Informed Trading around Biotech M&As

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ABSTRACT

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We compare the PIN estimates using the Easley, Hvidkjaer, and O'Hara (2002) and Yan and Zhang (2012) estimation methods over the takeover announcement life cycle based on intraday data for 54 U.S. biotech acquirers and 95 U.S. biotech targets between 2005 and 2011. We find that: (1) the Yan and Zhang method is subject to (generally not significantly) less downward bias; (2) the estimates for the Easley et al. method increase significantly as the number of observations used in their estimation increases; and (3) firm characteristics such as book-to-market ratio, financial leverage, firm size, insider holdings, institutional holdings, and research and development expenses are determinants of the PIN estimates. Consistent with the previous literature, the cumulative abnormal returns around announcement dates are more significant for targets than acquirers and are strongly associated with firm size and the book-to-market ratio.

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1. INTRODUCTION

The probability of information-based trading or PIN estimation introduced by Easley et al. (2002, 2010) or EHO PIN has been frequently employed in market microstructure, asset pricing, and corporate finance research. There is evidence for and against the application of the estimates. Criticisms about the accuracy of the measure center on two topics: the adverse effect of trade misclassifications on PIN estimates and PIN is a proxy of liquidity and not informed trading. Lin and Ke (2011) and Yan and Zhang (2012) present evidence documenting a downward bias for the measure that is due to the floating point exception phenomenon, and provide solutions to remedy the bias. Yan and Zhang (2012) introduce a new PIN estimation method by combining their new algorithm with the reformulated function of Lin and Ke (2011).

In the first section of the thesis, we compare the EHO PIN and YZ PIN estimates for U.S. biotech M&As from 2005 to 2011. Firstly, we find that both types of estimates change significantly over the takeover announcement life cycle for both acquirers and targets, and become significant over the three days centered on the announcement dates or ADs for both acquirers and targets and effective dates or EDs for acquirers only. Secondly, both types of estimates for acquirers are consistently lower than those for targets throughout an acquisition life cycle. Thirdly, we find that YZ PIN estimates are (generally not significantly) higher than EHO PIN estimates over a three-day AD for both acquirers and targets, and three-day ED for acquirers. Our empirical findings provide weak support for the conjecture that the YZ PIN estimation method produces estimates with lower downward biases.

Additionally, we address the sensitivity of the EHO PIN estimates to the number of observations in our sample and provide alternative sampling methods that help to estimate within-day PIN for short observation windows in M&As studies. We find that EHO PIN estimates increase significantly as the number of observations used in their estimation increases for acquirers over the three days centered on both the ADs and EDs, and for targets over the three days centered on the ADs.

In the second section, we test the information leakage around ADs for both acquirers and targets by examining the cumulative abnormal returns (CARs) based on the Carhart four-factor model (1997). We find that the CARs over the pre-ADs and ADs periods are significant (insignificant) for targets (acquirers) and that the CARs over the pre-ADs increase significantly (remain unchanged) from the pre-ADs period for targets (acquirers). For both acquirers and targets, we estimate the cross-sectional regressions of the means of the CARs over the three-day ADs on potential independent variables and find that firm size positively (negatively) affects the CARs for acquirers (targets) and that book-to-market ratios only positively affect the performance of the CARs for targets.

In the final section, we estimate the cross-sectional regressions of the means of both types of PIN estimates for the three-day ADs on potential independent variables. We find that acquirers with value stocks, higher insider holdings, and/or higher financial leverages are associated more with PINs. We also confirm that targets with lower firm sizes, lower R&D expenses, and/or higher institutional holdings are associated more with PINs.

Our research paper contributes to the literature on the estimation of PIN by examining the bias of the conventional estimation method introduced by Easley et al. (2002, 2010) by providing further evidence that the new estimation proposed by Yan and Zhang (2012) is (generally not significantly) less downward biased. Our research contributes to the literature on the existence of the leakage of information by examining CARs before and around takeover announcements and identifies links between the CARs and firm characteristics. Additionally, our examination of PIN determinants supports previous studies that identify specific firm characteristics as being associated with PIN.

The thesis is organized as follows. Section 2 reviews the literature on biotech M&As and the measures of PIN introduced by Easley et al. (2002) and Yan and Zhang (2012). Section 3 describes our sample and data. Section 4 and 5 present our EHO PINs and YZ PIN for acquirers and targets samples. Section 6 compares the PIN estimates between acquirers and targets. Section 7 compares the EHO PINs and YZ PINs for acquirers versus targets. Section 8 tests the sensitivity of the EHO PIN estimates to the within-day number of observations. Section 9 presents the tests for information leakage and its relation with firm characteristics. Section 10 presents the tests for the determinants of PINs. Section XI concludes the thesis.

2. REVIEW OF THE LITERATURE ON BIOTECH M&As AND MEASURES OF THE PROBABILITY OF INFORMATION-BASED TRADING

2.1 Mergers and Acquisitions Involving Biotech Firms

Some studies find that stock market valuations are positive only for high-tech acquirers that acquire high-tech targets (Anand and Singh, 1997; Hitt et al., 2001; Danzon, Epstein and Nicholson, 2004; Higgins and Rodriguez, 2006; Kallunki, Pyykko, and Laamanen, 2009). Higgins and Rodriguez (2006) note that biotechnology firms have a strong dependence on investment and the productivity of their research and development (R&D). Since R&D is strongly associated with information asymmetries due to the uncertainty of R&D successes and confidentiality, the lack of publicly available information about a firm's R&D should lead to a high probability of informed trading.

Lahteenmaki and Lawrence (2006) find that research partnerships between biotech companies increased from 27 to 58 percent from 1995 to 2005. Surveys in 2005 from Nature Biotechnology for 404 public companies and Ernst & Young for 671 companies report that the total net losses of public biotechnology firms of all sizes declined, meanwhile revenues grew at a rapid pace of about one-fifth from 2004 to 2005 in which large caps contributed two-thirds of total revenues. Mid-caps, small-caps, and micro caps also experienced increases in revenues during the period.

Aggarwal, Gupta and Bagchi-Sen (2006) study the patenting trend in the U.S. public biotech sector. They find that the trend increased continuously from 1995 to 2003, with a drop between 2004 and 2005. Small biotech companies face financial constraints due to high R&D costs, rapidly changing environments, and high competition. Medium-sized biotech companies exhibit a consistent but low rise in patenting over the ten-year period from 1993. Medium-sized companies invest more in producing generics, contract services, and software businesses. In their 2003 survey, 19 large-sized biotech companies have revenues over $500 million. The top 5 companies (Amgen, Monsanto, Genentech, Biogen Idec, and Chiron) own 699, 3763, 983, 183, and 834 total patents, respectively, over the period from 1976 to 2005. Moreover, there are more than 70 mid-sized biotech companies, whose revenues are between $50 and $500 million, which have lower but more stable patenting rate than large-sized biotech companies. These mid-sized companies focus strongly on R&D, generics, contract services, and software businesses. The top 5 mid-sized biotech companies (Millennium Pharmaceuticals, Genencor, Affymetrix, Sepracor, Symex Techonologies) own 424, 320, 275, 262, and 220 patents, respectively, from 1976 to 2005.With the consistent rise in patenting for biotech companies of all sizes, mergers mostly performed by small-sized firms and acquisitions mostly performed by large-sized firms due to the need for financial assistance of small firms and of building patent portfolios of larger firms.

2.2 Easley et al. PIN Method

In the microstructure literature, the estimation of the probability of informed trading introduced by Easley, Kiefer, and O'Hara (2002, 2010) or EHO PIN is widely used along with other measures such as the bid-ask spread, volume, trading liquidity, and duration to analyze how information is incorporated into stock values (Nyholm, 2002). Some authors call for caution when using this method in empirical studies due to evidence showing that EHO PIN estimates contradict some fundamental theories. Boehmer, Grammig, and Theissen (2007) state that EHO PIN estimation used observable information on buyer- and seller-initiated trades to infer the unobservable probability of informed trading. Based on a comparison of the EHO PIN estimates obtained by applying the Lee-Ready algorithm to classify trades with unbiased EHO PIN estimates for a sample of stocks from the NYSE, they find that the first EHO PIN estimates are underestimated by 18 percent. They recommend that their adjustment procedure should be used to mitigate the downward bias of the estimates which is caused by trade misclassifications.

Duarte and Young (2009) argue that the EHO PIN estimation method implies a negative correlation between buys and sells due to positive and negative private information, respectively. However, they find a strong positive correlation between buys and sells in their sample which is inconsistent with the implicit negative covariance in the EHO PIN model. They construct an adjusted PIN model which relaxes the assumption about the negative covariance in the EHO PIN model, and compare the PIN results from theirs and the EHO PIN model. They find that the significant difference between the two sets of estimates is systematically associated with variables that proxy for liquidity. They also find that the results from their adjusted PIN model are unrelated to average returns, unlike the estimates from the EHO PIN model. Thus, they conclude that EHO PIN and Adjusted PIN estimates are not proxies for information asymmetry, and that PIN is priced because of the illiquidity which happens when information is publicly announced (Grossman and Miller, 1988).

Akay, Cyree, Griffiths and Winters (2012) report supportive evidence for the adjusted PIN model of Duarte and Young (2009). While trade clustering can be caused by information-based trading and/or liquidity-based trading, Akay et al. (2012) report that EHO PIN estimates are priced due to trades clustering which is not associated with informed trading. They find positive EHO PIN estimates when they apply the EHO PIN estimation method on a sample of securities with minimal informed trading, specifically one-month T-bills and three-month GovPX data.

Akay et al. (2012) also test the adjusted PIN measure introduced by Duarte and Young (2009) but obtain poor PIN estimates due to the corner solutions phenomenon. After resolving the corner solutions problem, they obtain PIN results that are similar to those obtained using the EHO PIN method. When there is less liquidity provision, they find that the buy-sell imbalance is low (the T-bill market is less liquid) and the EHO PIN estimates are higher due to a higher likelihood that T-bills will be sold. The reverse is true when there is more liquidity provision. They also find that EHO PIN estimates are higher when bid-ask spreads are wider. While their findings strongly support the conjecture that EHO PIN estimates for T-bills are caused by a liquidity-based reason, they only provide indirect support for stocks.

Li, Wang, Wu, and He (2009) study the relation between expected returns of U.S. Treasury bonds and liquidity and information risk. Information asymmetry in the U.S. Treasury bonds market is largely due to the interpretation of public information (Green, 2004; Brandt and Kavajecz, 2004). The authors do not use any trade classification algorithm for their GovPX sample set since it includes the trades' initiators. They find that the mean and median of the EHO PIN estimates are positive, and that the rate of the information arrival is higher for on-the-run issues than off-the-run issues across different bond maturities for all trading days, and for trading days with and without macroeconomics news. Since the rate of information arrival is higher for trading days with than without macroeconomics news, they conclude that the EHO PIN estimates behave correctly throughout the macroeconomic announcement cycles. Furthermore, they find that issues that contain the highest EHO PIN estimates are those with the highest liquidity, shortest maturity, lowest spreads, and/or highest depth. The authors argue that their results support the EHO PIN estimation method and that they do not support the notions that trade misclassifications are the main reason for bias in EHO PIN estimates (Boehmer, Grammig, & Theissen, 2007) and that EHO PIN estimates are associated with illiquidity (Duarte and Young, 2009).

Easley, Hvidkjaer, and O'Hara (2010) also address the conclusion that EHO PIN is only a proxy of illiquidity (Duarte and Young, 2009). They examine a sample of ordinary common and NYSE- and AMEX-listed stocks from 1983 to 2001 while controlling for the size effect on information asymmetry by sorting stocks into size deciles, where size is determined by market capitalization. They observe that the EHO PIN estimates are higher for larger stocks within each PIN classification and for higher PIN stocks within each size classification. They find that their PIN factor (portfolio of long stocks with high PIN and short stocks with low PIN) in an augmented Fama-French model affects stocks returns, after controlling for the size and liquidity factors (liquidity risk factor of Pástor and Stambaugh (2003) and illiquidity measure of Amihud, 2002), and that PIN and liquidity have distinct impacts on stocks returns. Their findings refute the criticism that liquidity effects explain the relation between PIN and asset returns.

Lin and Ke (2011) note that the floating-point exception phenomenon is the cause of the downward bias of EHO PIN estimates. The authors adjust the maximum likelihood function to remedy the PIN estimation bias and employ the suggestion of Yan and Zhang (2006) to select a set of initial numbers for the five parameters used in the EHO PIN estimation. They provide evidence showing that the EHO PIN is underestimated due to floating-point exception phenomenon for their simulated sample of 2500 hypothetical stocks. They also provide empirical results for 1056 NYSE-listed stocks which had their IPOs before October 1, 2004 and had frequent trading during the fourth quarter of 2007. They use the Lee-Ready algorithm to classify trades and estimate the EHO PIN using the original and reformulated maximum likelihood functions. They find that 44 percent of the EHO PIN estimates using the original likelihood function are downward-biased and that this bias is more pronounced for active stocks. Lin and Ke (2011) argue that previous findings which argued that EHO estimates were biased also suffered from the floating point exception phenomenon.

