# *Indexing mergers and acquisitions*

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We measure the efficiency of mergers and acquisitions by putting forward an index (the "M&A Index") based on the stochastic frontier analysis. The M&A Index is calculated for each takeover deal and standardized between 0 and 1. The acquisition with a higher index encompasses higher efficiency. We find that takeover bids with higher M&A Indices are more likely to succeed. Moreover, M&A Index shows a strong and positive relation with acquirers' post-acquisition stock performance in the short-run and operating performance in the long run. After constructing three portfolios under a buy-and-hold strategy, we find that efficient portfolios with the highest indices earn higher equity returns and monthly alphas than inefficient portfolios with the lowest indices. Overall, our findings indicate that the M&A Index is positively associated with merger outcomes for acquirers.

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## 1. Introduction

Does an acquirer efficiently take over the target? Does the efficiency of acquisition imply significant post-acquisition performance in the short-run or the long-run? Questions as such have strong economic and trading implications. However, past literature presents little evidence on takeover efficiency and its potential relationship with merger outcomes[1]. The majority of M&A literature concentrates on partial acquisition issues[2] but lacks overall evaluations of takeover activities. In this paper, we redefine the concept of takeover efficiency[3] and build a composite index, the M&A Index, in order to provide a comprehensive understanding of takeover quality[4].

The composite index is superior to consolidate and simplify information from a complex process, especially when researchers are to standardize diverse empirical results so as to make comparisons. Therefore, indexing economic behavior attracts more and more public attention and interest (Sharpe, 2004). In the field of corporate finance, composite indicators are increasingly recognized and adopted. For example, the KZ Index is constructed to measure financial situations (Kaplan and Zingales, 1997), and Governance Index (Gompers et al., 2003) and Entrenchment index (Bebchuk et al., 2009) are to evaluate corporate governance. Both of the concepts of the financial situation and corporate governance are subjective, abstract and multi-dimensional. Researchers often need a basket of various financial ratios and descriptions so as to capture their ideas of the general conditions. Hence, it is practically important to build a standardized and meaningful indicator to make it easier to measure these issues quantitatively so as to be investigated in econometric models as a variable.

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[1] Merger outcomes include takeover deal completion, acquisition premium, and post-acquisition stock performance.

[2] Previous literatures on mergers and acquisitions segregate takeover process and investigate each segment and its determinant respectively (such as the probability of deal completion; bid premium; post-acquisition performance during announcement period or stock performance in the long-run).

[3] "Efficiency" in recent M&A studies refers to the "efficiency gain" --- acquirers'/ targets' announcement returns, which are whether acquisition partner earn abnormal return during announcement period. In this paper, however, efficiency is related with whole takeover process and used to measure the overall acquisition quality.

[4] Tehranian et al. (2013) illustrate that acquisition with high quality is the deal when bidding firms earn higher announcement return, pay less premium and have higher trading volume.

In general, as one of the largest corporate investments, M&A tends to exert strong and long-lasting influence on firms' operating and financial performance. Recent M&A literature lacks comprehensive evaluation for takeover activities. Previous studies mainly concentrate on the relation between merger outcomes and single or multiple factors of deal characteristic and corporate fundamentals. However, the impact of each determinant on post-acquisition performance is inconsistent due to the complication of the takeover. Therefore, a composite indicator, which can accurately gauge the overall takeover quality, is needed to re-evaluate and forecast financial consequences of acquisitions effectively. To our knowledge, we are the first to fill the research gap and hence enrich literature in M&A field.

We start M&A-indexing by firstly introducing the concept of "takeover efficiency" to assess the overall takeover quality[5]. Specifically, a deal is regard "efficient" if and only if acquisition could maximize the acquirer's gain[6] when announced to the public. In a market of strong-form efficiency (Fama, 1965), the stock movement on announcement day reflects market reaction and expectation to the takeover transaction. Higher announcement return indicates that the market is more optimistic towards the deal. In this study, we compare the acquirers' observed announcement return with the hypothetically maximum return to gauge the takeover efficiency.

Ideally, the acquisition is an efficient strategy for acquirers to develop and expand their business. Previous findings confirm that acquiring firms could benefit from synergy gain, including financial and operational improvement (Devos et al., 2009; Houston et al., 2001; Hoberg and Phillips, 2010). Therefore, acquirers should have gotten good feedback from the market. The announcement return in ideal acquisitions is the optimal and maximized return of bidders. However, the actual announcement return is less than the optimal gain due to various inefficiencies, including agency

[5] Tehranian et al. (2013) illustrate that acquisition with high quality is the deal when bidding firms earn higher announcement return, pay less premium and have higher trading volume. Herein, we adjust the standards for good quality acquisition and relate the deal quality with takeover efficiency.

[6] We construct M&A index with acquirers' stock performance rather than combined firms' stocks because acquirers generally have much larger firm-size than targets. The value-weighted announcement returns for combined firms are heavily affected by acquirer's stock performance on announcement day. Moreover, the post-acquisition performance in the long-run is mainly determined by bidding firms since acquirers take control of targets.

problems in acquirers and resistance from targets' management, etc[7]. Takeover efficiency is then used to estimate the gap between the actual and optimal announcement returns. Higher efficiency indicates that the actual announcement return is closer to the optimal market reaction, implying that acquirers can gain better post-acquisition performance. Accordingly, the M&A Index[8] is developed to directly and quantitatively scoring the degree of takeover efficiency for each deal. By design, the M&A Index is forward-looking and predicts merger outcomes, including the probability of deal completion, announcement return in the short run and post-acquisition operating performance in the long run.

To construct the M&A Index, we adopt the stochastic frontier analysis (SFA) approach[9]. In this paper, the SFA is implemented to measure the deviation from optimal market reaction to acquirers' takeover announcement. Hence, the SFA provides a benchmark of takeover efficiency. Specifically, the acquirer's return is examined as an output of SFA to quantify acquisition impact. Market optimism towards the deal would realize high announcement return for acquirers (positive impact). Inputs of the M&A Index include pre-bid characteristics of acquisition partners (bidders and targets) and the information revealed on the announcement day. Due to data availability, we only consider public acquisitions in which both acquirers and targets are public firms. Strong-form market efficiency is assumed, so that all public and private information regarding the deal is reflected in the stock price on the announcement day.

In essence, the M&A Index is the technical efficiency[10] of stochastic frontier models and is computed as a ratio of the actual acquirer's return against optimal return on the announcement day. The optimal announcement return represents a maximum feasible announcement return that a bidder could reach by assuming the absence of inefficiency

[7] Take an analogy, pasta is delicious and can be scored at 10 (optimal). The score of pasta will be lower, say 7 if too much salt is added or the pasta is overly boiled. "Pasta" the dish is takeover. "Too much salt" and "overly boiled" is the inefficiency.
[8] In the subsample with Entrenment index (Bebchuk et al., 2009), we find that M&A index are negatively related with entrenchment index (agency cost problem) and premium paid by acquirer (overpayment), indicating acquirer agency problem and overpayment reduce the M&A index. The choice of cash payment increases the M&A index. The findings indicate that the M&A index could reflect and capture the takeover effieicency.
[9] See Aigner et al., 1977; Meeusen and van denk Broeck, 1977.
[10] Technical efficiency in SFA is measured as firm's actual output over maximum output value.

factors. The value of the M&A Index ranges from 0 to 1[11]. A higher value indicates a smaller disparity between the actual and optimal announcement returns, and it, therefore, implies a better takeover quality.

