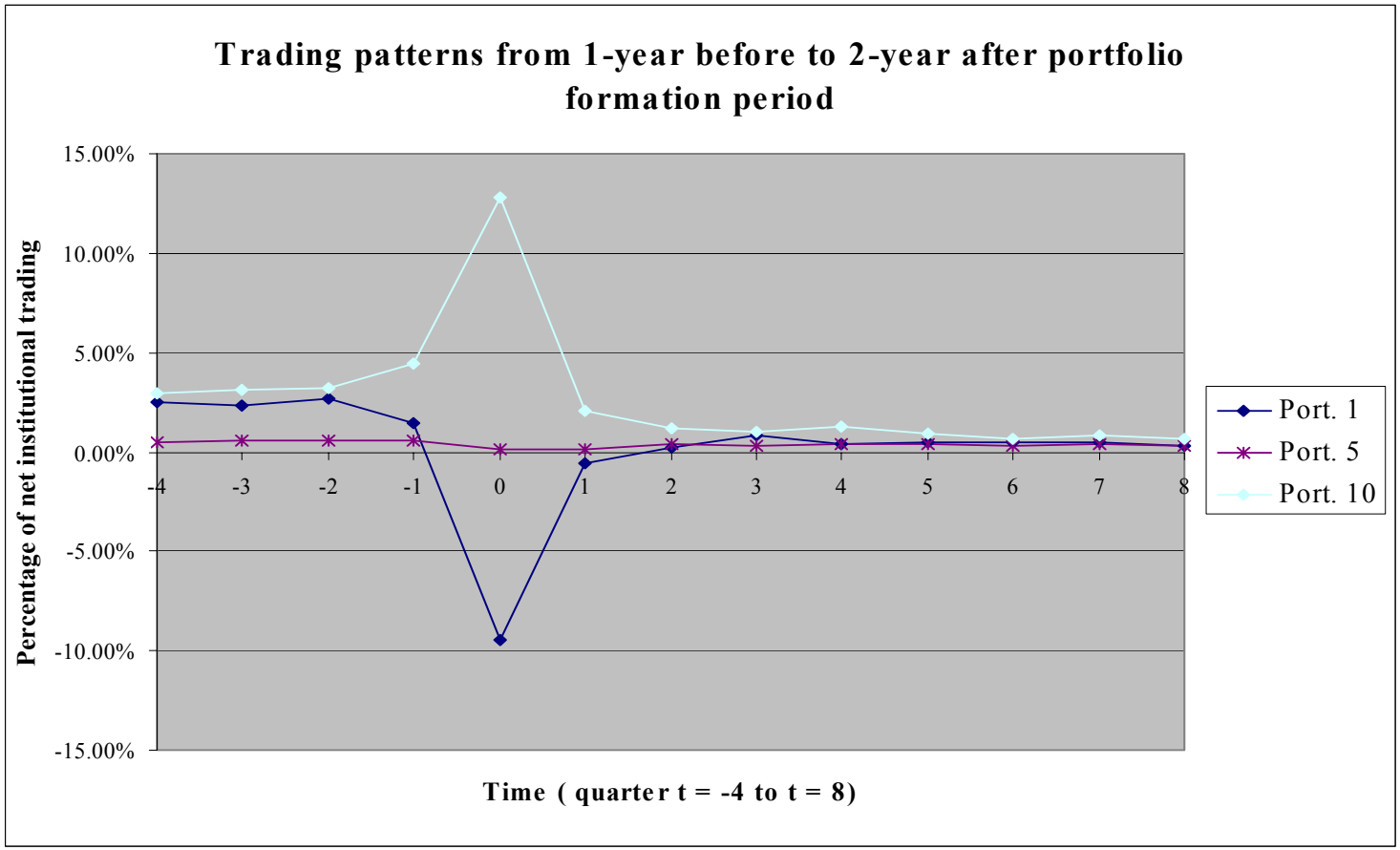

Trading patterns from 1-year before to 2-year after portfolio formation period
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
Percentage of net institutional trading
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
Time (quarter t = -4 to t = 8)
Port. 1
Port. 5
Port. 10