2.3 Yan and Zhang PIN Specification

Yan and Zhang (2012) report that the maximum likelihood functions of Easley et al. (2010) and of Lin and Ke (2011) are both subject to a boundary solutions problem, where the factorized likelihood functions produce results which likely fall on the boundary solutions. Yan and Zhang develop an algorithm that sets the initial values for the five parameters of the PIN estimation for the two factorizations. Since their empirical findings show that the PIN estimates are less biased when employing the Lin and Ke factorization than the EHO factorization, Yan and Zhang (2012) suggest that the reformulated maximum likelihood function of Lin and Ke in combination with their algorithm should be adopted to remedy the systematic downward bias due to the floating point exceptions phenomenon in the EHO PIN estimations. This section presents the Yan and Zhang specification that embodies the Easley et al. PIN method.

Yan and Zhang develop an algorithm that sets the initial values for the five parameters as follows: $\alpha^0 = \alpha_i$, $\delta^0 = \delta_j$, $\varepsilon_b^0 = \gamma_k.\bar{B}$, $\mu^0 = \frac{\bar{B}-\varepsilon_b^0}{\alpha^0(1-\delta^0)}$, and $\varepsilon_s^0 = \bar{S} - \alpha^0.\delta^0.\mu^0$; where α_i (alpha) is the probability that an event occurs at the beginning of each trading day o , δ_j (delta) is the probability that an event that occurs on day o is bad news, (1-δ_j) is the probability of good news, μ^0 (mu) is the daily arrival rate of order submissions by informed traders on day o, ε_b^0 (epsilon buy) is the daily arrival rate of buy orders submitted by uninformed traders on day o; ε_s^0 (epsilon sell) is the daily arrival rate of sell orders submitted by uninformed traders on day o, $\bar{B}$ is the average number of buys on day o , and $\bar{S}$ is the average number of sells on day o, and γ_k is a quotient of $\bar{B}/\varepsilon_b$, with the condition that α and δ are bounded between 0 and 1 and $\mu, \varepsilon_b, \varepsilon_s$ are no smaller than 0. The algorithm proceeds as follows. Firstly, 125 sets of initial values for each sample are obtained by assigning the five fractions of 0.1, 0.3, 0.5, 0.7, 0.9 to each of the parameters α_i,δ_j, γ_k, where the Lee-Ready (1991) 5-second rule algorithm is used to classify trades as buyer- or seller-initiated. Secondly, the Lin-Ke factorization of the joint likelihood function is run for all acceptable sets of parameters. It is given by:

$$L(B_i, S_i)_{i=1}^{I}|\theta) = \sum_{i=1}^{I}[-\varepsilon_b - \varepsilon_s + B_i \ln(\mu + \varepsilon_b) + S_i \ln(\mu + \varepsilon_s) + e_{\max i}] + \sum_{i=1}^{I} \ln[\alpha(1-\delta)\exp(e_{1i} - e_{\max i}) + \alpha\delta\exp(e_{2i} - e_{\max i}) + (1-\alpha)\exp(e_{3i} - e_{\max i})] \quad (1)$$

where $\theta = (\alpha, \mu, \varepsilon_b, \varepsilon_s, \gamma), e_{\max i} = \max(e_{1i}, e_{2i}, e_{3i}), e_{1i} = -\mu - S_i \ln(1 + {}^{\mu}/_{\varepsilon_s}),$

$$e_{2i} = -\mu - B_i \ln(1 + {}^{\mu}/_{\varepsilon_b}), e_{3i} = -B_i \ln(1 + {}^{\mu}/_{\varepsilon_b}) - S_i \ln(1 + {}^{\mu}/_{\varepsilon_s}).$$

In contrast, the EHO factorization of the joint likelihood function (Easley, Hvidkjaer, and O'Hara, 2010) is given by:

$$L(B_i, S_i)_{i=1}^{I}|\theta) = \sum_{i=1}^{I}[-\varepsilon_b - \varepsilon_s + M_i(\ln x_b + \ln x_s) + B_i \ln(\mu + \varepsilon_b) + S_i \ln(\mu + \varepsilon_s)] \quad (2)$$

$$+\sum_{i=1}^{I} \ln[\alpha(1-\delta)e^{-\mu} x_s^{S_i - M_i} x_b^{-M_i} + \alpha\delta e^{-\mu} x_b^{B_i - M_i} x_s^{-M_i} + (1-\alpha) x_s^{S_i - M_i} x_b^{B_i - M_i}]$$

where $\theta = (\alpha, \mu, \varepsilon_b, \varepsilon_s, \gamma), M_i = \frac{\min(B_i, S_i) + \max(B_i, S_i)}{2}, x_s = \frac{\varepsilon_s}{\mu + \varepsilon_s}, x_b = \frac{\varepsilon_b}{\mu + \varepsilon_b}$

Thirdly, the parameters of the solution for the Lin and Ke factorization of the joint likelihood function that has the highest value of the objective function within the boundary are selected for each estimation period for each stock in the sample. When all solutions of the function fall on the boundary, the parameters of the solution with the highest value among the solutions are selected. Finally, the parameters selected are used to estimate the probability of informed trading (Easley et al., 2002), where $\alpha\mu + \varepsilon_B + \varepsilon_S$ is the rate at which all orders arrive and $\alpha\mu$ is that rate at which information-based trades arrive (Easley et al., 2002). Thus, PIN, which is the ratio of the mean informed trades to the mean total trades, is given by:

$$PIN = \frac{\alpha\mu}{\alpha\mu + \varepsilon_B + \varepsilon_S} \quad (3)$$

In this paper, we subsequently estimate PIN for our sample sets using both the Easley et al. and Yan and Zhang (which employs their algorithm on the Lin and Ke factorization) estimation methods, and make comparisons for the different windows over the two parties in an acquisition 'life cycle'. The next section presents our sample and data sets.

3. SAMPLE AND DATA

Our sample is collected from the SDC Financial Thomson database that consists of AMEX-, NASDAQ-, and NYSE-listed biotech firms that engaged in completed acquisitions in the United States from 2005 to 2011. The reason for us to choose acquisition events for our sample is that past studies report evidence about the extent of informed trading around the announcements of M&As (Ascioglu, McInish, and Wood, 2002;

Kryzanowski and Lazrak, 2007; Lipson and Mortal, 2007; Linciano, 2003; King, 2009). The biotechnology industry is unique in many ways, including its social network structure, the weight of and the secrecy involved with intellectual property, and competitive pricing (Scheweizer, 2002). From 1997 onward, consolidation activities in the biotech industry intensified, especially with biotech-to-biotech mergers and pharma-to-biotech mergers, due to the greater need to benefit from economies of scales and their higher attractiveness to capital market participants (Scheweizer, 2002).

The individual transaction values of the acquisitions in our sample exceed five million dollars. Real estate investment trusts and stocks of companies incorporated outside of the U.S. are deleted from the sample. We also eliminate stocks with less than 60 trading days because Easley et al. (2012) suggest that this is the minimum number of observations required to estimate PIN. Our final sample consists of 41 NYSE-listed acquirers, 14 NASDAQ-listed acquirers, 2 AMEX-listed acquirers, 8 NYSE-listed targets, 90 NASDAQ-listed targets, and 1 AMEX-listed target. The acquisition announcement and effective dates are also collected from the SDC Financial Thomson database. Table 1 reports the summary statistics of our sample sets, table 1a and 1b list the acquirers and targets in our sample sets, along with acquisition announcement dates and effective dates.

[Please place table 1 here.]

From the NYSE Trades and Automated Quotations database, we collect trades and quotes from 9:30 am to 4:00 pm for the acquirers and targets from their primary venues so that we have the data within the primary trading period for the firms in our samples. We exclude the quotes whose conditions are described in the Appendix A. We select quotes where bid and offer sizes are no smaller than zero. In order to maintain positive bid-ask spreads, we eliminate orders where the offer price is smaller or equal to the bid price.[1] Only quotes posted on the firm's primary listing venue are retained to minimize the inclusion of passive auto-quotes from inactive dealers. We only include good trades that are regular (i.e., cash-only basis, cash sale, next-day settlement only, next day, opened last, seller's option, and sold sale) and not later corrected, changed, or signified as canceled due to error.

[1] Price is actual trade price per share, which is truncated to five implied decimal places according to TAQ User's Guide, New York Stock Exchange, Inc., Version 3.31.

In a preliminary second step, we apply the Lee-Ready algorithm (1991) to classify trades as buys or sells and then calculate the total number of buys and sells per trading day for each stock. The reason for the application of the Lee-Ready algorithm is due to a large literature that demonstrates the high success rates of this algorithm in comparison with the tick, quote, at-the-quote, and Ellis, Michaely and O'Hara algorithms (Lee and Radhakrishna, 2000; Chakrabarty et al., 2007; Asquith, Oman, and Safaya, 2010; Aktas and Kryzanowski, 2013). Since we are interested in the probability of informed trading around both the announcement date (hereafter AD) and the effective date (hereafter ED) of each acquisition announcement, we examine the following five windows for each acquirer: 60 days pre-announcement or [AD-60: AD-2], three days centered on the announcement date [AD-1: AD+1], the period between AD and ED or [AD+2: ED-2], and 60 days after the ED or [ED+2: ED+60]. We also examine the following three windows for each target: 60 days pre-announcement or [AD-60: AD-2], three days centered on the announcement date [AD-1: AD+1], and the period between AD and ED or [AD+2: ED-2]. Since the targets cease to trade on their EDs, we cannot examine the last two periods that we examine for acquirers.

According to Easley, Hvidkjaer and O'Hara (2002), a PIN estimate from a sample that has less than 60 observations is biased when applying their information-based trading model. With only 3 days centered on both AD and ED, we estimate PIN for these two periods by increasing the number of observations. Kryzanowski and Lazrak (2007) divide each trading day into 78 successive intervals of five-minute lengths (hereafter called trading blocks).The authors assign the trading blocks into 10 samples based on a rolling basis. For example, the first trading block is assigned to the first sample, the second trading block to the second sample, and so on. This design allows them to estimate daily PIN for only three days of observations. Following their intuition, we assign 78 trading blocks into 13 samples, 26 samples and 39 samples, instead of 10 samples to ensure that our samples have an equal number of trading blocks of 6, 3 and 2, respectively.

4. PIN ESTIMATES FOR ACQUIRERS AND TARGETS USING THE EASLEY ET AL. MODEL

Ascioglu, McInish and Wood (2002) find that the causes of the increase in volume trading and positive abnormal returns for targets before merger announcements is informed trading and after merger announcements is largely due to liquidity traders. During the four days before mergers announcements, the authors find that there is a marked increase in trading volume (measured as average cumulative excess volumes) and abnormal returns (measured as average cumulative excess returns and average excess returns). Also, they find that after mergers announcements, there is a large decrease in bid-ask spreads, bid-ask spread standard deviations and the adverse-selection components of the spread. They conclude that this phenomenon implies that informed trading activity takes place before mergers announcements. For the post-announcement period, the authors find that the average trade size is markedly higher than the pre-announcement period and that large size trading indicates that trades are performed by large liquidity traders. These findings are consistent with the conclusion that high trading activity in the post-announcement period is due to uninformed large liquidity traders. Both informed trading before announcements and uninformed large liquidity trading after announcements lead to an increase in the correlation of order flow across markets.

Kryzanowksi and Lazrak (2007) also examine the acquisition as a material event to study the extent of information asymmetry. They study trading activity and liquidity for the periods around the announcements and effective dates of tender offers, the extent of changes of abnormal returns and the probability of informed trading over an acquisition's life cycle. They find that, upon tender offer announcements, trading activity and liquidity for targets increase substantially and that there is a strong pressure for targets, especially when the cash payment method occurs. They observe that EHO PIN estimates reduce markedly after the tender offer announcement for targets. Throughout an acquisition's life cycle, EHO PIN is greater before and upon a tender offer announcement and subsides after the announcement, which demonstrates that trades which take place before tender offer announcements are highly associated with informed trading and that post-announcement trades (or after the release of private and material information) are likely associated with uninformed trading.