Empirical results show that the M&A Index can be regarded as a measurement of takeover efficiency, and it provides forecasts of the post-acquisition performance. We find that the M&A Index positively correlates with the completion rate, signaling deals with higher indices are more likely to be successful. Additionally, deals with higher M&A Indices tend to have better post-acquisition stock performance in the short run and better operating performance in the long run, and this is statistically significant at 1% significance level.

Furthermore, we develop a buy-and-hold trading strategy based on the M&A Index over the post-acquisition period. We construct three different portfolios: Portfolio 1 with the least efficient deals (lowest indices); Portfolio 2 with the deals of moderate efficiency; Portfolio 3 with the most efficient deals (highest indices). Results show that acquirers in the highest quantile of the M&A Index (Portfolio 3) earn much higher returns and monthly alphas than the ones in lowest quantile (Portfolio 1). This superior performance is significant and also robust to different asset pricing models[12]. On average, the portfolio with most-efficient deals (Portfolio 3) earns 7% higher than the portfolio with least-efficient transactions (Portfolio 1) for one to six-month holding periods. Monthly alpha of Portfolio 3 also dominates Portfolio1 by 9.08% for a holding period of one month. And the persistence of this pattern proves to be statistically significant at 1% significance level.

To our knowledge, this paper is the first to develop a methodology to score the efficiency for takeovers. The M&A Index may also be used to forecast merger

[11] Stochastic frontier analysis assumes that optimal output is the maximum value that a firm could realize. The actual output is less than optimal output. The technical efficiency $\frac{actual\ output}{optiamal\ output}$ is therefore less than 1. In this paper, we also assume that acquirers 'optimal announcement return is larger than the actual announcement return. Therefore, M&A Index which equals to$\frac{acquirers'\ actual\ announcement\ return}{acquirers'\ optiamal\ announcement\ return}$, is limited to 1.

[12] We employ four asset pricing models to estimate monthly alpha, including CAPM model, Fama-French 3 factors model, Fama-French 4 factors model and Fama-French 5 factors.

outcomes, and thereby financial practitioners can evaluate acquisitions in a much simpler way, and researchers can treat the M&A Index as a factor in measuring the impact of acquisitions in asset pricing models.

The contribution of this paper is three-folded. First, this paper introduces an effective and forward-looking composite index of the M&A quality. Second, this paper provides an alternative indicator for market reaction to acquisition announcement which is proved to be efficient. Third, this paper implements the stochastic frontier analysis (SFA) in the M&A field, which enriches the application of SFA in event studies.

The paper is structured as follows: Section 2 presents our hypothesis; Section 3 describes the methodology and variables to construct the M&A Index; Section 4 describes the dataset and the M&A Indices; Section 5 reports empirical results and the corresponding interpretations; Section 6 presents robustness check for our findings; Section 7 concludes the paper.

## 2. Hypothesis

Luo (2005) illustrates that the probability of deal completion is affected by market reaction to takeover announcement since managements of acquiring firms learn from market to determine whether to consummate takeover transactions. The M&A index by design may be regarded as an alternative indicator for market perspective to announced deal because it is a ratio of actual acquirer announcement return to the optimal return on the announcement day. The announcement return is the market response to an acquisition deal immediately after the public release. The optimal announcement return is the highest level that a bidder could reach if the takeover is completely efficient. A higher ratio indicates that the acquisition is close to an efficient deal and therefore has a better takeover quality. It is likely that acquiring firms would be motivated to complete the deal if market appraisal were to be significant. Therefore, we propose the following hypotheses:

***H1: Higher values of the index (of a bidding firm) indicate a higher probability of deal completion.***

Olson and Pagano (2005) illustrate that short-term stock reaction reflects the investors' expectation of takeover deals. Therefore, acquisition partners would benefit from higher stock return if investors have better reaction and expectation for takeover transactions. M&A index measures the shortfall between actual acquirers' return and optimal return at the announcement, which shows a market response to an acquisition attempt. A higher index implies that the market positively responds to the acquisition. Therefore, more efficient deal (with higher index) is expected to have better stock performance in the short run. Hence, we assume:

***H2: Acquirers with higher M&A indices earn higher abnormal return than the firms with lower indices in the short term after the acquisition.***

Andrade et al. (2001) indicate that post-merger operating performance reflects whether acquirers eventually obtain expected gain at the announcement. Therefore, long-run operating performance signifies the takeover quality and synergy gain to acquirers. Deals with higher M&A Indices represent that market participants are more optimistic towards merger outcomes. Therefore, more efficient deals are expected to generate more synergy gain in the acquisition, which would be realized in the form of post-merger profitability. Higher M&A index implies better long-run operating performance. Therefore, we assume:

***H3: M&A Indices are positively related to the post-merger operating performance in the long run.***

## 3. Methodology

### *3.1 The M&A index*

### *3.1.1 Takeover efficiency and acquirers' announcement return*

In an efficient market, security price would adjust fully and immediately after the information is released. Therefore, acquirers' stock[13] on the announcement day would reflect the market reaction and expectation to the takeover bids. Higher acquirers' return at announcement suggests that market is more optimistic towards the merger outcomes, including the probability of deal completion and the post-acquisition performance.

Ideally, takeover is an efficient investment strategy for acquirers to grow the business and enhance competitiveness. Acquirers could benefit from synergy gain, including financial and operational improvement (Devos et al., 2009; Houston et al., 2001; Hoberg and Phillips, 2010). Hence, acquirers should have received good market reaction to the takeover announcements. The return gained in the ideal takeover transactions is the optimal announcement return for bidding firms. However, the observed stock return is not as large as optimal announcement return since market anticipation would be reduced by the concern of acquirers' agency cost, such as CEO hubris problem, the motivation of empire-building, resistance from targets' management and overpayment for the target. A smaller difference between the actual and optimal announcement returns indicates fewer agency problems in takeover deals and therefore implies a better merger quality.

In this paper, we define the takeover efficiency as that acquisition maximizes the acquirers' announcement return. Higher-efficiency deals often suggest smaller deviation of actual acquirers' return from the optimal stock performance. Hence, they imply less agency cost and better takeover qualities.

[13] We construct M&A index with acquirers' stock performance rather than combined firms' stocks because acquirers generally have much larger firm-size than targets. On average, acquirer' firm-size is 32.9044 times larger than targets' in the full sample. The value-weighted returns of combined firms are strongly affected by acquirers' announcement return. Additionally, we limit the takeover sample to the deals in which acquirers take control of target after acquisition.

### *3.1.2 Constructing a benchmark for takeover efficiency*

To estimate the takeover efficiency, we employ the production function in the stochastic frontier analysis (SFA) (Aigner et al., 1977; Meeusen and Broeck, 1977). SFA is a parametric approach used to measure the firms' ability to maximize the output given a set of input (production function) or minimize the cost given a set of output (cost function). In this study, takeover efficiency is the technical efficiency of the production function and is computed as a ratio of acquirers' observed return to the optimal level at the announcement. We start with production function and adopt the acquirers' return on announcement day $ACQ\_RET_i$ as the output. To measure the acquisition impact, we adjust the observed acquirers' return $Ret_i$ at date announced from CRSP database with hypothetical return $E(R_{it})$, which is estimated with market model (Brown and Warner, 1985) and acquirers' stock information prior to the announcement.

$$ACQ\_RET_i = \frac{Ret_i}{E(R_{it})} \tag{1}$$

$$E(R_{it}) = \beta_0 + \beta_i R_{mt} + \xi_i \tag{2}$$

Where $ACQ\_RET_i$ measures the acquirer's announcement return of the $i^{th}$ firm. $Ret_i$ is observed return for $i^{th}$ firm on the date announced from CRSP. $E(R_{it})$ is the expectation of return calculated by the market model (Brown and Warner, 1985). $R_{it}$ is the rate of return for the $i^{th}$ firm on day *t* from CRSP, $R_{mt}$ is the market value-weighted excess return on day *t* from CRSP.