Figure 2

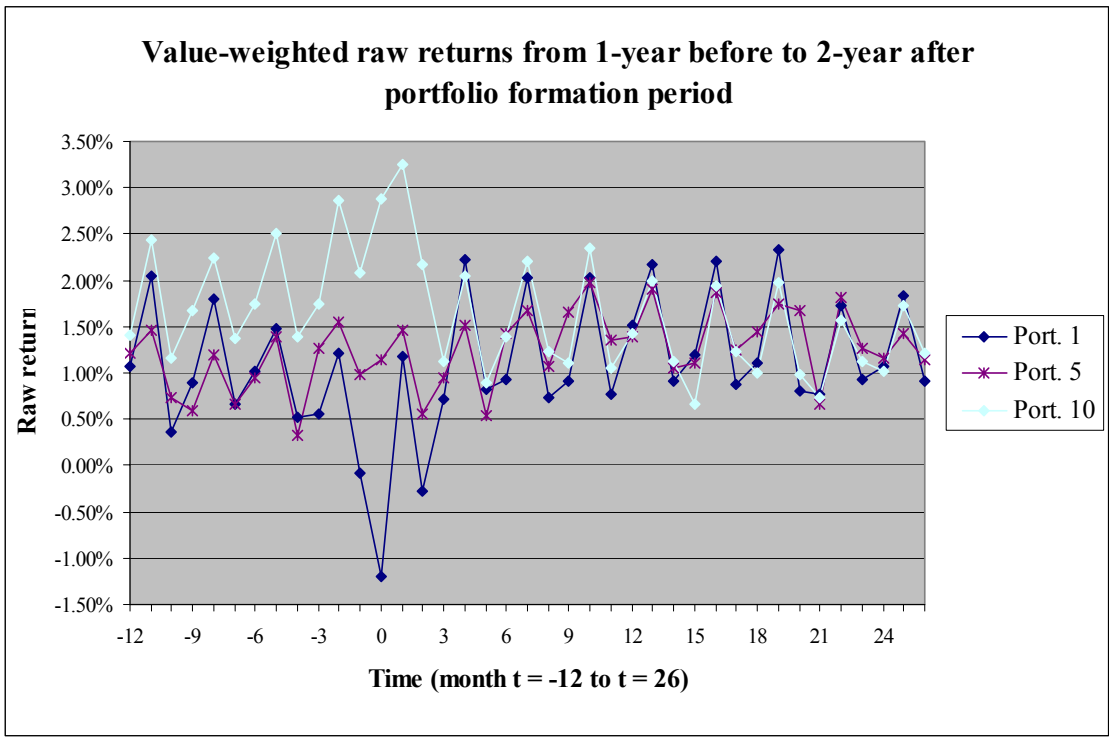


Figure 3

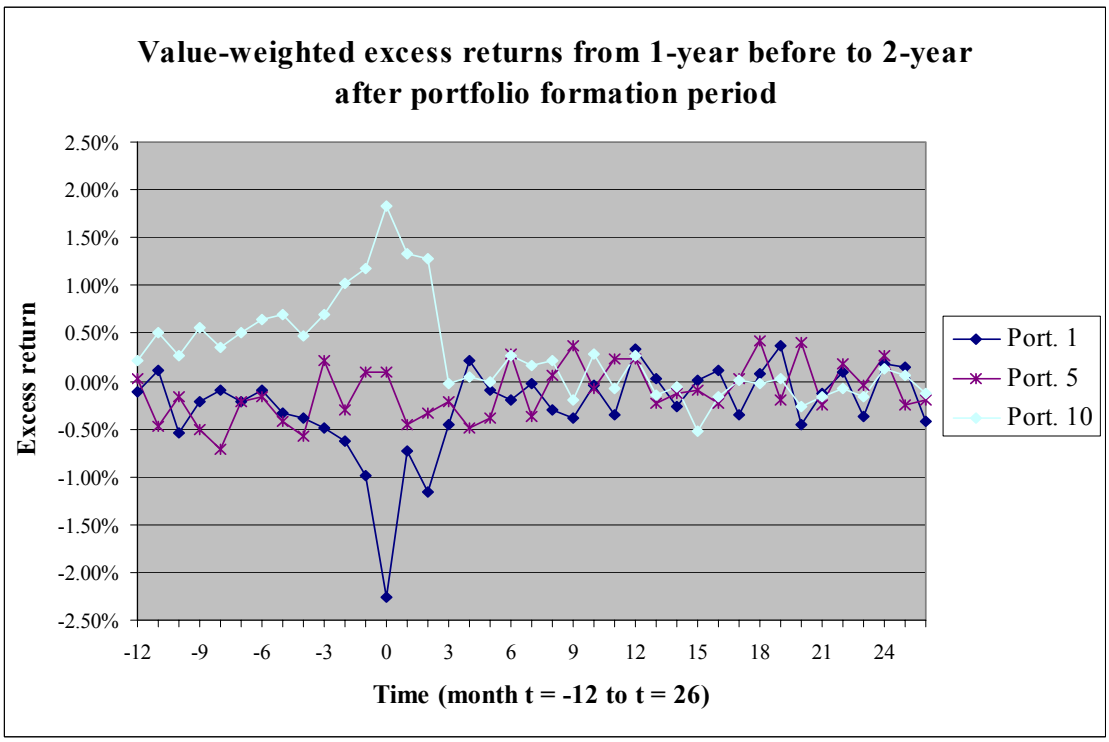
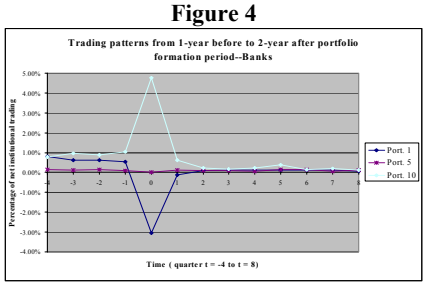