Therefore, for our samples, we expect that EHO PIN estimates are high over the window centered on announcement dates and then weaken afterwards. Since the announcement of the conclusion of an acquisition is also a material event, we expect that EHO PIN estimates increase again over the window covering this event. Specially, we expect that EHO PIN estimates for the second and the fourth windows to be higher than those of the other windows for both acquirers and targets. This conjecture leads to the following hypotheses:

H_0^{1a}: *The EHO PIN estimates do not change throughout the windows identified for the acquisition life cycle for acquirers and targets.*

H_0^{1b}: *The EHO PIN estimates are the same for the AD and ED windows for acquirers and for targets.*

4.1 EHO PIN Estimates for the Acquirers

The PIN estimates using the Easley et al. method for the five acquisition life-cycle periods for the sample of acquirers and tests of significant differences between the periods based on the Wilcoxon signed ranks sum test are reported in tables 2 and 3, respectively. Based on table 2, the mean (median) EHO PIN increases from 13.8% (11.6%) in the first window or pre-AD to 17% (14.8%) in the second window or AD. The mean in the third window or between AD and ED is lower at 12% (10.4%), increases to 19.2% (15.8%) in the fourth window or ED, and drops to 12.1% (10.2%) in the fifth window or post-ED. Our EHO PIN estimates are reasonably similar to the EHO PIN estimates obtained by a number of other studies that are reported in Appendix B.

Based on the Wilcoxon test results reported in table 3, we find that the mean (median) EHO PIN estimates of the first window are significantly lower than those of the second and the fourth windows at the 0.05 (0.01) and 0.01 levels, respectively; but are insignificantly higher than those of the third and the fifth windows. The mean (median) EHO PIN estimates of the second window are significantly higher than those of the first, third, and fifth windows at the 0.05 (0.01), 0.01, and 0.10 (0.01) levels, respectively; but are insignificantly lower than that of the fourth window. The mean and median EHO PIN estimates of the third window are significantly lower than those of the second and the fourth windows at the 0.01 level, but are insignificantly higher than those of the first and the fifth windows. The mean and median EHO PIN estimates of the fourth window are higher than those of the first, third, and fifth windows at the 0.01 level, but are insignificantly higher than that of the second window. The mean (median) EHO PIN estimates of the fifth window are significantly lower than those of the second and the fourth windows at the 0.10 (0.01) and 0.01 levels, respectively; but are insignificantly lower and higher than those of the first and the third windows, respectively. Therefore, based on the significance of the differences in the means and medians, we are able to reject the hypothesis H_0^{1a} that the EHO PIN estimates are unchanged over the five windows in an acquirer's acquisition life cycle, but unable to reject the hypothesis H_0^{1b} that the EHO PIN estimates are significantly different between the second and the fourth windows. In other words, we find that the EHO PIN for the announcement (second) and effective day (fourth) windows are not significantly different from each other but tend to be higher than for the other three windows.

[Please place tables 2 and 3 about here.]

4.2 EHO PIN Estimates for the Targets

The PIN estimates using the Easley et al. method for the three acquisition life-cycle windows for the sample of targets and tests of significant differences between these periods based on the Wilcoxon signed ranks sum test are reported in tables 4 and 5, respectively. Based on Table 4, the average (median) of the EHO PIN estimates in the first window rises in the second window or AD from 20.2% (17.9%) to 36.6%, (33.5%) and decreases to 28% (26.8%) in the third window or between AD and ED. Once again, our EHO PIN estimates are close to the results of previous studies presented in Appendix B.

Based on the Wilcoxon test results reported in table 5, we find that the mean and median EHO PIN estimates of the first window (pre-AD) are significantly lower than those of the second (AD) and the third window (between AD and ED) at the 0.01 level. The mean and median EHO PIN estimates of the second window are significantly higher than those of the first and the third at the 0.01 level. The mean and median EHO PIN estimates of the third window are significantly higher and lower than those of the first and the second windows, respectively, at the 0.01 level. Thus, we are able to reject the hypothesis H_0^{1a} that the EHO PIN estimates are unchanged over the three windows in a target's acquisition life cycle. As expected the EHO PIN estimates are significantly higher during the AD than its surrounding periods.

[Please place tables 4 and 5 about here.]

5. PIN ESTIMATES FOR ACQUIRERS AND TARGETS USING THE YAN AND ZHANG ESTIMATION METHOD

As in the previous section, we formulate the following hypotheses for the PIN estimates using the Yan and Zhang method or YZ PIN estimates:

H_0^{2a}: *The YZ PIN estimates do not change over the windows identified for the acquisition life cycle for acquirers and targets.*

H_0^{2b}: *The YZ PIN estimates are the same for the AD and ED windows for acquirers and for targets.*

5.1 YZ PIN Estimates for the Acquirers

The YZ PIN estimates for the five acquisition life-cycle periods for the sample of acquirers and tests of significant differences between the periods based on the Wilcoxon signed ranks sum test are reported in tables 6 and 7, respectively. Based on table 6, the average (median) of the YZ PIN estimates move from 14.1% (11.3%) in the first window to 25.2% (24.3%) in the second window or AD to 14.1% (10.7%) in the third window or between AD and ED to 25.1% (23.9%) in the fourth window or ED to 14.7% (11.9%) in the fifth window or post-ED. Yan and Zhang (2012) estimate YZ PIN for their sample of NYSE- and AMEX-listed stocks over the period from January 1, 1993 to December 31, 2004 (i.e., for 78,934 stock-quarters). They find that the mean (median) YZ PIN estimates for each quarter range from 0.135 (0.117) to 0.174 (0.169). Our YZ PIN estimates in some windows with a lower likelihood of informed trading are reasonably close to their estimates. As expected, our YZ PIN estimates for the second and fourth windows are considerably higher than those of Yan and Zhang (2012) due most likely to our study of M&A events.

Based on the Wilcoxon test results reported in table 7, we find that the mean and median YZ PIN estimates of the first window (pre-AD) are significantly lower than those of the second (AD) and the fourth (ED) windows at the 0.01 level, but are insignificantly higher and lower than those of the third (between AD and ED) and the fifth (post-ED) windows.

The mean and median YZ PIN estimates of the second window are significantly higher than those of the first, the third, and the fifth windows at the 0.01 level, but are insignificantly higher than that of the fourth window. The mean and median YZ PIN estimates of the third window are significantly lower than those of the second and the fourth windows, but are insignificantly lower than those of the first and the fifth windows. The mean and median YZ PIN estimates of the fourth window are significantly higher than those of the first, the third, and the fourth windows at the 0.01 level, but are insignificantly lower than that of the second window. The mean and median YZ PIN estimate of the fifth window are significantly lower than those of the second and the fourth windows at the 0.01 level, but are insignificantly higher than those of the first and the third windows. Therefore, based on the results of the tests for significance differences between means and medians, we are able to reject the hypothesis H_0^{2a} that the YZ PIN estimates are unchanged over the five windows in an acquirer's acquisition life cycle, but are not able to reject the hypothesis H_0^{2b} that the YZ PIN estimates are unchanged for the second (AD) and the fourth (ED) windows.

[Please place tables 6 and 7 about here.]

5.2 YZ PIN Estimates for the Targets

The YZ PIN estimates for the three acquisition life-cycle windows for the sample of targets and tests of significant differences between the periods based on the Wilcoxon signed ranks sum test are reported in tables 8 and 9, respectively. Based on Table 8, the average (median) of the YZ PIN estimates in the first window or pre-AD increases from 20.6% (17.8%) to 37.2% (35.6%) in the second window or AD before declining to 26.9% (25.3%) in the third window or between AD and ED. Compared to the YZ PIN estimates of Yan and Zhang (2012), our YZ PIN estimates for our targets over a target's life cycle are considerably larger.

Based on the Wilcoxon test results reported in table 9, we find that the mean and median YZ PIN estimates of the first window (pre-AD) are significantly lower than those of the second (between AD and AD) and the third (between AD and ED) windows at the 0.01 level. The mean and median YZ PIN estimates of the second window are significantly higher than those of the first and the third windows at the 0.01 level. Therefore, we are able to reject the hypothesis H_0^{2a} that YZ PIN estimates remain unchanged over a target's acquisition life cycle over the three windows. Once again, we find that the PIN estimates become significantly higher for the period around ADs compared to the surrounding periods of time.

[Please place tables 8 and 9 here.]

6. COMPARISON OF THE PIN ESTIMATES BETWEEN ACQUIRERS AND TARGETS FOR EACH ESTIMATION MODEL

Some studies find that informed trading is associated more with targets than with acquirers. Ascioglu, McInish, and Wood (2002) show that trading volume and abnormal returns for targets before and after a merger announcement are significantly higher than in other periods and are more pronounced than for acquirers. Kryzanowski and Lazak (2007) find that trading activity for targets is more active than for acquirers upon merger announcements and the degree of information asymmetry for targets changes more significantly than for acquirers throughout an acquisition's life cycle. We posit that the PIN estimates for targets are higher than for acquirers. Therefore, we test the following hypotheses:

H_0^{3a}: *The EHO PIN estimates for acquirers and targets are unchanged over the comparable windows*

H_0^{3b}: *The YZ PIN estimates for acquirers and targets are unchanged over the comparable windows*

6.1 Comparison of the EHO PIN Estimates for Acquirers and Targets

The statistical differences of EHO PIN estimates for the three acquisition life-cycle periods between acquirers and targets are tested by using Whitney Man Wilcoxon test. The results are reported in table 10. Based on these results, we find that the mean and median EHO PIN estimates for acquirers are significantly lower than those for targets at the 0.01 level for all three common windows. Therefore, we are able to reject the hypothesis H_0^{3a} that the EHO PIN estimates are the same for acquirers and targets before the AD of an acquisition.

[Please place table 10 about here.]

6.2 Comparison of the YZ PIN Estimates for Acquirers and Targets

The statistical differences of the mean and median YZ PIN estimates for the three acquisition life-cycle periods (pre-AD, AD, and between AD and ED) between acquirers and targets are tested by using the Whitney-Man-Wilcoxon test and the results are reported in table 11. Based on these results, we find that the mean and median YZ PIN estimates for acquirers are significantly lower than those for targets for all three common windows at the 0.01 level. Thus, we are able to reject the hypothesis H_0^{3b} that the YZ PIN estimates are the same for acquirers and targets before, during, and after the announcement dates.

[Please place table 11 about here.]

7. COMPARISON OF THE TWO PIN ESTIMATES FOR ACQUIRERS AND FOR TARGETS

Lin and Ke (2011) state that the numerical maximum likelihood functions, which take into account the daily average buys and sells per stock, used in the EHO PIN estimation are subject to a floating-point exception, which involves overflow and underflow possibilities,[2] and thus lead to the elimination of the actual parameters of stocks that have large daily average buys and sells. Lin and Ke (2011) reconstruct the maximum likelihood functions and prove that the EHO likelihood functions lead to a downward bias in the EHO PIN estimations. The authors claim that their reconstructed functions can mitigate the floating-point exception phenomenon, and also provide empirical evidence using their simulation and historical data showing that the EHO PIN estimates are subject to a downward bias for stocks with a large number of trades. Yan and Zhang (2012) support Lin and Ke (2011) statement and provide evidence showing that the PIN estimations using the EHO factorized likelihood functions are subject to a downward bias due to the boundary solutions to the floating-point exceptions phenomenon. They find that their PIN estimation method, which applies the Lin and Ke (2011) factorized likelihood function, produces PIN estimates that are larger than the PIN estimates using the EHO PIN

[2] The CMU Common Lisp defines underflow as "This exception occurs when the result of an operation is too small to be represented as a normalized float in its format. If trapping is enabled, the floating-point-underflow condition is signalled. Otherwise, the operation results in a denormalized float or zero" and overflow as "This exception occurs when the result of an operation is too large to be represented as a float in its format. If trapping is enabled, the floating-point-overflow exception is signalled. Otherwise, the operation results in the appropriate infinity."

estimation method. In this section, we compare the EHO and YZ PIN estimates for the acquirers and for the targets over their acquisition life cycles.

We expect that EHO PIN estimates are smaller than those of YZ PIN estimates for both acquirers and targets over their corresponding acquisition windows, especially the windows where the PIN estimates are significantly larger than those of the other windows. Our expectations lead to the following hypotheses:

H_0^{4a}: *The EHO PIN estimates are the same as the YZ PIN estimates for acquirers*

H_0^{4b}: *The EHO PIN estimates are the same as the YZ PIN estimates for targets*

7.1 Comparison of PIN Estimates between the Two Estimation Methods for Acquirers

The tests of significant differences between EHO PIN and YZ PIN estimates based on the Wilcoxon signed ranks sum test over the acquisition life cycle of the five windows for acquirers are reported in table 12. Based on these results, we find that the mean and median YZ PIN estimates are significantly higher than the mean and median EHO PIN estimates at the 0.01 level for the second (AD) and the fourth (ED) windows. For the first, the third, and the fifth windows, the mean and median YZ PIN estimates are insignificantly higher than the mean and median EHO PIN estimates. Therefore, we are able to reject the hypothesis H_0^{4a} that the EMO PIN estimates are the same as the YZ PIN estimates for corresponding AD and ED windows for acquirers.

[Please place table 12 about here.]

7.2 Comparison of PIN Estimates between the Two Estimation Methods for Targets

The tests for significant differences between EHO PIN and YZ PIN estimates based on the Wilcoxon signed ranks sum test over the acquisition life cycle of the three windows for targets are reported in table 13. Based on these results, we find that the mean and median YZ PIN estimates are insignificantly higher than the mean and median EHO PIN estimates for all three windows. Therefore, we cannot reject the hypothesis H_0^{4b} that the EHO PIN estimates are the same as the YZ PIN estimates for targets.