Herein, $ACQ\_RET_i$[14], the output of production frontier, is computed as a ratio of the acquirer's return on announcement day $Ret_i$ over the predicted return $E(R_{it})$. The predicted return is calculated by the market model (Brown and Warner, 1985) with estimation period starting from 200 trading days to 20 trading days before the announcement day. We then regress firm's daily return on value-weighted the market

[14] The reason why we do not use abnormal return (difference between actual return and the return predicted by asset pricing model) is that SFA requires the log transformation of output. Therefore, output is limited to positive value. To include more takeover transactions, we use the ratio of actual announcement return over predicted return instead of abnormal return.

return over estimation period to obtain coefficients. Finally, we get estimated return $E(R_{it})$ by using the coefficients and market return at announcement day.

The original production function for takeover efficiency can be estimated as follows:

$$ACQ\_RET_i = f(\mathrm{X}_i, \beta) \exp(\varepsilon_i) \quad (3)$$

$$\varepsilon_i = v_i - \mu_i \quad (4)$$

where $ACQ\_RET_i$ measures the acquirer's announcement return of the $i^{th}$ firm. $X_i$ is an input vector which affects the acquirer's return. $\beta$ is a vector of the estimated coefficients. $\varepsilon_i$ is a composite error component. $v_i$ is the idiosyncratic component for the $i^{th}$ deal, $u_i$ is the inefficiency in the $i^{th}$deal.

Different with conventional econometric method, SFA decomposes error term $\varepsilon_i$ into two components, a random error $v_i$ and deviation from the optimal value $u_i$. Deviation from the optimal estimation $u_i$ represents the inefficiency which is attributed to human error and can be reduced or even eliminated. $v_i$ is identically and independently distributed with Gaussian distribution $v_i \sim N(0, \sigma_v^2)$. $u_i$ is an error with one-side distribution.[15]

Next, we select a vector of inputs which affect the acquirers' announcement return to consider different characteristics of acquisition partners and takeover transactions. These inputs are often included in the previous M&A literature as control variables. Definitions of our input variables are listed in the Appendix A. We then take a logarithmic transformation[16] of equation (3) and include dummy variables to characterize deals.

Specifically, a frontier function for takeover efficiency can be written as:

[15] Aigner et al. (1977) assume inefficiency is distributed as half-normal distribution. Meeusen and Broeck (1977) assume the inefficiency component as exponential distributed. Stevenson (1980) assumes the inefficiency term as truncated normal distributed.

[16] In SFA, log transformation is commonly applied due to the concern of skewness in the sample.

$$\ln(ACQ\_RET_i) = \beta_0 + \beta_1 \ln(Acquirer\ M/B_i) + \beta_2 \ln(Acquirer\ leverage_i) +$$
$$\beta_3 \ln(Acquirer\ MV_i) + \beta_4 \ln(Target\ M/B_i) + +\beta_5 \ln(Target\ leverage_i) +$$
$$\beta_6 \ln(TransactionValue_i) + \beta_7\ Hostile + \beta_8\ Tender + \beta_9\ Toehold + \beta_{10}\ Stock +$$
$$\beta_{11} Competing + \beta_{12}\ Diversification + v_i - \mu_i \quad (5)$$

In this study, we assume the inefficiency component, $u_i \geq 0$, and is distributed as exponential distribution (Meeusen and van denk Broeck, 1977). For takeover transactions, inefficiencies are mainly due to agency problems or hubris, leading to empire building[17] and overpayment. When inefficiency exits ($u_i > 0$), actual acquirers' announcement return would be reduced, less than the optimal value. When acquisition is fully efficient ($u_i = 0$), actual acquirers' stock performances are equal to the optimal announcement return. We then estimate the above model (5) by maximum likelihood estimation (MLE). In order to confirm the presence of inefficiency in takeover, we run a likelihood-ratio test and estimate model (5) by ordinary least square (OLS) as comparison.

*[Insert Table 1]*

Table 1 tabulates coefficients of the independent variables for the production function and results estimated by OLS for comparison purpose. The remarkable difference between SFA and OLS is the error component. SFA decompose the error term into random error and inefficiency component while OLS regards error as idiosyncratic error. The OLS method assumes that all takeover deals achieve the optimal (maximum) return on the announcement day. Therefore, estimation results should be identical to the results by the SFA if and only if the inefficiency component does not exist. A series of likelihood-ratio tests are then conducted to examine the existence of inefficiency. The null hypothesis that inefficiency does not exist is rejected at 1% significant level. Moreover, a ratio of lambda, $\lambda = \sigma_u/\sigma_v$, is calculated standing for the standard deviation of inefficiency against the standard deviation of a random shock. Herein,

[17] Empire building refers to the situation that acquirers' management initiate acquisition attempt in the interest of management since their compensation is positively associated with firm size.

*lambda* $\lambda$ equals 0.4371. That is, the standard deviation of inefficiency component is 43.71% of the standard error of idiosyncratic component, which indicates that the inefficiency in the acquisitions should not be neglected. Therefore, the SFA is a more appropriate method to estimate the M&A Index than the OLS.

We then calculate M&A Index to score the degree of efficiency for each transaction. A takeover deal is defined as efficient if acquisition maximizes the acquirer's return on the announcement day. Therefore, the M&A Index gauges the takeover efficiency by estimating the distance between the actual acquirer's return and optimal return when the deal is announced to the public. The optimal announcement return is the maximized feasible return for the acquirer, and it can be reached by reducing the inefficiency issues (agency cost in acquisitions). Specifically, the M&A Index is calculated as a ratio of the actual announcement return to optimal return for acquirers, which in nature is a technical efficiency. We specify the formula for M&A Index as follows:

$$\text{M\&A Index} = \exp\{-u_i\} = \frac{ACQ\_RET_i}{ACQ\_RET_i^*}$$

where $u_i$ represents a one-side error for inefficiency in the $i^{th}$deal, $ACQ\_RET_i$ is the observed acquirer's announcement return, $ACQ\_RET_i^*$ is the optimal acquirers' announcement return on the announcement day.

Due to the existence of inefficiency, $ACQ\_RET_i$ is less than $ACQ\_RET_i^*$. Therefore, merger efficiency index (M&A Index) is normalized, ranging from 0 to 1. If the index equals one exactly, then the bid is on the frontier, which indicates the acquirer receives the highest abnormal return on the announcement day.