Figure 4



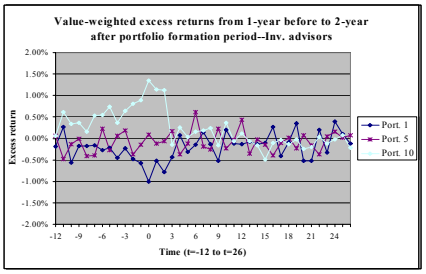


Figure 7

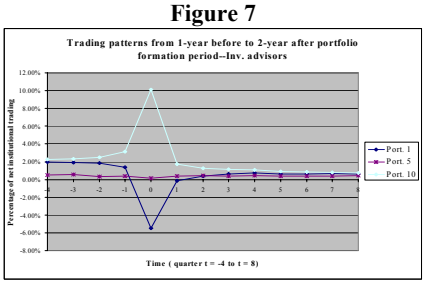
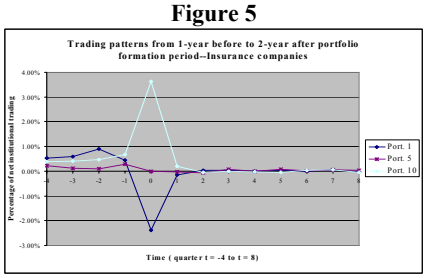


Figure 5



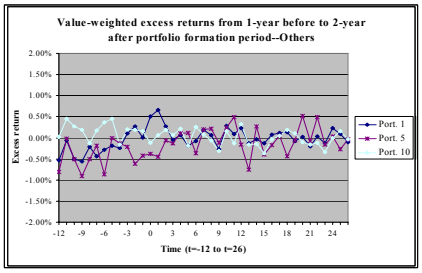
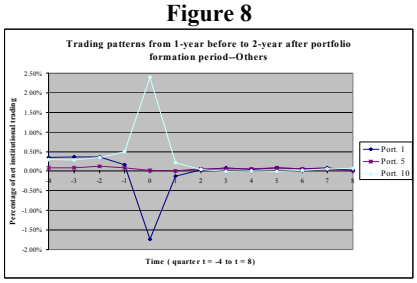


Figure 8



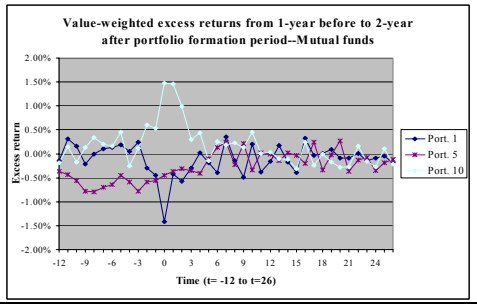


Figure 6