[Please place table 13 about here.]

8. TESTS OF THE SENSITIVITY OF THE EHO PIN ESTIMATES TO THE WITHIN-DAY NUMBER OF SAMPLES FOR THE AD AND ED WINDOWS

Easley, Hvidkjaer and O'Hara (2002) claim that their PIN estimations are biased for a sample that has less than 60 observations. In this section, we examine the extent of the sensitivity of the PIN estimates to the number of observations by comparing the EHO PIN estimates between the 13, 26, and 39 samples for the second and the fourth windows. We expect that the EHO PIN estimates will change markedly between different samples where each sample contains different numbers of trading blocks. The specific hypothesis tested are:

> H_0^{5a}: *The EMO PIN estimates do not change across the three samples with different trading blocks assignments for acquirers*
>
> H_0^{5b}: *The EMO PIN estimates do not change across the three samples with different trading blocks assignments for targets*

8.1 PIN Estimate Sensitivity to Number of Observations for the AD and ED for Acquirers

The PIN estimates using the Easley et al. method for the second window (AD) for the three trading blocks assignments (13, 26, and 39 samplings) for acquirers and tests of significant differences between them based on the Wilcoxon signed rank sums tests are reported in table 14. Based on these results, we find that the mean and median EHO PIN estimates of the 13 samplings are significantly lower than those of the 26 and the 39 samplings at the 0.01 level. The mean and median EHO PIN estimates of the 26 sampling are significantly lower than those of the 39 sampling at the 0.01 and 0.10 levels, respectively. Therefore, we are able to reject the hypothesis H_0^{5a} that the EHO PIN estimates are unchanged across the three samplings with different trading blocks assignment for acquirers. The EHO PIN estimates significantly increase when the number of samplings increase, and thus are quite sensitive to the number of observations used in their estimation.

[Please place table 14 about here.]

The PIN estimates using the Easley et al. method for the fourth (or ED) window for the three trading blocks assignments for acquirers and tests of their significant differences are reported in table 15. Based on these results, we find that the mean and median EHO PIN estimates of the 13 samplings are significantly lower than those of the 26 and the 39 samplings at the 0.01 level. The mean and median EHO PIN estimates of the 26 samplings are significantly lower than that of the 39 samplings at the 0.01 and 0.10 levels, respectively. Therefore, we are able to reject the hypothesis H_0^{5a} that the EHO PIN estimates are unchanged across the three samplings with different trading blocks assignments for acquirers. As for AD, we find that the EHO PIN estimates increase significantly as the number of observations used in their estimation increases.

[Please place table 15 about here.]

8.2 PIN Estimate Sensitivity to Number of Observations for the AD for Targets

The PIN estimates using the Easley et al. method for the second (or AD) window for the three trading blocks assignments for targets and tests of significant differences between them based on the Wilcoxon signed rank sums tests are reported in table 16. Based on these results, we find that the mean (median) EHO PIN estimates of the 13 samplings are significantly lower than those of the 26 at the 0.01 (0.10) level and those of the 39 samplings at 0.01 level. The mean (median) EHO PIN estimates of the 26 samplings are significantly lower than those of the 39 samplings at the 0.01 (0.05) level. Therefore, we are able to reject the hypothesis H_0^{5b} that the EHO PIN estimates are unchanged across the three samplings with different trading blocks assignments for targets. Thus, the EHO PIN estimates also increase significantly when the number of observations used in their estimation increases.

[Please place table 16 about here.]

9. TESTS FOR INFORMATION LEAKAGE

Some studies (Anilowski *et al.*, 2009 and Sanders and Zdanowicz, 1992) report that takeover negotiations begin around three to five months before the first public announcements and that information leakage takes place during that period. In this section, we begin with a review of the relevant literature before proceeding to a specification of the hypotheses to be tested and a presentation of the results of such tests.

9.1 Relevant Literature

There is considerable empirical evidence that document the stock price run-up (decrease or break-even) phenomenon observed in target (acquirer) firms over the three days around ADs (Leeth and Borg, 2000; Mitchell, Pulvino, and Stafford, 2004; Agrawal and Nasser, 2012; Fu, Lin and Officer, 2013). The explanations of the phenomenon include the information asymmetry or the leakage of private information (Schwert, 1996; Agrawal and Nasser, 2012), the change of financial regulations (Leeth and Borg, 2000), agency problems (Fu, Lin and Officer, 2013), and the downward price pressure caused by mergers arbitrageurs (Mitchell, Pulvino, and Stafford, 2004). Our research provides supportive evidence that information asymmetry contributes partially to the short-term changes of the wealth of the shareholders of targets and acquirers upon M&A announcements.

Schwert (1996) suggests that the information leakage and market anticipation of a merger in the two months prior to announcements lead to the pre-bid price run-ups. For a sample consisting of 1814 targets from 1975 to 1991, Schwert finds that CARs start to increase significantly (remain highly positive) during the two months before (around) ADs. After ADs, the CARs increase (decrease) for a year if the takeovers are successful (unsuccessful). When testing for the relation between the pre-bid price run-ups and the premiums paid by bidders for successful acquired targets, Schwert finds a positive correlation of 1. This is consistent with the markup pricing hypothesis (Walkling and Edmister, 1985; Comment and Schwert, 1995) that the pre-bid price run-ups are unrelated to post-bid price run-ups and that the final deal price paid by bidders increases under the pre-bid price run-ups effect. His findings suggest that there is informed trading activity before ADs and the cost is suffered by bidders.

Leeth and Borg (2000) document evidence of pre-bid price run-ups for their samples of acquirers and targets over the 1919-1930 period. They argue that financial regulations do not explain the performance of shareholders' wealth upon merger announcements. Given the unique financial and economic environment of the 1920s, the authors examine the wealth changes of shareholders upon merger announcements and find that shareholders gains, measured by monthly market-adjusted abnormal returns, in the 1920s are not significantly different from those in the 1960s.

Mitchell, Pulvino, and Stafford (2004) show that merger arbitrage before and upon M&A announcements and index rebalancings around M&A closings are the causes of losses for the shareholders of acquirers upon M&As. The authors find that the negative CAARs over the period around ADs for a set of 2130 mergers from 1994 to 2000 are due to the downward price pressure caused by mergers arbitrageurs who short-sell acquirers' stocks and buy targets' stocks in fixed-exchange-ratio transactions. The short-time downward-sloping demand curves for the stocks of acquirers challenges the assumption of perfect elasticity of the demand curves for stocks. Additionally, the authors report that index rebalancings around merger closings cause the outward shifts of the demand curves of stocks for acquirers and that the increase in the demand does not relate to information used to predict the future returns for acquirers.

Fu, Lin and Officer (2013) prove evidence for the overvaluation of acquisitions and that this is caused by agency problems (Jensen, 2005). They examine acquisition premiums, measured by cumulative abnormal returns (CARs), for the period of 42 days before AD for three groups: cash acquisitions and stock acquisitions that are classified as driven versus not driven by stock overvaluation. They find that only stock acquisitions that are driven by stock overvaluation have a significant decline in acquisition premiums during the pre-AD period. Specifically, acquisitions premiums increase when the overvaluation of acquirers relative to targets increases. They also find that acquisition premiums are positively (negatively) correlated with size (leverage) and with hostile deals. Tobin's Q, returns on assets from operating activities, market-adjusted 12 month stock returns prior to the AD, and the standard deviation of returns for the 213 days before the bid period cannot explain the acquisition premiums. Fu, Lin and Officer (2013) examine the change of performances (measured by operating ROAs and asset turnovers) of the three groups of acquisitions for the nine fiscal years surrounding AD and find that only overvalued stock acquirers are subject to a abnormal declines in operating performances after their acquisitions. The comparison of the performances of overvalued acquirers and those of matched-and-overvalued non-acquiring firms shows that the latter do not suffer significant abnormal declines during the nine fiscal years surrounding the ADs. Finally, the authors find that the CEOs of overvalued acquirers gain a higher increase in wealth than those of overvalued non-acquirers. Therefore, they conclude that agency problems (Jensen, 2005) are the cause of the overvalued acquisitions.

Apris, Foley, and Frino (2012) find that target price run-ups before M&A announcements are explained by the market anticipation derived from public information (Jensen and Ruback, 1983). The authors adjust event dates without a rumors effect for their targets and examine the changes of CARs for the 30 days before ADs. They find that the acquisition of toeholds, regardless of size, shortly prior to takeover announcements causes the pre-bid target price run-up. This finding supports the theory (Jensen and Ruback, 1983; Bris, 2002) that the market anticipation of a successful takeover signalled by the toehold activity leads to the target price run-up before takeover announcements. The price run-up is positively correlated with the target size which is measured by using market value as a proxy. Since the authors find that there is no significant difference between the CARs of their selected targets and matched targets with unsuccessful takeovers, they conclude that insider trading does not explain the target price run-up before ADs.

Bae, Chang, and Kim (2013) examine possible CAR determinants for the AD windows for 672 U.S. acquirers and their international public and private targets over the period from 1996 to 2002. Not only are 60 percent of the M&As within the same industry but the proportion of high-tech M&As is material. Determinants include acquirers' characteristics (Tobin's q ratio, total assets and total debt ratio based on data from Compustat for the fiscal year preceding the year of the M&A), industry factors (high-tech, same industry, publicly or privately traded) for targets, national and market factors (market liquidity, market transparency and information asymmetry of the country of the targets) and deal characteristics (payment method, and if hostile or tender-offer). They find that the CARs of acquirers acquiring private targets are significantly larger when their total assets are smaller and/or their R&D ratios are higher and when acquiring public targets. The differences in the CARs are more significant when the targets are located in low-liquidity markets. In low transparency countries, acquirers obtain higher CARs when they acquire private targets. Their results are generally robust when self-selection models (Heckman, 1979) are used to correct for any endogeneity bias in the univariate tests.

9.2 Hypotheses on the Changes of CARs Before and Around ADs for Acquirers and Targets

Based on the findings of the above literature, we begin by examining the significance of the CARs for the acquirers and targets for the period of sixty days before the announcement day or [AD-60, AD-2] and the period of three days around the announcement day or [AD-1, AD+1] windows, and their changes from the previous to the later period. We test the following hypotheses:

H_0^{6a}: *CARs over the pre-announcement and announcement periods are insignificant for acquirers.*

H_0^{6b}: *CARs over the pre-announcement and announcement periods are insignificant for targets.*

H_0^{7a}: *CARs on the announcement days are unchanged in comparison with those for the 60-day period before the AD for acquirers*

H_0^{7b}: *CARs on the announcement days are unchanged in comparison with those for the 60-day period before the AD for targets*

9.3 Empirical Results on the CARs Before and Around ADs for Acquirers and Targets

9.3.1 Examination of the Changes of CARs for Acquirers and Targets Before and Around ADs

To test hypotheses H_0^{6a} and H_0^{7a}, we first obtain the CARs for the period of sixty days before the announcement days or [AD-60, AD-2] window and the period of three days centered on the announcement days or [AD-1, AD+1] window for both acquirers and targets by using the Carhart four-factor model (1997), where the market index is alternatively equally-weighted and value-weighted. We run a one-sample t-test and both sign and sign ranked tests to examine the significance of mean and median CARs, respectively, for acquirers and targets over the two windows.

Table 17 reports the results of the one sample t-test (sign and signed rank tests) for the means (medians) of CARs for acquirers and targets in panel A (B). Based on panel A, the mean CARs based on both market indexes decrease insignificantly over the [AD-60, AD-

2] and [AD-1, AD+1] windows for acquirers. However, for targets, the means of the CARs based on both market indexes increase significantly over [AD-60, AD-2] window at the 0.05 and 0.0001 levels, respectively. Based on panel B, the median CARs for acquirers based on both market indexes are insignificantly changed over the two windows. However, the medians CARs based on both market indexes are significantly positive over the [AD-60, AD-2] and [AD-1, AD+1] windows at the 0.001 and 0.0001 levels, respectively. These findings show that there is a pre-bid price run-up for targets only. Therefore, we are unable to reject the hypothesis H_0^{6a} that CARs over the pre-announcement and announcement periods are insignificant for acquirers, but are able to reject the hypothesis H_0^{6b} for targets.

[Please place table 17 about here.]

Table 18 reports the results of the Wilcoxon sign ranked sum tests on the differences in the means (panel A) and medians (panel B) CARs over the [AD-60, AD-2] window from those over the AD-1, AD+1] window for acquires and targets, separately. We observe that both the means and medians of the CARs based on both market indexes for acquirers are insignificantly different between the pre-announcement and announcement periods. However, both the means and medians of the CARs based on both market indexes for targets increase significantly at the 0.0001 percent level from the pre-announcement to the announcement period. Therefore, we are unable to reject the hypothesis H_0^{7a} that the mean CARs around the announcement days are the same as those over the period of 60 days before the ADs for acquirers, but are able to reject hypothesis H_0^{7b} for targets.