## 4. Data

Data is gathered from several databases. We collect takeover events and relevant information from Thomson ONE. Our combined data covers the period from January 1, 1980 to December 31, 2012. Due to data availability, only public acquisitions are

considered, in which acquirers and targets are public firms. The original sample is 28,065 including both successful and failed transactions. We drop the takeover deals worth less than $1 million. We also require that acquirers take over control of targets (own more than 50% of targets' stake) after acquisitions. And it leaves us with 14,706 deals. Financial information and price/return data are obtained from COMPUSTAT and CRSP, respectively. We merger the takeover sample with the COMPUSTAT and CRSP by excluding missing values. Finally, we have a sample of 6,254 deals after the above selection procedure.

*[Insert Table 2]*

We then estimate the M&A Index for each takeover deal. Table 2 reports the M&A Index for the full sample and the distribution of M&A Indices across industries (Fama-French industry classification). On average, the M&A Index for the full sample is as high as 0.9795 with a minimum of 0.6928 and maximum of 0.9969. Among 6,254 deals, only 30 bids have indices less than 0.90. This fact [18] indicates that public acquisitions are quite efficient, which could be explained by the nature of public deals reinforced by market efficiency. Compared to acquisitions involving private targets, acquiring firms in public transactions get complete information and therefore identify better takeover deals, resulting in more accurate valuations and better market responses. However, M&A Indices are all significantly different from 1 (at 1% level), suggesting that deals are not completely efficient.

In Table 2, Panel B shows M&A Index and the number of acquisitions distributed by year. In general, the difference of the M&A Index is little among deals for each year. There is a merge "boom" between 1994 and 2000, during which the number of takeover transactions is above 300. The average efficiency degree gradually decreases. In the early years of the boom (1994 and 1995), acquisitions are more efficient than the ones occur before the boom. Conversely, the M&A Indices in the later period (1996 to 2000)

[18] The high average M&A Indices are also due to the limitation of SFA since SFA requires the log transformation for variables. This restriction of SFA limits our sample to deals with positive return on announcement day.

are much lower, indicating that acquisitions driven by the merger boom are less efficient due to more irrational decisions made by acquirers. Moreover, takeover efficiency is negatively affected by financial crisis. Lower M&A indices are frequently around the year 2008.

In Panel C of Table 3, acquisitions are classified according to different industries. Transactions are concentrated in the business equipment and financial industries. Interestingly, statistics show that takeover deals in the financial industry yield to relatively higher values of the M&A index than of the other industries.

*[Insert Table 3]*

Table 3 presents the summary statistics of corporate fundamentals and deal characteristics. We further divide the full sample based on the M&A Index and test the difference between the low- and high-efficiency deals. Results confirm the difference to be statistically significant, and the M&A Index to be positively monotonic to the level of efficiency. However, acquirers in high-efficiency deals pay lower premiums than bidding firms in deals with low efficiency. Moreover, acquirers in high-efficiency deals have better financial and operating performance than those in low-efficiency ones.

## 5. Empirical results

### *5.1 Deal completion*

As a proxy for the takeover quality, M&A Index is expected to be positively correlated with the probability of deal completion. Therefore, we implement both univariate and multivariate models to examine this relationship. Firstly, the whole sample is split into two subsamples based on whether acquisition attempts eventually complete or fail. Panel A of Table 4 shows the index for the unsuccessful subsample is 0.9778 on average and this is lower than the successful subsample by 0.0019. This disparity is

highly significant at 1% level. This finding indicates that acquirers with higher index are more likely to complete the takeover transactions.

*[Insert Table 4]*

We then test the relationship between the index and the deal completion rate with probit regressions. Results are listed in Panel B of Table 4. The dependent variable is a dummy variable taking a value of one if a deal is completed, or zero otherwise. The independent variable is the M&A Index. We also control variables for the firm and deal characteristics, which are commonly used in previous M&A literature. In panel B, Model 2 controls the year and industry fixed effects. We also consider acquirer clustering effect in model 3 and model 4. Coefficients on M&A Index are positive and significant at 1% in all the models, which supports findings in the univariate analysis. Therefore, the acquisition is more likely to be successful when the actual acquirer's announcement return approaches the optimal level. A higher index, which has a smaller difference between the actual and optimal return, indicates that market appraises favorably to the acquisition deal. According to Luo (2005), acquirers' management would learn from market reactions to determine whether to consummate takeover transactions. Hence, bidding firms with a better market response are motivated to complete the takeover deal. Additionally, higher-efficiency deals suffer less resistance from targets' management, which leads to higher rate of completion.

Moreover, transactions of larger value tend to reduce the probability of success. We also observe a negative relationship between hostile deals and the likelihood of completion. Results are consistent with documented findings (Schwert, 2000; Baker et al., 2012). The completion rate also decreases when the deal involves multiple bidders (Walkling, 1985). In contrast, the transaction is more likely to be successful when the deal is a tender offer (Baker et al., 2012).

### *5.2 Post-acquisition stock performance*

In this section, we study whether the M&A Index predicts acquirers' stock performance shortly after the deal announcement. We estimate the short-run performance proxy by the cumulative abnormal returns (CARs) over the period from 3 days to 5 days after the announcement (ACAR (+3, +5))[19]. We calculate the cumulative abnormal returns based on market-model (Brown and Warner, 1985). The estimation period for market model parameters is starting 220 trading days, ending 20 trading days preceding the announcement day. Then we compute acquirers' CARs with a post-event period of three days (ACAR (+3, +5)). Table 5 reports the relationships between the M&A Index and ACAR (+3, +5) in Panel A (univariate) and Panel B (multivariate analysis).

*[Insert Table 5]*

In Panel A, the full M&A sample is divided into low-efficiency and high-efficiency groups according to the index. On average, the ACAR (+3, +5) is 0.0563% in the group with high-efficiency deals, which is 0.1145% higher than the ACAR obtained from the low-efficiency ones. Hence, the univariate analysis indicates that acquirers in higher-efficiency deals earn more return shortly after the announcement day. To check the robustness of this finding, we regress the 3-day ACAR on the M&A Index. Regressions are estimated by the ordinary least square (OLS) method. Control variables are included in both models, including firm and deal characteristics. Additionally, Model 2 incorporates year, and industry effects. Model 3 and Model 4 control acquirer clustering. Panel B of Table 5 presents regression results and further supports the findings in the univariate analysis even after controlling other variables and fixed-effects. Coefficients for the index are positive and statistically significant. Higher M&A Index indicates a smaller deviation from the optimal announcement return, implying market optimism towards a given M&A activity. Acquisitions with higher indices are closer to efficiency. Our findings suggest that efficient deals perform better in the short run.

[19] Since the return on announcement day (day 0) is included in the M&A Index, we exclude the date surrounding day 0 to avoid endogenous issue.

### *5.3 Post-acquisition operating performance*

According to Andrade et al. (2001), the expected gains on takeover announcements are realized in the form of post-merger profitability. Long-run operating performance is, therefore, an indicator of takeover quality and synergy gain. In this section, we investigate the relation between the M&A Index and post-merger operating performance, which is estimated as an "Industry-Adjusted Return on Asset" (Healy et al., 1992) for acquirers. The IAROA is calculated as a difference between the acquirer's ROA and the median ROA across the belonging industry.

*[Insert Table 6]*

In Table 6, the dependent variable is the averaged IAROA of acquirers (A_IAROA) over a three-year window after acquisitions. Control variables are included for firm and deal characteristics in all regressions. We also control fixed effects of year and industry in model 2. In mode 3 and 4, acquirer clustering is considered. In Table 6, coefficients of the M&A Index are positive[20] and statistically significant at 1% in all the regressions. These findings indicate that deals with higher levels of efficiency perform better regarding post-merger profitability. Therefore, empirical evidence confirms that the M&A Index is forward-looking and has a significant prediction power towards the long-run operating performance of the acquirers.

### *5.4 Trading strategy*

Previous literature develops trading strategy on the spread (Elliott et al., 2005), risk (Thurner et al., 2003) and trend (James, 2003). This study enriches this thread of research by building up strategies based on efficiency (the M&A Index). We construct trading strategies according to the value of the M&A Indices. Specifically, the full ordered-sample[21] is divided into three subsamples (portfolios) by three quantiles (tertiles) based on the averaged M&A Index. Portfolio 1 includes deals with the lowest

[20] Moreover, the un-tabulated results also show that M&A Index is significantly and positively associated with C_IAROA for each fiscal period over three years after announcement.
[21] Here, order stands for the ranking of the values of the M&A Index from the minimum to maximum.

M&A Indices; Portfolio 2 includes deals with medium indices; Portfolio 3 includes deals with the highest indices. The trading strategy that we employ is to buy and hold the acquirers' stocks after the announcement. The holding period lasts one, two, three, four, five and six months, respectively[22].

The return, $r_{it}$, for the $i^{th}$deal on day $t$ is the acquirer's daily return obtained from CRSP. We then compound daily returns over the holding period $T$. $R_T = \prod_{i=1}^{T}(1 + r_{it}) - 1$. The monthly return is the geometric mean of holding period return, denoted by $R = (1 + \mathrm{R_T})^{30/\mathrm{T}} - 1$. We further measure the performance by calculating alphas from a standard CAPM model (Sharpe, 1964) and the Fama-French factor models (Fama and French, 1993; Carhart, 1997; Fama and French, 2015).

*[Insert Table 7]*

In Table 7, Panel A presents the average return over various holding periods for the three portfolios. Strikingly, we find that the acquiring firms earn around 7% more return than the bidders with the lowest indices in the same holding period. The difference between the most efficient (Portfolio 3) and least efficient (Portfolio 1) deals is highly significant and yields to the largest value, 7.89%, when stocks of the acquiring firms are held for one month after the announcement. Returns monotonically increase with the length of holding periods in every portfolio, but the gap between Portfolio 3 and 1 reduces from 7.59 % to 6.92%. Similarly, acquirers in Portfolio 3 profit more than bidders in Portfolio 2. The discrepancy between these two groups ranges from 2.17% (six-month holding) to 3.97% (one-month holding) and are significant at 1%.

We further examine the performance of the proposed buy-and-hold strategy relative to popular benchmark models. We regress daily (monthly return) on market premium and multiple factors to get alphas from the CAPM and Fama-French models, respectively. In general, we observe similar patterns of the alphas for the three portfolios in Panel B of Table 7. The alpha in Portfolio 3 is significantly larger than the one in the rest two

[22] To avoid possible large price swings accompanying merger announcements, we exclude the announcement day and start to hold acquirers' stocks from the day after announced date.

portfolios, and the difference is statistically significant at 1%. On average, holding an acquirer's stock for one-month yields to a monthly alpha of 11% in the case of Portfolio 3. The smallest difference of alphas between Portfolio 3 and Portfolio 1 is as large as 9.08% in the CAPM. When acquirers stocks are held for more than one month, bidders in Portfolio 3 keep outperforming the firms in Portfolio 2 and Portfolio 1.

We further expand the holding period to twelve, twenty-four and thirty-six months, respectively. Results[23] show limited consistency and confirm that the trading strategy is much more effective when the holding period is within six months after the takeover announcement.

*[Insert Table 8]*

We then re-categorize the full sample according to the industry classification. We further divide deals belonging to the same industry into the three subgroups based on their M&A Indices. Table 8 examines the acquirer's return and monthly alpha over one month after the announcement. In most industries, M&A Indices are positively associated with holding period returns. Investors can profit by investing the acquirers in the most efficient deals (in the energy and telephone industry, the acquirers return in the group with the highest indices is around 13.3% more than the portfolio with the lowest indices).

*[Insert Table 9]*

Similarly, we recompose all takeover transactions by every five years. Overall, we find that more efficient deals could bring higher return (in pre-specified holding periods) and higher monthly alpha for investors. The alpha difference between Portfolio 3 and Portfolio 1 is the largest over the period from 1980 to 1994. Interestingly, the acquirer returns and monthly alphas are marginally significant from 2005 to 2009, during which the one-month return is 4.89%, and monthly alpha is 3.53% in the most efficient deals.

[23] Due to the limited length of paper, we do not show the tables for twelve months, twenty-four months and thirty-six months.

The adverse stock performance could be attributed to the financial crisis in 2007-2008. However, in most efficient deals(with highest M&A Indices), the acquirers earn 9.76% more in return while average monthly alpha of the acquirers is 9.76% more than bidders in the least efficient deals. In all, higher indices are associated with better stock performance in most industries across time. Investors could benefit the most from holding stocks of acquirers in the most efficient deals.

## 6. Robustness Check

Since the values of the M&A Index are often above 0.90, its probability distribution may wildly deviate from Gaussian. Therefore, results of standard regressions and tests could be misleading. In this section, we employ a bootstrapping method as a robustness check. By resampling the takeover deals randomly with replacement, we manage to generate large numbers of artificial efficiency ratios. We find that the inefficiency indeed exists in the takeover samples. [24] In addition, the bootstrapping confirms that the M&A Index is significantly different from 0 and 1. The full sample is further divided into three groups according to different values of the index.

Moreover, we include Entrenchment index (E-index) (Bebchuk et al., 2009) to test whether the M&A index could reflect the takeover efficiency. Due to the limited data resources, we employ the E-index published and contributed by Professor Bebchuk who create the E-index. The public data only covers the S&P 500 and some important firms over the period from 1990 to 2006. Finally, we have 989 deals after merging the E-index file and the sample of M&A index. Bebchuk et al.(2009) find that firms with higher E-index are associated with lower firm value and stock returns, implying that firms with higher E-index may suffer higher agency cost. The results show that M&A index is negatively related with E-index (agency cost) and acquisition premium (overpayment), indicating that high agency cost in acquirers (high Entrenchment index) and overpayment (high premium) lead to takeover inefficiencies and reduce M&A index. Moreover, Cash payment increases the efficiency degree of transactions. These

[24] Due to the length restriction, results of robustness checks are not shown. They can be provided by request.

findings are consistent with common sense and the assumption of M&A index, suggesting that the M&A index could reflect the takeover efficiency.

We also re-test the relationship between the M&A Indices and deal completion rates, premium, short-run and long-run performance, respectively. All bootstrapping results unanimously confirm identical properties that we find in practical market observations.

## 7. Conclusion

In this paper, a new measurement of efficiency is introduced and applied to M&A practices. Takeover efficiency measures whether the acquirers' return is maximized on the announcement day given a set of firm and deal information. Acquirers' announcement returns are reduced due to inefficiency factors, such as agency cost in acquirers and resistance from targets' management. As a proxy for the takeover efficiency, the M&A Index indicates the technical efficiency on the production frontier, and its value is standardized between 0 and 1. The reason for choosing acquirers' announcement returns as the output of the SFA is that they reflect the general market reaction to the acquisition events. Therefore, the M&A Index measures the gap between actual investor responses (as observed from the market) and the theoretical evaluation of takeover. By construction, the deal with the higher index is more efficient than the one with a lower index.