[Please place table 18 about here.]

The above findings on the CARs around the ADs of acquires and targets are consistent with the previous empirical findings on the wealth changes for shareholders before and around takeover announcements as the CARs are highly positive before ADs for targets, but remain unchanged or negative for acquirers. In the next section, we identify significant determinants of the positive CARs for acquirers (even though their CARs are insignificant) and targets.

9.3.2 Empirical Results on the Determinants of CARs around ADs for Acquirers and Targets

Based on the literature about the determinants of CARs around takeover announcements discussed above, we run cross-sectional regressions for our samples of acquirers and targets, where the dependent variables are the CARs around the ADs, and the independent variables are described as follows:

- Debt-to-Equity ratio or *DTE* is the ratio of total liabilities to total equity of shareholders, which is a proxy for a firm's financial risk, measured at fiscal year-end before the ADs of the acquirers and targets.
- Book-to-Market Value ratio or *BTM* is the ratio of total book value to market value in millions of dollars, measured at fiscal year-end before the ADs of the acquirers and targets.
- The natural logarithm of total assets in millions of dollars, which is a proxy for a firm's size, measured at the fiscal year end before the ADs of acquirers and targets, or *Size(LnTA)*.
- The natural logarithm of one plus the ratio of shares owned by institutional investors to total common shares traded or *IH,* following Hartzell and Starks (2003), Cornett, Marcus, and Tehranian (2008), and Brennan, Huh and Subrahmanyam (2013), measured at the fiscal year end before the ADs.
- The natural logarithm of one plus the ratio of stock that is held directly by insiders to total shares tradable or *ISHD*, following Starks and Titman (2006) and Sias and Whidbee (2010), of the 12 months before to 2 months prior to the ADs. Since we find significant CARs over the 60 days before the ADs for targets, we want to examine the potential effect of direct insider holdings on CARs before this period of significant change in the CARs around ADs.[3]
- The natural logarithm of total R&D expenses in millions of dollars based on the fiscal year end before the ADs for acquirers and targets, or *LnRD.*

All the financial statement variables are obtained from Compustat for the fiscal year-end preceding the ADs of each firm. The institutional and insider holdings data are collected from the (13f) Holding and Insider Filing Table 1, respectively, in the Thomson Reuters database for the year-end that is at least two months prior to the AD of each firm.

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[3] In unreported test results, we find that total direct insider holdings, total direct plus indirect insider holdings, and total institutional holdings change insignificantly from the twelve months to the six months before the two months prior to the takeover announcements for acquirers and targets.

We obtain our expectations for the expected relation between the CARs and their potential determinants from the literature. Fu, Lin and Officer (2013) show that premiums paid by overvalued acquirers are paid by acquirers with larger size, with lower leverage, and /or engaged in hostile deals. Bea et al. (2013) find that CARs around ADs of targets have a significant and negative relationship with both public targets and target size. Thus, we conjecture that the size of acquirers (targets) is positively (negatively) correlated with the CARs around ADs, and that the leverage of acquirers (targets) is negatively (positively) correlated with CARs around ADs. Ikenberry, Lakonishok, and Vermaelen (1995) find a positive correlation between the book-to-market ratio and the average abnormal returns upon share repurchase announcements, which is largely caused by the mistaken response of the market to the information content of the announcements. We conjecture that there is a positive relation between our CARs around ADs and book-to-market ratios.

Bea et al. (2013) also find a negative relation between the R&D ratio and the CARs of targets around ADs. However, since R&D activities are associated with high information asymmetry (Aboody and Lev, 2000; Higgins and Rodriguez, 2006), we conjecture that R&D expense is a positive determinant of CARs around ADs of both acquirers and targets.

Schwert (1996) finds an insignificant and negative relation between pre-bid insider holdings and pre-bid price run-ups. Agrawal and Nasser (2012) only find that the pre-bid price run-ups of targets are positively associated with the net numbers of shares bought by insiders during a year before the ADs. If the insignificant CARs for acquirers are caused largely by strong monitoring of informed trading in their stocks, we expect that the number of insider holdings for acquirers should be negatively related to their CARs around the ADs. Vice versa, we conjecture that the relation is positive for targets because of the stronger effect of the leakage of information about the possible success of the takeovers of the targets.

Sias, Starks and Titman (2006) find a significant and positive (negative) relation between the changes in the number and percentage of quarterly institutional holdings with the cumulative monthly and weekly abnormal returns over the previous (subsequent) 12 months. The authors state that institutional investors are more informed than the public and incorporate their information into their trading and cause the upward movement of the

CARs. Larger institutional investors have more impact on the movement than smaller institutional investors. We conjecture a positive correlation between our CARs and the number of institutional holdings over the fiscal year ended before the ADs for both our acquirers and targets.

We estimate the cross-sectional regressions of the means of the CARs for the [AD-1, AD+1] windows on the potential independent variables. The cross-sectional regressions results for acquirers and targets are reported in tables 19 and 20, respectively. In table 19, we find that only the size of acquirers is significantly and positively correlated with the CARs for the [AD-1, AD+1] window based on both equally and value weighted market indexes for acquirers at the 0.05 level. These findings are consistent with our conjecture based on the findings of Fu, Lin and Officer (2013) that the cost of the overvaluation of the stocks of acquirers before and around the ADs are paid for by their shareholders.

[Please place tables 19 and 20 about here.]

In table 20, we find that only the size of targets is significantly and negatively correlated with the CARs for the [AD-1, AD+1] window based on both equally and value weighted market indexes for acquirers at the 0.05 level. These findings are consistent with our conjecture based on the finding of Bea et al. (2013) that CARs around ADs of targets have a significant and negative relationship with targets whether or not they are public or private companies. Additionally, we find that the book-to-market ratios are significantly and positively correlated with the CARs for the [AD-1, AD+1] window based on both equally and value weighted market indexes for targets at the 0.10 percent. This finding only for targets is consistent with the finding of Ikenberry, Lakonishok, and Vermaelen (1995) that value stocks are more related with positive CARs around ADs.

In summary, we find that firm size positively (negatively) affects the performance of the CARs for the ADs for acquirers (targets) and that book-to-market ratios only positively affect the performance of the CARs for the ADs for targets.

10. DETERMINANTS OF THE PROBABILITY OF INFORMATION-BASED TRADING

10.1 Relevant Literature

As reported in section 8, the EHO and YZ PIN estimates are significant for the announcement (AD) and effective day (ED) windows. Thus, the question that we address next is: What are the determinants of this proxy for information asymmetry or informed trading for high-tech M&As? We begin with a review of the relevant literature before proceeding to a specification of the hypotheses to be tested and a presentation and discussion of the results from conducting such tests.

Chae, Chung, and Yang (2007) run cross-sectional regressions for the CARs for M&A ADs on information asymmetry variables derived from the Glosten-Harris and Hasbrouck-Foster-Viswanathan models. For their M&A sample for acquirers listed on the Korean stock market from 1994 to 2005, they find that higher information asymmetries are negatively associated with firm size, credit ratings, cash flow surplus, and leverage rates.

Aslan, Easley, Hvidkjaer, and O'Hara (2008) find the determinants of their PIN estimates for 35,722 firm-years of NYSE- and AMEX-listed stocks over the period from 1983 to 1999. They do this by running cross-sectional regressions where the firm characteristics are estimated by using pooled regressions and Fama-MacBeth (1973) regressions over each firm-year. They find that PINs are negatively and significantly associated with firm size, firm age, analyst coverage, Tobin's q and share turnover, and positively and significantly associated with returns on assets, and the annualized standard deviations of daily returns. They also find that firms in more stable and less dynamic industries have lower PINs.

Brennan, Huh, and Subrahmanyam (2013) decompose the PIN measure into the probabilities of informed trading based on good and bad news (PIN_G and PIN_B, respectively). They use the Yan and Zhang (2010) algorithm with 125 pre-specified sets of initial values for the five parameters to obtain PIN, PIN_G, and PIN_B estimates for a set of 985,007 firm-months for selective NYSE-and AMEX-listed stocks over the period from January 1983 to December 2010. Their first finding based on monthly cross-sectional regressions for each PIN measure is that the standard deviations of daily returns for the previous 12 months (insider holdings) are only negatively (positively) associated with

PIN_B (PIN_G). This finding indicates that stocks with higher return volatilities are associated with less informed trading based on bad news, and are unrelated with informed trading based on good news. Their second finding is that value stocks (growth stocks) are associated more with PIN_B (PIN_G). Their third finding is that analyst coverage is significantly and negatively associated with the three PIN measures although the relation is stronger for PIN_B than for PIN_G. Their fourth finding is that firm size or the month-end market value of equity has the strongest negative effect on the three PIN measures. Finally, they find that high-tech firms are more exposed to the probability of informed trading, and mostly to the informed trading that is based on good news.

A cross-sectional test in Kumar and Popescu (2014) reveals a strong and positive correlation between their PIN estimates and the natural logarithm of insider trading volumes, and a strong negative correlation between their PIN estimates and the natural logarithms of market values and share turnovers. Moreover, their PIN estimates are highly and positively related to the EHO PIN estimates and with measures of the price impacts of trades.

10.2 Methodology and Empirical Results on Determinants of PINs for Acquirers and Targets

10.2.1 Cross-sectional regression tests and results

In this section, we run cross-sectional regressions using the firm characteristics variables described in section 9 to test the determinants of PINs for the ADs. Based on the literature review above, we expect that PINs for the ADs of acquirers are positively related to the financial leverage ratio as firms with high information asymmetries require higher internal financing (Chae, Chung, Yang, 2007). We also expect that the PINs of acquirers (targets) are negatively (positively) correlated with firm size because larger firms have less private information due to a higher external monitoring of their activities (Chae, Chung, and Yang, 2007; Aslan, Easley, Hvidkjaer, and O'Hara, 2008; Brennan, Huh, and Subrahmanyam, 2013) and targets are generally smaller than acquirers. Higgins and Rodriguez (2006) show that the uncertainties associated with R&D successes lead to higher information asymmetry. Thus, we expect the PINs to be positively correlated with R&D expenses. Brennan, Huh, and Subrahmanyam (2013) suggest that firms with higher insider holdings tend to have higher informed trading on good news. We conjecture that the relations between insider holdings and the PINs are negative for acquirers and positive for targets because the CARs for M&As announcements are bad (good) news for the shareholders of acquirers (targets). Since institutional investors are likely to be informed investors, we expect a positive relationship between institutional holdings and PINs (Aslan, Easley, Hvidkjaer, and O'Hara, 2008). Based on the finding of Brennan, Huh, and Subrahmanyam (2013) that value (growth) stocks are associated more with PIN_B (PIN_G), we expect a positive relation between our PINs and the book-to-market ratios.

Table 21 reports the cross-sectional regressions results for the YZ PINs and EMO PINs for the ADs for the acquirers in panels A and B, respectively. We find that the book-to-market-ratio and the natural logarithm of one plus the ratio of stocks held directly by insiders to total shares traded are positively associated with YZ PINs around ADs for acquirers at the 0.05 level and with EMO PINs for the ADs for acquirers at the 0.01 and 0.05 levels, respectively. We find that the ratio of total liabilities to total equities of shareholders or the proxy for a firm's financial risk are positively associated with YZ PINs for the ADs for acquirers at the 0.10 level but is insignificantly associated with EMO PINs for the ADs for acquirers.

Our first finding indicates that value stocks of acquirers are associated more with PINs. In the previous section, our CARs around the ADs for acquirers are unchanged from the 60 days before the ADs to the three days around the ADs. Takeover announcements are thus deemed bad news for the stockholders of acquirers. Therefore, our finding on the positive relation between the book-to-market ratio and PINs is consistent with the finding of Brennan, Huh, and Subrahmanyam (2013) that value stocks (growth stocks) are associated more with PIN_B (PIN_G).

Our second finding is that acquirers with higher direct insider holdings over the 12 months prior to the two months before the ADs are associated more with PIN. This is consistent with previous findings that positive PINs reflect insider activities upon takeover intentions. Brennan, Huh, and Subrahmanyam (2013) find that insider holdings are negatively associated with the probability of trading that is based on good news. If takeover announcements are deemed bad news for acquirer stockholders, the relation between PINs for the ADs for acquirers and PINs should be negative, which is counter to what we find in our test results. We leave a closer examination on this good versus bad news story for future research.

Our third finding on the positive and significant association between the financial leverage of acquirers and YZ PINs for the ADs is consistent with our expectation that PINs for the ADs of acquirers are positively related to the financial leverage ratio as firms with high information asymmetries require higher internal financing (Chae, Chung, Yang, 2007) and supports the pecking order theory (Myers, 1984) that "companies with high information asymmetry which require more internal reserves have higher leverage and will benefit more through M&A since they will be able to increase internal financing sources" (page 30).

[Please place table 21 about here.]

Table 22 reports the cross-sectional regression results for the targets. We find a significant and negative relation between firm size with YZ PIN (EHO PIN) estimates at the 0.05 (0.01) level. The natural logarithm of total R&D expense is significantly and negatively correlated with YZ PIN estimates at the 0.05 level. There is also a significant and positive relation between the natural logarithm of one plus the ratio of shares owned by institutional investors to total common shares traded and the YZ PIN and EHO PIN estimates at the 0.10 level.

Our first finding indicates that targets with larger sizes are associated with less PINs around the ADs. This finding is consistent with previous findings (Chae, Chung, and Yang, 2007; Aslan, Easley, Hvidkjaer, and O'Hara, 2008; Brennan, Huh, and Subrahmanyam, 2013; Kumar and Popescu, 2014) which supports the theory that larger firms have economies of scale in reducing information asymmetry.

Our second finding indicates that targets with larger R&D expenses have less PINs around the ADs. This negative relation does not support the argument of Higgins and Rodriguez (2006) that the success uncertainty of R&D investment activities leads to higher information asymmetry.

Our third finding indicates that institutional holdings have a positive effect on PINs around the ADs for targets, which is consistent with our conjecture that since institutional investors are likely to be informed traders and that their trading should reflect informed information (Aslan, Easley, Hvidkjaer, and O'Hara, 2008).

[Please place table 22 about here.]

11. CONCLUSIONS

We examine the PIN for biotech M&As that occurred from 2005 to 2011 by employing the Easley et al. and newly introduced Yan and Zhang estimation methods. We find positive PIN estimates under both measures throughout the acquisition life cycles for both acquirers and targets. These findings are consistent with the large literature on the extent of information asymmetry around M&As. We find that the Yan and Zhang PIN estimation method has less downward-bias that is generally not significantly different than that from the Easley et al. estimation method. We provide supportive evidence that the reformulated likelihood function introduced by Lin and Ke (2011) and the Yan and Zhang algorithm can (generally not significantly) mitigate the downward bias of the EHO PIN estimation method for our samples of acquirers and targets. In addition, by elaborating on the sampling procedure proposed by Kryzanowski and Lazrak (2007), we demonstrate that EHO PIN estimates are sensitive to the number of observations.

We find that firm size has a positive and negative impact on the CARs for ADs for acquirers and targets, respectively and that the book-to-market ratio has a positive impact on the CARs for ADs for targets. We conclude that there is leakage of information prior to M&A announcements which is strongly affected by some firm characteristics. The book-to-market ratio, insider holdings and financial leverage are identified as having a positive impact on PINs for acquirers around takeover announcement dates and institutional holdings have a positive impact on PINs for targets. Firm size and R&D expense are identified as having a negative impact on PINs for targets. These findings prove that PIN partially reflects the activities of insiders and other informed investors about takeover intentions.

There are many avenues for further research. Possibilities include an examination of: (1) the impact of good and bad PIN; (2) the behavior of PIN around pre-AD rumors for M&As; and (3) whether there is any PIN spill-over effect to other potential targets in the same industry as the target to a M&A.

APPENDIX A

This appendix describes the quote conditions that are excluded from our data. The descriptions are drawn from the TAQ User's Guide, New York Stock Exchange, Inc., Version 3.31.

- Fast trading – where quotes are recorded on a best efforts basis during extremely active and short trading periods
- Order imbalance – where the severe order imbalance is too severe that the trading is halted
- Closed market maker
- Non-firm quote – which happens for 30 minutes due to a regulatory halt
- News pending – a regulatory halt or delayed opening due to expected dissemination of news that can affect the stock trading
- Trading halt in view of common – a non-regulatory halt that prevents the matters that affect common stock and other securities of the same company
- Order influx – a non-regulatory halt is made due to extremely large arrivals of buy or sell orders
- No open/no resume – a trading halt or an opening delay for the entire trading day
- Opening (Re-opening) price
- Related security news dissemination – a regulatory halt that works in the similar fashion with trading halt in view of common, but for news that relate to one security that affect other securities
- Related security news pending – a regulatory halt that works in the similar fashion with the above, but for expected news
- Additional Information – a regulatory halt or delayed opening that is made upon a request of an exchange to disseminate more information about a security
- Additional Information due to related security – a regulatory halt or delayed opening that is made upon a request of an exchange to disseminate more information about a security that affects the trading of related securities.
- Resume – when halting or delayed opening is lifted for a security and its bid and offer sizes are assigned as zero
- Related Security News pending – works in the same fashion as News Pending, but for expected news
- Quotes with spread greater than 20% of the midquote (following Chordia, Roll, and Subrahmanyam, 2001)

APPENDIX B

This appendix lists the means and medians of the probabilities of information-based trading (PIN) found in some selected studies over the whole sample or over windows that comprise the dates around announcement dates (ADs) and effective dates (EDs).

Past research	Sample	Mean	Median
Easley et al. (2002)	1,311 to 1,846 NYSE-listed stocks from 1983 to 1998	0.191	0.185
Nyholm (2002)	54 high-volume and 54 low volume NYSE-listed stocks for August 1997	Volume group: 0.1106 for high; 0.138 for low	N/A
Jayaraman (2007)	Easley, Hvidkjaer, & O'Hara (2002) sample of 2,817 firms from 1988 to 2001 (18,625 firm-years)	0.20	0.19
Boehmer et al. (2007)	1,043 representative NYSE-listed securities during the fourth quarter of 2002 from TAQ	0.136	0.129
Aktas et al. (2007)	87 M&A announcements on Euronext Paris from 1995 to 2000	0.1861 for [AD-180; AD-66]; 0.1767 for [AD-65; AD-6]; 0.2029 for [AD+3; AD+63]	N/A
Easley et al. (2008)	NYSE-and AMEX-list stocks (35,722 firm-years) from 1983 to 1999.	0.211	0.199
Duarte & Young (2009)	representative NYSE- & AMEX-listed stocks (48,512 firm-years) for 1983-2004	N/A	0.20
Li, Wang, Wu, He (2009)	All U.S. Treasury bonds, Jan. 1992 to December 2002 (notSept. 2001) from GovPX database	0.2619	0.2652
Easley, et al. (2010)	1,826 NYSE-and AMEX-listed stocks (37,907 firm-years) from 1983 to 2001	0.194	N/A
Lin and Ke (2011)	A sample of 1,056 representative NYSE-listed securities during the fourth quarter of 2007	0.136	0.1341
Yan & Zhang (2012)	Easley et al. (2010) sample for the period 1993-2004 (79,393 stock-quarters)	0.198	0.187

Kryzanowski & Lazrak (2007)	252 NASDAQ-listed targets & 111 NYSE-listed targets, 277 NASDAQ-listed acquirers & 191 NYSE-listed acquirers during the year 2001	0.238 for pre-AD, NASDAQ-targets; 0.198 for AD, NASDAQ-targets; 0.154 for pre-AD, NYSE-targets; 0.189 for AD, NYSE-targets; 0.161 for pre-AD, NASD-acquirers; 0.17 for AD, NASD-acquirers; 0.135 for post-ED, NASD-acquirers; 0.181 for ED, NASD-acquirers; 0.128 for pre-AD, NYSE-acquirers; 0.16 for AD, NYSE -acquirers; 0.131 for post-ED, NYSE -acquirers; 0.154 for ED, NYSE-acquirers	0.25 for pre-AD,NASDAQ-targets; 0.204 for AD, NASDAQ-targets; 0.151 for pre-AD, NYSE-targets; 0.173 for AD, NYSE-targets; 0.182 for pre-AD, NASD-acquirers; 0.157 for AD, NASD-acquirers; 0.145 for post-ED, NASD-acquirers; 0.156 for ED, NASD-acquirers' 0.123 for pre-AD, NYSE-acquirers; 0.14for AD, NYSE -acquirers; 0.13 for post-ED, NYSE -acquirers; 0.119 for ED, NYSE-acquirers

Table 1: Summary statistics for the sample of acquirers and targets

This table provides the summary statistics of the sample sets that consist of 57 biotech acquirers and 99 biotech targets from 2005 to 2011 whose primary exchanges are either the NYSE, NASDAQ, or AMEX.

	NYSE	NASDAQ	AMEX	TOTAL
ACQUIRERS				
2005	4	0	0	4
2006	8	4	0	12
2007	9	3	2	14
2008	6	2	0	8
2009	4	5	0	9
2010	8	0	0	8
2011	2	0	0	2
TOTAL	41	14	2	57
TARGETS				
2005	0	4	0	4
2006	0	6	0	6
2007	2	16	0	18
2008	3	17	0	20
2009	1	21	0	22
2010	1	16	1	18
2011	1	10	0	11
TOTAL	8	90	1	99

Table 2: Descriptive statistics for the PIN estimates using the Easley et al. method for acquirers

This table provides summary statistics for the PIN estimates using the Easley et al. method for the five acquisition windows for the sample of 57 acquirers. The labels descriptions are: W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_13_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 13 samples; W2_26_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 26 samples; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2]; W4_13_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 13 samples; W4_26_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 26 samples; W4_39_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples; and W5_EHO: EHO PIN estimates for the 60 days after the ED or [ED+2: ED+60], and AD and ED are the announcement and effective dates, respectively.

	W1_EHO	W2_13_EHO	W2_26_EHO	W2_39_EHO	W3_EHO	W4_13_EHO	W4_26_EHO	W4_39_EHO	W5_EHO
Mean	0.138	0.128	0.148	0.17	0.12	0.136	0.167	0.192	0.121
Standard Error	0.011	0.009	0.008	0.01	0.009	0.013	0.013	0.014	0.009
Median	0.116	0.106	0.131	0.148	0.104	0.117	0.142	0.158	0.102
Standard Deviation	0.085	0.07	0.061	0.078	0.07	0.096	0.102	0.107	0.065
Sample Variance	0.007	0.005	0.004	0.006	0.005	0.009	0.01	0.011	0.004
Kurtosis	0.029	8.722	1.744	3.943	1.846	17.399	12.151	11.879	1.443
Skewness	0.994	2.292	1.225	1.68	1.237	3.512	2.887	2.811	1.103
Range	0.333	0.448	0.298	0.436	0.326	0.626	0.628	0.657	0.321
Minimum	0	0.019	0.066	0.046	0	0.048	0.066	0.09	0.001
Maximum	0.333	0.467	0.364	0.482	0.326	0.675	0.694	0.747	0.322
Sum	7.86	7.294	8.426	9.694	6.832	7.727	9.544	10.963	6.9
Count	57	57	57	57	57	57	57	57	57
Confidence Level (95%)	0.023	0.019	0.016	0.021	0.018	0.025	0.027	0.028	0.017

Table 3: Tests of differences in EHO PIN estimates for acquirers between the five acquisition windows

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO PIN estimates with their p-values reported in the parentheses. This is followed the medians of the EHO PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of the five acquisition windows for acquirers. The label descriptions are: W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_13_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 13 samples; W2_26_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 26 samples; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2]; W4_13_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 13 samples; W4_26_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 26 samples; W4_39_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples; and W5_EHO: EHO PIN estimates for the 60 days after the ED or [ED+2: ED+60], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Acquirers	W1_EHO	W2_39_EHO	W3_EHO	W4_39_EHO	W5_EHO
W1_EHO	1				
W2_39_EHO	-2.585**(0.0124) [-3.1 ***(0.0019)]	1			
W3_EHO	1.458 (0.1505) [0.915 (0.3601)]	4.954***(<.0001) [4.253*** (<.0001)]	1		
W4_39_EHO	-3.279*** (0.0018) [-3.797***(0.0001)]	-1.641 (0.1063) [-0.864 (0.3875)]	-6.402***(<.0001) [-5.007***(<.0001)]	1	
W5_EHO	0.222 (0.8251) [0.686 (0.4929)]	1.924*(0.0594) [4.188***(<.0001)]	-0.728 (0.4694) [-0.176 (0.8605)]	4.997***(<.0001) [4.823*** (<.0001)]	1

Table 4: Descriptive statistics for the PIN estimates using the Easley et al. method for targets

This table provides summary statistics for the PIN estimates using the Easley et al. method for the five acquisition windows for the sample of 99 targets. The label description are: W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_13_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 13 samples; W2_26_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 26 samples; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; and W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively.