We then examine the relationship between the M&A Index and the acquisition outcome, including the probability of deal completion, acquirers' short-run stock performance and post-acquisition operating performance in the long run. We observe that deals with higher indices (or to say, more efficient acquisitions) are more likely to complete. In the short run, the M&A Index is positively related to abnormal returns for acquirers. In the long term, acquirers with higher M&A Index perform better regarding post-merger operating performance.

Finally, we managed to construct three portfolios based on different rankings of the

M&A Index by imposing buy-and-hold trading strategy to acquirers' stocks after the takeover announcement. Empirical results show that portfolios with higher M&A Indices significantly outperform the portfolios with lower indices, especially for the six-month holding period. The most efficient portfolio (with highest M&A Indices) earns 7.89% higher than least efficient portfolio (with the lowest M&A Indices) when holding acquirers' stocks for one month. We further calculate alphas from the CAPM and Fama-French multi-factor models. Monthly alphas for the most efficient portfolio are as high as 11.4% by holding acquirers' stocks for one month after the takeover announcement, and this result is robust to different models.

In sum, we apply the stochastic frontier analysis to takeover practice and put forward M&A index to measure acquisition efficiency. This study contributes to the current M&A literature by providing a new perspective to review the takeover process and post-acquisition performance in both short run and long run. Due to the significant relation with takeover outcomes, M&A index could be used as a supplemental tool for analyst and investor to forecast firm performance and design trading strategies. Moreover, academic research may consider including M&A Index in regression models to gauge the impact of acquisitions.

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## Table 1 Estimation of M&A Index

Table 1 shows the estimation results of M&A Index estimated by maximum likelihood method (MLE) and ordinary least square (OLS). The table tabulates the coefficient for input variables for production function in the stochastic frontier analysis (SFA). The variables are same in the ordinary least square (OLS). Definitions of variables are listed in the Appendix A. T-values are showed in the table. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

| Estimation method | Stochastic Frontier Analysis (SFA) | Ordinary Least Square (OLS) |
|---|---|---|
| Acquirer Tobin's Q | 0.0001 | 0.0001 |
| | (0.86) | (0.67) |
| Acquirer leverage | 0.0108** | 0.0104** |
| | (2.20) | (2.08) |
| Acquirer MV | -0.0010** | 0.0001 |
| | (-2.03) | (0.08) |
| Target Tobin's Q | 0.0001 | 0.0001 |
| | (0.82) | (0.60) |
| Target leverage | -0.0028 | -0.0011 |
| | (-0.67) | (-0.24) |
| Transaction Value | -0.0037*** | -0.0046*** |
| | (-7.25) | (-9.05) |
| Hostile | -0.0118*** | -0.0084** |
| | (-2.97) | (-2.07) |
| Tender offer | 0.0229*** | 0.0222*** |
| | (12.73) | (12.11) |
| Toehold | -0.0023 | -0.0008 |
| | (-1.46) | (-0.51) |
| Stock | -0.0148** | -0.0157*** |
| | (-8.45) | (-8.77) |
| Competing | -0.0028 | -0.0028 |
| | (-0.78) | (-0.78) |
| Diversification | -0.0097*** | -0.0098*** |
| | (-5.68) | (-5.57) |
| Constant | 0.0483*** | 0.0235*** |
| | (16.76) | (8.77) |
| Observation: | 6254 | 6254 |
| Log likelihood | 9527.1399 | N/A |
| Adjusted R-square | N/A | 0.0876 |

## Table 2 Descriptive data

Table 2 lists the descriptive data for M&A Index. Specifically, the table shows the observation (number of M&A Indices), mean, median, Sd (standard deviation), minimum, quintile and maximum for M&A Indices. We also tabulate the distribution of M&A Indices classified by industry and year. The industry classification is according to Fama-French 12 industry classification.

**Panel A: M&A Index for the full sample**

| | Observation | Mean | Median | Standard deviation | Min | 25% | 75% | Max |
|---|---|---|---|---|---|---|---|---|
| M&A Index | 6254 | 0.9795 | 0.9814 | 0.0125 | 0.6928 | 0.9786 | 0.9837 | 0.9969 |

**Panel B: M&A Index classified by year**

| Year | Observation | Percent | Mean | Median | Sd | Min | 25% | 75% | Max |
|---|---|---|---|---|---|---|---|---|---|
| 1980 | 4 | 0.06% | 0.9790 | 0.9781 | 0.0029 | 0.9767 | 0.9768 | 0.9812 | 0.9830 |
| 1981 | 25 | 0.40% | 0.9781 | 0.9796 | 0.0077 | 0.9496 | 0.9768 | 0.9818 | 0.9889 |
| 1982 | 46 | 0.74% | 0.9797 | 0.9804 | 0.0046 | 0.9664 | 0.9772 | 0.9817 | 0.9905 |
| 1983 | 86 | 1.38% | 0.9796 | 0.9804 | 0.0048 | 0.9570 | 0.9782 | 0.9821 | 0.9906 |
| 1984 | 206 | 3.29% | 0.9800 | 0.9814 | 0.0086 | 0.9121 | 0.9787 | 0.9836 | 0.9926 |
| 1985 | 97 | 1.55% | 0.9796 | 0.9809 | 0.0083 | 0.9141 | 0.9783 | 0.9828 | 0.9911 |
| 1986 | 98 | 1.57% | 0.9784 | 0.9808 | 0.0124 | 0.8988 | 0.9778 | 0.9831 | 0.9891 |
| 1987 | 136 | 2.17% | 0.9799 | 0.9816 | 0.0103 | 0.8950 | 0.9786 | 0.9847 | 0.9947 |
| 1988 | 143 | 2.29% | 0.9797 | 0.9810 | 0.0110 | 0.8694 | 0.9784 | 0.9838 | 0.9944 |
| 1989 | 163 | 2.61% | 0.9806 | 0.9813 | 0.0059 | 0.9570 | 0.9784 | 0.9841 | 0.9964 |
| 1990 | 153 | 2.45% | 0.9794 | 0.9810 | 0.0076 | 0.9469 | 0.9780 | 0.9836 | 0.9935 |
| 1991 | 113 | 1.81% | 0.9800 | 0.9813 | 0.0050 | 0.9632 | 0.9777 | 0.9828 | 0.9903 |
| 1992 | 98 | 1.57% | 0.9804 | 0.9819 | 0.0081 | 0.9318 | 0.9786 | 0.9846 | 0.9934 |
| 1993 | 134 | 2.14% | 0.9808 | 0.9821 | 0.0074 | 0.9238 | 0.9795 | 0.9840 | 0.9923 |
| 1994 | 304 | 4.86% | 0.9810 | 0.9817 | 0.0057 | 0.9296 | 0.9789 | 0.9836 | 0.9969 |
| 1995 | 331 | 5.29% | 0.9802 | 0.9812 | 0.0059 | 0.9178 | 0.9785 | 0.9830 | 0.9949 |
| 1996 | 401 | 6.41% | 0.9799 | 0.9812 | 0.0122 | 0.7933 | 0.9790 | 0.9834 | 0.9967 |
| 1997 | 370 | 5.92% | 0.9799 | 0.9814 | 0.0150 | 0.7205 | 0.9789 | 0.9838 | 0.9924 |
| 1998 | 406 | 6.49% | 0.9796 | 0.9813 | 0.0107 | 0.8306 | 0.9783 | 0.9838 | 0.9937 |
| 1999 | 421 | 6.73% | 0.9799 | 0.9817 | 0.0105 | 0.8872 | 0.9784 | 0.9845 | 0.9960 |
| 2000 | 471 | 7.53% | 0.9769 | 0.9816 | 0.0206 | 0.6928 | 0.9776 | 0.9846 | 0.9946 |
| 2001 | 274 | 4.38% | 0.9783 | 0.9810 | 0.0150 | 0.8065 | 0.9778 | 0.9837 | 0.9946 |
| 2002 | 147 | 2.35% | 0.9793 | 0.9808 | 0.0090 | 0.9176 | 0.9768 | 0.9837 | 0.9944 |
| 2003 | 193 | 3.09% | 0.9764 | 0.9808 | 0.0220 | 0.8220 | 0.9773 | 0.9830 | 0.9931 |
| 2004 | 194 | 3.10% | 0.9788 | 0.9810 | 0.0108 | 0.8824 | 0.9787 | 0.9833 | 0.9930 |
| 2005 | 177 | 2.83% | 0.9794 | 0.9817 | 0.0163 | 0.8262 | 0.9797 | 0.9834 | 0.9920 |
| 2006 | 187 | 2.99% | 0.9804 | 0.9820 | 0.0090 | 0.9028 | 0.9796 | 0.9838 | 0.9921 |
| 2007 | 196 | 3.13% | 0.9790 | 0.9817 | 0.0233 | 0.7286 | 0.9796 | 0.9834 | 0.9916 |
| 2008 | 163 | 2.61% | 0.9792 | 0.9810 | 0.0107 | 0.8925 | 0.9781 | 0.9838 | 0.9939 |
| 2009 | 112 | 1.79% | 0.9794 | 0.9807 | 0.0090 | 0.9344 | 0.9774 | 0.9836 | 0.9953 |
| 2010 | 136 | 2.17% | 0.9805 | 0.9816 | 0.0062 | 0.9337 | 0.9785 | 0.9835 | 0.9913 |
| 2011 | 131 | 2.09% | 0.9802 | 0.9819 | 0.0097 | 0.9082 | 0.9796 | 0.9840 | 0.9940 |
| 2012 | 138 | 2.21% | 0.9812 | 0.9824 | 0.0066 | 0.9483 | 0.9797 | 0.9797 | 0.9931 |

**Panel C: M&A Index classified by industry**

| Industry | Observation | Percent | Mean | Median | Sd | Min | 25% | 75% | Max |
|---|---|---|---|---|---|---|---|---|---|
| Consumer durables | 118 | 1.89% | 0.9800 | 0.9812 | 0.0102 | 0.895 | 0.9812 | 0.9842 | 0.9930 |
| Consumer nondurables | 315 | 5.04% | 0.9809 | 0.9819 | 0.0074 | 0.9176 | 0.9819 | 0.9842 | 0.9927 |
| Business equipment | 1203 | 19.24% | 0.9775 | 0.9815 | 0.0198 | 0.6928 | 0.9815 | 0.9839 | 0.9946 |
| Chemical products | 173 | 2.77% | 0.9816 | 0.9815 | 0.0039 | 0.9684 | 0.9815 | 0.9845 | 0.9927 |
| Oil, Gas, and Coal | 216 | 3.45% | 0.9768 | 0.9804 | 0.0175 | 0.8262 | 0.9804 | 0.9831 | 0.9924 |
| Healthcare | 502 | 8.03% | 0.9785 | 0.9815 | 0.014 | 0.8601 | 0.9815 | 0.9838 | 0.9940 |
| Manufacturing | 546 | 8.73% | 0.9792 | 0.9811 | 0.0144 | 0.7808 | 0.9811 | 0.9836 | 0.9930 |
| Finance | 1875 | 29.98% | 0.9806 | 0.9814 | 0.0059 | 0.8755 | 0.9814 | 0.9832 | 0.9964 |
| Wholesale and retail | 470 | 7.52% | 0.9799 | 0.9813 | 0.0097 | 0.8851 | 0.9813 | 0.9838 | 0.9969 |
| Telephone and television | 188 | 3.01% | 0.9799 | 0.9818 | 0.012 | 0.8857 | 0.9818 | 0.984 | 0.9953 |
| Utilities | 108 | 1.73% | 0.9795 | 0.9817 | 0.0111 | 0.8927 | 0.9817 | 0.9833 | 0.9926 |
| Others | 540 | 8.63% | 0.9801 | 0.9812 | 0.0082 | 0.9187 | 0.9812 | 0.9843 | 0.9960 |

## Table 3 Descriptive statistics

Table 3 provides the descriptive statistics of variables for takeover deals in the full sample and the subsample classified by the value of M&A Index. The table lists the mean (number) and standard deviation (percent) of variables (dummy variables) for firm and deal characteristics. M&A Index is the measurement of takeover efficiency, calculated as a ratio of actual acquirers' announcement return over optimal announcement return (estimated by SFA). Definitions of variables are listed in the Appendix A. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

| Variables | Full sample (I) | | Low-efficiency deals (II) | | High-efficiency deals (III) | | Difference |
|---|---|---|---|---|---|---|---|
| | Mean (Number) | Standard deviation (percent) | Mean (Number) | Standard deviation (percent) | Mean (Number) | Standard deviation (percent) | (III)- (II) |
| **Panel A: Acquirer related** | | | | | | | |
| Market Value | 8562.2610 | 30415.9600 | 5410.0420 | 22071.1100 | 11713.5800 | 36652.3800 | 6303.5330*** |
| Tobin's Q | 3.0026 | 23.9070 | 2.5716 | 10.6347 | 3.4334 | 32.0883 | -0.8618 |
| Leverage | 0.1610 | 0.1705 | 0.1678 | 0.1751 | 0.1542 | 0.1655 | -0.0136*** |
| Return on Assets (ROA) | 0.0350 | 0.1183 | 0.0308 | 0.1279 | 0.0392 | 0.1077 | 0.0084*** |
| **Panel B: Target related** | | | | | | | |
| Market Value | 2853.0660 | 15288.8500 | 1589.5170 | 9162.8300 | 4105.3370 | 19471.0300 | 2515.8200*** |
| Tobin's Q | 2.4153 | 15.3577 | 2.1075 | 6.9847 | 2.7230 | 20.5610 | 0.6155* |
| Leverage | 0.1571 | 0.1924 | 0.1603 | 0.1959 | 0.1538 | 0.1888 | -0.0065 |
| Return on Assets (ROA) | -0.0120 | 0.6810 | -0.0254 | 0.9320 | 0.0015 | 0.2424 | 0.0269* |
| **Panel C: Deal related** | | | | | | | |
| M&A Index | 0.9795 | 0.0119 | 0.9754 | 0.0153 | 0.9846 | 0.0025 | 0.0093*** |
| Transaction value ($millions) | 773.5128 | 3510.8970 | 709.5833 | 3661.0230 | 837.4240 | 3353.4130 | 127.8407 |
| Premium (%) | 0.1204 | 1.5178 | 0.1381 | 1.9352 | 0.1026 | 0.9266 | -0.0355 |
| Hostile takeover | 242 | 3.87% | 124 | 3.97% | 118 | 3.77% | |
| Tender Offer | 1275 | 20.39% | 787 | 25.17% | 488 | 15.61% | |
| Toehold | 5132 | 82.06% | 2571 | 82.22% | 2561 | 81.90% | |
| Competing bid | 288 | 4.61% | 142 | 4.54% | 146 | 4.67% | |
| Diversification | 1328 | 21.23% | 614 | 19.64% | 714 | 22.83% | |
| Cash | 4032 | 64.47% | 1975 | 63.16% | 2057 | 65.78% | |
| Stock | 1292 | 20.66% | 560 | 17.91% | 732 | 23.41% | |
| **Number of observations** | 6254 | | 3127 | | 3127 | | |