Targets	W1_EHO	W2_13_EHO	W2_26_EHO	W2_39_EHO	W3_EHO
Mean	0.202	0.285	0.315	0.366	0.280
Standard Error	0.009	0.015	0.015	0.015	0.012
Median	0.179	0.252	0.287	0.335	0.268
Standard Deviation	0.092	0.150	0.148	0.154	0.118
Sample Variance	0.009	0.022	0.022	0.024	0.014
Kurtosis	1.641	2.000	1.800	0.478	2.187
Skewness	1.099	1.336	1.068	0.833	1.168
Range	0.524	0.745	0.883	0.728	0.696
Minimum	0.004	0.088	0.001	0.124	0.015
Maximum	0.528	0.833	0.884	0.852	0.712
Sum	19.996	28.260	31.208	36.192	27.695
Confidence Level (95%)	0.018	0.030	0.030	0.031	0.024

Table 5: Tests of differences in EHO PIN estimates for targets between the three acquisition windows

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the EHO PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of the three acquisition windows for targets. The label descriptions are: W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; and W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively

Targets	W1 _EHO	W2_39 _EHO	W3 _EHO
W1 _EHO	1		
W2_39 _EHO	-11.094*** (Pr > |t|=<.0001) [-8.194***(Pr > |Z|=<.0001)]	1	
W3 _EHO	-6.242*** (Pr > |t| <.0001) [-5.485***(Pr > |Z|=<.0001)]	5.627***(Pr > |t|<.0001) [4.274***(Pr > |Z|=<.0001)]	1

Table 6: Descriptive statistics for the PIN estimates using the Yan and Zhang method for acquirers

This table provides summary statistics for the PIN estimates using the Yan and Zhang method for the five acquisition windows for the sample of 57 acquirers. The label description are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2]; W4_39_YZ: YZ PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples; and W5_YZ: YZ PIN estimates for the 60 days after the ED or [ED+2: ED+60], and AD and ED are the announcement and effective dates, respectively.

	W1_YZ	W2_39_YZ	W3_YZ	P4_39_YZ	W5_YZ
Mean	0.141	0.252	0.141	0.251	0.147
Standard Error	0.013	0.009	0.015	0.01	0.015
Median	0.113	0.243	0.107	0.239	0.119
Standard Deviation	0.098	0.064	0.11	0.072	0.111
Sample Variance	0.01	0.004	0.012	0.005	0.012
Kurtosis	6.42	4.07	5.446	1.433	5.892
Skewness	2.517	1.35	2.419	0.997	2.475
Range	0.478	0.359	0.47	0.357	0.523
Minimum	0.048	0.163	0.038	0.135	0.023
Maximum	0.526	0.522	0.508	0.493	0.545
Sum	8.063	14.352	8.042	14.286	8.376
Confidence Level (95%)	0.026	0.017	0.029	0.019	0.03

Table 7: Tests of differences in YZ PIN estimates for acquirers between the five acquisition windows

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the YZ PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the YZ PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of the five acquisition windows for acquirers. The label descriptions are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2]; W4_39_YZ: YZ PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples; and W5_YZ: YZ PIN estimates for the 60 days after the ED or [ED+2: ED+60], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Acquirers	W1_YZ	W2_39_YZ	W3_YZ	W4_39_YZ	W5_YZ
W1_YZ	1				
W2_39_YZ	-7.539***(<.0001) [-7.271*** (<.0001)]	1			
W3_YZ	0.018 (0.9853) [0.657 (0.5109)]	7.043***(<.0001) [7.118***(<.0001)]	1		
W4_39_YZ	-6.999***(<.0001) [-7.056***(<.0001)]	0.115 (0.909) [0.204 ***(0.8383)]	-6.865***(<.0001) [-6.965***(<.0001)]	1	
W5_YZ	-0.29 (0.7727) [-0.385 (0.7007)]	6.759***(<.0001) [7.231***(<.0001)]	-0.508 (0.6135) [-1.037 (0.2997)]	5.933***(<.0001) [7.056***(<.0001)]	1

Table 8: Descriptive statistics for the PIN estimates using the Yan and Zhang method for targets

This table provides summary statistics for the PIN estimates using the Yan and Zhang method for the five acquisition windows for the sample of 99 targets. The label description are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; and W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively.

	W1_YZ	W2_39_YZ	W3_YZ
Mean	0.206	0.372	0.269
Standard Error	0.011	0.011	0.010
Median	0.178	0.356	0.253
Standard Deviation	0.105	0.106	0.098
Sample Variance	0.011	0.011	0.010
Kurtosis	0.662	-0.328	2.473
Skewness	1.173	0.352	1.366
Range	0.413	0.537	0.531
Minimum	0.064	0.136	0.119
Maximum	0.477	0.673	0.650
Sum	20.413	36.819	26.626
Confidence Level (95%)	0.021	0.021	0.019

Table 9: Tests of differences in YZ PIN estimates for targets between the three acquisition windows

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the YZ PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the YZ PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of the three acquisition windows for targets. The label descriptions are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; and W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Targets	W1_YZ	W2_39_YZ	W3_YZ
W1_YZ	1		
W2_39_YZ	-12.461***(<.0001) [-8.989***(<.0001)]	1	
W3_YZ	-4.935***(<.0001) [-5.276***(<.0001)]	8.757***(<.0001) [6.913***(<.0001)]	1

Table 10: Tests of differences in EHO PIN estimates between acquirers and targets for the three acquisition windows

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the EHO PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of the three acquisition windows for acquirers and targets. The label descriptions are: W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Targets \ Acquirers	W1 _EHO	W2_39 _EHO	W3 _EHO
W1 _EHO	-4.29***(<.0001) [-5.04***(<.0001)]		
W2_39 _EHO		-8.96***(<.0001) [-8.295 ***(<.0001)]	
W3 _EHO			-9.34 ***(<.0001) [-8.413***(<.0001)]

Table 11: Tests of differences in YZ PIN estimates between acquirers and targets for the three acquisition windows

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the YZ PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the YZ PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of the three acquisition windows for acquirers and acquirers. The label descriptions are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Targets \ Acquirers	W1_YZ	W2 _39_YZ	W3_YZ
W1_YZ	-3.80***(0.0002) [-5.215 ***(<.0001)]		
W2_39_YZ		-7.78*** (<.0001) [-7.092***(<.0001)]	
W3_YZ			-7.53*** (<.0001) [-7.997***(<.0001)]

Table 12: Tests of differences between the EHO PIN estimates and YZ PIN estimates for acquirers

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO and YZ PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the EHO and YZ PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of EHO and YZ PIN estimates for the five acquisition windows for acquirers. The label descriptions are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2]; W4_39_YZ: YZ PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples; W5_YZ: YZ PIN estimates for the 60 days after the ED or [ED+2: ED+60]; W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2]; W4_39_EHO: EHO PIN estimates for the three days centered on the effective date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples; and W5_EHO: EHO PIN estimates for the 60 days after the ED or [ED+2: ED+60], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Acquirers	W1_YZ	W2_39_YZ	W3_YZ	W4_39_YZ	W5_YZ
W1_EHO	0.269 (0.789) [0.159 (0.8739)]				
W2_39_EHO		10.274***(<.0001) [6.189***(<.0001)]			
W3_EHO			1.384 (0.1718) [0.43 (0.6667)]		
W4_39_EHO				6.48***(<.0001) [4.71***(<.0001)]	
W5_EHO					1.689 (0.0967) [1.275 (0.2023)]

Table 13: Tests of differences between the EHO PIN estimates and YZ PIN estimates for targets

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO and YZ PIN estimates with their p-values reported in the parentheses. This is followed by the medians of the EHO and YZ PIN estimates with their respective Z-values reported in the parentheses within the square brackets for the pairs of EHO and YZ PIN estimates for the three acquisition windows for targets. The label descriptions are: W1_YZ: YZ PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_YZ: YZ PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_YZ: YZ PIN estimates for the period between AD and ED or [AD+2: ED-2]; W1_EHO: EHO PIN estimates for the 60 days pre-announcement or [AD-60: AD-2]; W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples; W3_EHO: EHO PIN estimates for the period between AD and ED or [AD+2: ED-2], and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Targets	W1_YZ	W2_39_YZ	W3_YZ
W1_EHO	0.59 (0.5566) [-0.233 (0.8156)]		
W2_39_EHO		0.526 (0.6003) [1.081 (0.2795)]	
W3_EHO			-1.27 (0.207) [-0.635 (0.5254)]

Table 14: Tests of differences in EHO PIN estimates for acquirers between the 13, 26, and 39 samples for the second window

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO PIN estimates based on the three sample sizes with their p-values reported in the parentheses. This is followed by the medians of the EHO PIN estimates based on the three sample sizes with their respective Z-values reported in the parentheses within the square brackets for the pairs of the five acquisition windows for acquirers. The label descriptions are: W2_13_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 13 samples; W2_26_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 26 samples; and W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples, and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Acquirers	W2_13_EHO	W2_26_EHO	W2_39_EHO
W2_13_EHO	1		
W2_26_EHO	-3.609***(0.0007) [-2.267**(0.0234)]	1	
W2_39_EHO	-8.975***(<.0001) [-3.6***(0.0003)]	-4.449***(<.0001) [-1.83*(0.0672)]	1

Table 15: Tests of differences in EHO PIN estimates for acquirers between the 13, 26, and 39 samples for the fourth window

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO PIN estimates based on the three sample sizes with their p-values reported in the parentheses. This is followed by the medians of the EHO PIN estimates based on the three sample sizes with their respective Z-values reported in the parentheses within the square brackets for the pairs of the fourth windows (ED) for acquirers. The label descriptions are: W4_13_EHO: EHO PIN estimates for the three days centered on the announcement date [ED-1: ED+1] when assigning 78 trading blocks into 13 samples; W4_26_EHO: EHO PIN estimates for the three days centered on the announcement date [ED-1: ED+1] when assigning 78 trading blocks into 26 samples; and W4_39_EHO: EHO PIN estimates for the three days centered on the announcement date [ED-1: ED+1] when assigning 78 trading blocks into 39 samples, and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Acquirers	W4_13_EHO	W4_26_EHO	W4_39_EHO
W4_13_EHO	1		
W4_26_EHO	-7.189***(<.0001) [-2.7***(0.0069)]	1	
W4_39_EHO	-10.041***(<.0001) [-4.313***(<.0001)]	-4.662***(<.0001) [-1.7* (0.0891)]	1

Table 16: Tests of differences in EHO PIN estimates for targets between the 13, 26, and 39 samples for the second window

This table provides the results of the Wilcoxon signed ranks tests for the differences of the means of the EHO PIN estimates based on pairs of the three sample sizes with their p-values reported in the parentheses. This is followed by the medians of the EHO PIN estimates based on the three sample sizes with their respective Z-values reported in the parentheses within the square brackets for the pairs of the five acquisition windows for acquirers. The label descriptions are: W2_13_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 13 samples; W2_26_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 26 samples; and W2_39_EHO: EHO PIN estimates for the three days centered on the announcement date [AD-1: AD+1] when assigning 78 trading blocks into 39 samples, and AD and ED are the announcement and effective dates, respectively. The Wilcoxon signed rank test is performed for the mean difference between the values on the column and the rows. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Targets	W2_13 _EHO	W2_26 _EHO	W2_39 _EHO
W2_13 _EHO	1		
W2_26 _EHO	-3.648***(0.0004) [-1.85*(0.0643)]	1	
W2_39 _EHO	-8.826***(<.0001) [-4.069***(<.0001)]	-5.077***(<.0001) [-2.5**(<.0125)]	1

Table 17: Pre-bid acquisition gains for acquirer and target U.S. biotech firms from 2005 to 2011

Panel A (B) in this table presents the one sample t-test (sign and signed rank tests) for the means (medians) of the CARs of acquirer and target firms, which are calculated by applying the Carhart four factors model (1997) and using equal and value-weighted market factors, over the [AD-60, AD-2] and [AD-1, AD+1] windows. The label descriptions are: p*re60E* is the CARs over the 60 days before ADs using the equal-weighted index, *pre1E* is the CARs over the 3 days around ADs using the equal-weighted index, pre60M is the CARs over the 60 days before ADs using the value-weighted index, *pre1M* is the CARs over the 3 days around ADs using the value-weighted index.

	Acquirers				Targets			
Panel A: One sample t-test for means of CARs								
	pre60E	pre1E	pre60M	pre1M	pre60E	pre1E	pre60M	pre1M
Mean	-0.0544	-0.0108	-0.0539	-0.00962	0.1333	0.5267	0.1356	0.5303
Degree of freedom	53	53	53	53	94	94	94	94
t-value	-1.58	-1.48	-1.73	-1.4	2.31	8.03	2.51	8.08
Pr>/t/	0.1191	0.1439	0.09	0.1683	0.023	<.0001	0.0139	<.0001
Panel B: One sample sign and signed rank test for medians of CARs								
	pre60E	pre1E	pre60M	pre1M	pre60E	pre1E	pre60M	pre1M
Median	0.01225	0.00285	-0.033	0.00175	12.62	34.95	13.54	34.52
Degree of freedom	53	53	53	53	94	94	94	94
Sign test	1	1	-5	1	17.5	43.5	15.5	43.5
Pr>/M/	0.8919	0.8919	0.2203	0.8919	0.0004	<.0001	0.0019	<.0001
Signed rank test	-130.5	-58.5	-187.5	-32	896.5	2236.5	865	2243
Pr>/S/	0.2651	0.619	0.107	0.7858	0.0007	<.0001	0.001	<.0001

Table 18: Changes in pre-bid acquisition gains from the 60 days before ADs to 3 days around ADs periods for acquirer and target U.S. biotech firms from 2005 to 2011

Panel A (B) in this table presents the Wilcoxon sign ranked sum test for the changes of the means and medians of the CARs of acquirer and target firms, which are calculated by applying the Carhart four factors model (1997) and using equal and value-weighted market factors from the [AD-60, AD-2] to [AD-1, AD+1] windows. The label descriptions are: p*re60E* is the CARs over the 60 days before ADs using the equal-weighted index, *pre1E* is the CARs over the 3 days around ADs using the equal-weighted index, pre60M is the CARs over the 60 days before ADs using the value-weighted index, *pre1M* is the CARs over the 3 days around ADs using the value-weighted index.

	Acquirers		Targets	
Panel A: Paired t-test for the means of the pairs pre60E and pre1E and pre60M and pre1M				
	pre60E - pre1E	pre60M - pre1M	pre60E - pre1E	pre60M - pre1M
Mean	-0.04366	-0.0442352	-0.39337	-0.39473
Degree of freedom	53	53	94	94
t-value	-1.19464	-1.3183	-4.35152	-4.4477
Pr>/t/	0.2375	0.1931	<.0001	<.0001
Panel B: Paired sign and signed rank tests for the medians of the pairs pre60E and pre1E and pre60M and pre1M				
Median	0.00295	-0.0295	-0.2723	-0.2424
Degree of freedom	53	53	94	94
Sign test	1	-4	-20.5	-20.5
Pr>/M/	0.8919	0.3409	<.0001	<.0001
Signed rank test	-92.5	-160.5	-1318	-1315
Pr>/S/	0.4309	0.1691	<.0001	<.0001

Table 19: Regression of the mean CARs for the [AD-1, AD+1] window on the firm characteristics for acquirers

Panels A and B of this table report coefficient estimates from regressions of CARs means for the [AD-1, AD+1] window using equal and market value indexes, respectively, against various firm characteristics for 54 acquirers. The independent variables are described as follows. *BTM* is the ratio of total book value to market value in millions of dollars for the fiscal year end before the ADs. *DTE* is debt-to-equity ratio or the ratio of total liabilities to total equity of shareholders, which is a proxy for a firm's financial risk, measured at the fiscal year end before the ADs. *IH is* the natural logarithm of one plus the ratio of shares owned by institutional investors to total common shares traded for the fiscal year ended before the ADs. *ISHD* is the natural logarithm of one plus the ratio of stock that is held directly by insiders to total shares traded for the fiscal year end before the ADs. *LnRD is the* natural logarithm of total R&D expense in millions of dollars for the fiscal year end before the ADs. *Size(LnTA)* is the natural logarithm of total assets in millions of dollars, which is a proxy for a firm's size, measured at the fiscal year end before the ADs. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

ACQUIRERS							
Independent variable	Degree of freedom	Parameter Estimate	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Panel A: Mean CARs for [AD-1, AD+1] based on equally weighted market index							
Intercept	1	-0.2738	0.10438	-2.62	0.0117	.	0
BTM	1	0.033	0.03638	0.91	0.369	0.74687	1.33892
DTE	1	-0.00991	0.00877	-1.13	0.2638	0.50971	1.96189
SizeLnTA	1	0.01351	0.00544	2.48**	0.0167	0.39217	2.54994
LnRD	1	-0.00241	0.00203	-1.19	0.2419	0.49631	2.01486
ISHD	1	0.15607	0.25785	0.61	0.5479	0.57262	1.74637
IH	1	-9.58062	40.30022	-0.24	0.8131	0.55115	1.81438
R-Square = 0.16, Adjusted R-Square = 0.0528, Root MSE = 0.05195							
Panel B: Mean CARs for [AD-1, AD+1] based on value weighted market index							
Intercept	1	-0.25777	0.0983	-2.62	0.0117	.	0
BTM	1	0.03558	0.03426	1.04	0.3043	0.74687	1.33892
DTE	1	-0.0091	0.00825	-1.1	0.2759	0.50971	1.96189
SizeLnTA	1	0.01282	0.00512	2.50**	0.0159	0.39217	2.54994
LnRD	1	-0.00247	0.00191	-1.29	0.2037	0.49631	2.01486
ISHD	1	0.14072	0.24284	0.58	0.565	0.57262	1.74637
IH	1	-8.81211	37.95317	-0.23	0.8174	0.55115	1.81438
R-Square = 0.1712, Adjusted R-Square = 0.0654, Root MSE = 0.04893							

Table 20: Regression of means CARs over the [AD-1, AD+1] window on firm characteristics for targets

Panels A and B of this table report coefficient estimates from regressions of CARs means for the [AD-1, AD+1] window using equal and market value indexes, respectively, against various firm characteristics for 95 targets. The independent variables are described as follows. *BTM* is the ratio of total book value to market value in million dollars for the fiscal year end before the ADs. *DTE* is debt-to-equity ratio or the ratio of total liabilities to total equity of shareholders, which is a proxy for a firm's financial risk, measured at the fiscal year end before the ADs. *IH is* the natural logarithm of one plus the ratio of shares owned by institutional investors to total common shares traded for the fiscal year ended before the ADs. *ISHD* is the natural logarithm of one plus the ratio of stock that is held directly by insiders to total shares traded for the fiscal year end before ADs. *LnRD is the* natural logarithm of total R&D expense in millions of dollars for the fiscal year end before the ADs. *Size(LnTA)* is the natural logarithm of total assets in millions of dollars, which is a proxy for a firm's size, measured at the fiscal year end before the ADs. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

TARGETS							
Independent variable	Degree of freedom	Parameter Estimate	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Panel A: Mean CARs for [AD-1, AD+1] based on equally weighted market index							
Intercept	1	3.07093	1.01623	3.02	0.0033	.	0
BTM	1	0.23565	0.12294	1.92*	0.0585	0.83344	1.19984
DTE	1	-0.00619	0.00713	-0.87	0.3880	0.95829	1.04352
SizeLnTA	1	-0.14937	0.05904	-2.53**	0.0132	0.49182	2.03324
ISHD	1	-0.03347	0.69096	-0.05	0.9615	0.93707	1.06715
IH	1	0.04042	0.25524	0.16	0.8745	0.91521	1.09265
lnRD	1	0.06760	0.05808	1.16	0.2476	0.48035	2.08183
R-Square = 0.1021, Adjusted R-Square = 0.0409. Root MSE = 0.6261276							
Panel B: Mean CARs for [AD-1, AD+1] based on value weighted market index							
Intercept	1	3.10530	1.01674	3.05	0.0030	.	0
BTM	1	0.23242	0.12300	1.89*	0.0621	0.83344	1.19984
DTE	1	-0.00619	0.00714	-0.87	0.3878	0.95829	1.04352
SizeLnTA	1	-0.15077	0.05907	-2.55**	0.0124	0.49182	2.03324
ISHD	1	-0.04114	0.69131	-0.06	0.9527	0.93707	1.06715
IH	1	0.03409	0.25537	0.13	0.8941	0.91521	1.09265
lnRD	1	0.06765	0.05810	1.16	0.2474	0.48035	2.08183
R-Square = 0.1024, Adjusted R-Square = 0.0412, Root MSE = 0.62645							

Table 21: Cross-sectional regression results for firm characteristics variables on the YZ PINs and EMO PINs around ADs for acquirers

Panels A and B of this table report coefficient estimates from regressions of YZ PINs and EMO PINs, respectively, for the [AD-1, AD+1] window using equal and market value indexes, respectively, against various firm characteristics for 54 acquirers. The independent variables are described as follows. *BTM* is the ratio of total book value to market value in million dollars for the fiscal year end before the ADs. *DTE* is debt-to-equity ratio or the ratio of total liabilities to total equity of shareholders, which is a proxy for a firm's financial risk, measured at the fiscal year end before the ADs. *IH is* the natural logarithm of one plus the ratio of shares owned by institutional investors to total common shares traded for the fiscal year ended before the ADs. *ISHD* is the natural logarithm of one plus the ratio of stock that is held directly by insiders to total shares traded for the fiscal year end before ADs. *LnRD is the* natural logarithm of total R&D expense in millions of dollars for the fiscal year end before the ADs. *Size(LnTA)* is the natural logarithm of total assets in millions of dollars, which is a proxy for a firm's size, measured at the fiscal year end before the ADs. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Panel A: The dependent variable is YZ PINs around the [AD-1, AD+1] window							
Independent Variable	DF	Parameter Estimates	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.39507	0.10709	3.69	0.0006	.	0
BTM	1	0.09074	0.03733	2.43**	0.0189	0.74687	1.33892
DTE	1	0.01585	0.00899	1.76*	0.0844	0.50971	1.96189
SizeLnTA	1	-0.00798	0.00558	-1.43	0.1595	0.39217	2.54994
LnRD	1	-0.0005787	0.00209	-0.28	0.7827	0.49631	2.01486
ISHD	1	0.59473	0.26454	2.25**	0.0293	0.57262	1.74637
IH	1	-20.62036	41.34554	-0.5	0.6203	0.55115	1.81438
R-Square = 0.3871, Adjusted R-Square = 0.3089, Root MSE = 0.0533							
Panel B: The dependent variable is EMO PINs around the [AD-1, AD+1] window							
Intercept	1	0.36219	0.11867	3.05	0.0037	.	0
BTM	1	0.12596	0.04137	3.05***	0.0038	0.74687	1.33892
DTE	1	0.01436	0.00997	1.44	0.1561	0.50971	1.96189
SizeLnTA	1	-0.01026	0.00619	-1.66	0.1039	0.39217	2.54994
LnRD	1	0.0001657	0.00231	0.07	0.9432	0.49631	2.01486
ISHD	1	0.75657	0.29316	2.58**	0.013	0.57262	1.74637
IH	1	-66.42475	45.8193	-1.45	0.1538	0.55115	1.81438
R-Square = 0.4248, Adjusted R-Square = 0.3514, Root MSE = 0.05907							

Table 22: Cross-sectional regression results for firm characteristics variables on the YZ PINs and EMO PINs around ADs for targets

Panels A and B of this table report coefficient estimates from regressions of YZ PINs and EMO PINs, respectively, for the [AD-1, AD+1] window using equal and market value indexes, respectively, against various firm characteristics for 95 targets. The independent variables are described as follows. *BTM* is the ratio of total book value to market value in million dollars for the fiscal year end before the ADs. *DTE* is debt-to-equity ratio or the ratio of total liabilities to total equity of shareholders, which is a proxy for a firm's financial risk, measured at the fiscal year end before the ADs. *IH is* the natural logarithm of one plus the ratio of shares owned by institutional investors to total common shares traded for the fiscal year ended before the ADs. *ISHD* is the natural logarithm of one plus the ratio of stock that is held directly by insiders to total shares traded for the fiscal year end before ADs. *LnRD is the* natural logarithm of total R&D expense in millions of dollars for the fiscal year end before the ADs. *Size(LnTA)* is the natural logarithm of total assets in millions of dollars, which is a proxy for a firm's size, measured at the fiscal year end before the ADs. ***, **, * correspond to significance levels of 1, 5, and 10%, respectively.

Panel A: The dependent variable is YZ PINs around the [AD-1, AD+1] window							
Independent Variable	Degree of freedom	Parameter	Standard Error	t Value	Pr > |t|	Toleranc e	Variance Inflation
Intercept	1	0.7921	0.14725	5.38	<.0001	.	0
BTM	1	-0.00287	0.01781	-0.16	0.8725	0.83344	1.19984
DTE	1	-0.0008573	0.00103	-0.83	0.409	0.95829	1.04352
SizeLnTA	1	-0.02055	0.00855	-2.40**	0.0184	0.49182	2.03324
lnRD	1	-0.0169	0.00842	-2.01**	0.0477	0.48035	2.08183
ISHD	1	0.03706	0.10012	0.37	0.7122	0.93707	1.06715
IH	1	0.06811	0.03698	1.84*	0.0689	0.91521	1.09265
R-Square = 0.3154, Adjusted R-Square = 0.2687, Root MSE = 0.09072							
Panel B: The dependent variable is EMO PINs around the [AD-1, AD+1] window							
Intercept	1	1.23992	0.19526	6.35	<.0001	.	0
BTM	1	0.01837	0.02362	0.78	0.4388	0.83344	1.19984
DTE	1	-0.0008047	0.00137	-0.59	0.5586	0.95829	1.04352
SizeLnTA	1	-0.04507	0.01134	-3.97***	0.0001	0.49182	2.03324
lnRD	1	-0.01837	0.01116	-1.65	0.1033	0.48035	2.08183
ISHD	1	0.08089	0.13277	0.61	0.5439	0.93707	1.06715
IH	1	0.09639	0.04904	1.97*	0.0525	0.91521	1.09265
R-Square = 0.4289, Adjusted R-Square = 0.39, Root MSE = 0.12031							

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