## Table 4 Analysis for probability of deal completion

Table 4 presents analysis for the rate of successful deals. Panel A shows the M&A Index for successful and unsuccessful transactions. Panel B tabulates the probit regression results. The dependent variable is the dummy variable which equals 1 when the takeover deal is finally completed and equals 0 when the transactions are failed or withdrawn. The independent variable is the M&A Index calculated by stochastic frontier analysis (SFA). We also control the firm and deal characteristics. Definitions of variables are listed in the Appendix A. Fixed effects are considered in model 2, including industry and year fixed effects. Model 3 and model 4 incorporates acquirer clustering. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

**Panel A: Univariate analysis**

| Classification | Failed (I) | Completion (II) | Difference (II)-(I) |
|---|---|---|---|
| Mean | 0.9778*** | 0.9797*** | 0.0019*** |
| Standard Deviation | 0.0211 | 0.0107 | |
| Observation | 775 | 5479 | |

**Panel B: Multivariate analysis**

| Completion | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| M&A index | 5.2729*** | 4.5600*** | 4.8676*** | 4.5600*** |
| | (3.53) | (2.98) | (3.08) | (2.83) |
| Acquirer Tobin's Q | 0.0002 | 0.0003 | 0.0003 | 0.0003 |
| | (0.86) | (1.25) | (1.49) | (1.51) |
| Acquirer Price To Earnings | 0.0000 | 0.0002 | 0.0001 | 0.0002 |
| | (-0.04) | (0.44) | (0.64) | (1.01) |
| Acquirer Leverage | -0.0514 | -0.1464 | -0.0468 | -0.1464 |
| | (-0.55) | (-1.46) | (-0.44) | (-1.33) |
| Acquirer Cash Flow To Asset | 0.1802 | 0.2475 | 0.1111 | 0.2475 |
| | (0.82) | (1.13) | (0.53) | (1.19) |
| Target Tobin's Q | -0.0029 | -0.0018 | -0.0029 | -0.0018 |
| | (-1.04) | (-0.61) | (-1.31) | (-0.87) |
| Target Price To Earnings | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| | (0.24) | (0.08) | (0.05) | (0.10) |
| Target Leverage | 0.0094 | -0.0166 | 0.0169 | -0.0166 |
| | (0.13) | (-0.22) | (0.18) | (-0.16) |
| Target Cash Flow To Asset | -0.1156 | -0.1013 | -0.0902 | -0.1013 |
| | (-0.82) | (-0.72) | (-0.67) | (-0.75) |
| Relative deal size | -0.2465*** | -0.2439*** | -0.2544*** | -0.2439*** |
| | (-6.39) | (-6.11) | (-4.77) | (-4.71) |
| Hostile takeover | -1.6988*** | -1.6977*** | -1.7183*** | -1.6978*** |
| | (-15.96) | (-15.62) | (-15.58) | (-15.30) |
| Tender offer | 0.5901*** | 0.6383*** | 0.5961*** | 0.6383*** |
| | (9.03) | (9.41) | (8.04) | (8.54) |
| Pure Cash deal | -0.2846*** | -0.2833*** | -0.2692*** | -0.2833*** |
| | (-5.94) | (-5.28) | (-4.68) | (-4.91) |
| Competing bid | -0.8927*** | -0.9459*** | -0.9592*** | -0.9459*** |
| | (-9.63) | (-9.84) | (-9.16) | (-9.10) |
| Diversification | 0.0164 | 0.0315 | 0.0080 | 0.0315 |
| | (0.29) | (0.53) | (0.13) | (0.52) |
| Constant | -3.7407*** | -3.3872** | -3.5894** | -3.3872** |
| | (-2.56) | (-2.25) | (-2.31) | (-2.13) |
| Year-fixed-effects | No | Yes | Yes | Yes |
| Industry-fixed-effects | No | Yes | No | Yes |
| Firm clustering | No | No | Yes | Yes |
| Observations | 6254 | 6254 | 6254 | 6254 |
| Pseudo R2 | 0.132 | 0.170 | 0.163 | 0.170 |

## Table 5 Analysis for post-acquisition stock performance in the short-run

Table 5 shows analysis for post-acquisition stock performance in the short-run. In panel A, the full sample is divided into low-efficiency and high-efficiency subsamples based on M&A Index. Panel A presents short-run stock performance in low-efficiency and high-efficiency group. Panel B shows the regression results for post-acquisition performance in the short-run. The dependent variable is the cumulative abnormal return for acquirers over the period 3 days to 5 days after announcement day (ACAR (+3, +5)). The independent variable is the M&A Index calculated by stochastic frontier analysis (SFA). We also control the firm and deal characteristics. Definitions of variables are listed in the Appendix A. Fixed effects are considered in model 2, including industry and year fixed effects. Model 3 and model 4 incorporates acquirer clustering. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

**Panel A: Univariate analysis**

| **ACAR(+3,+5)** | **Low-efficiency (I)** | **High-efficiency (II)** | **Difference (II)-(I)** |
|---|---|---|---|
| Mean | -0.0582% | 0.0563% | 0.1145%*** |
| Standard Deviation | 0.0424 | 0.0488 | |
| Observation | 3127 | 3127 | |

**Panel B: Multivariate analysis**

| ACAR(+3,+5) | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| M&A index | 0.1704*** | 0.1861*** | 0.1857* | 0.1861* |
| | (3.64) | (3.95) | (1.65) | (1.66) |
| Acquirer Tobin's Q | -0.0001 | -0.0001 | 0.0000 | 0.0000 |
| | (-0.95) | (-0.92) | (-1.64) | (-1.43) |
| Acquirer Price To Earnings | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| | (0.47) | (0.31) | (0.92) | (0.84) |
| Acquirer Leverage | 0.0002* | 0.0002* | 0.0002* | 0.0002* |
| | (1.89) | (1.72) | (1.86) | (1.83) |
| Acquirer Cash Flow To Asset | 0.0038* | 0.0041* | 0.0037 | 0.0041 |
| | (1.70) | (1.80) | (0.96) | (1.06) |
| Target Tobin's Q | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| | (0.71) | (0.80) | (0.59) | (0.62) |
| Target Price To Earnings | -0.0001 | -0.0001 | 0.0000 | -0.0000* |
| | (-1.56) | (-1.51) | (-1.63) | (-1.70) |
| Target Leverage | -0.0002 | -0.0002 | -0.0002 | -0.0002 |
| | (-0.90) | (-0.93) | (-0.89) | (-0.81) |
| Target Cash Flow To Asset | -0.0003 | -0.0002 | -0.0002 | -0.0002 |
| | (-0.84) | (-0.76) | (-0.86) | (-0.81) |
| Relative deal size | 0.0007 | 0.0008 | 0.0007 | 0.0008 |
| | (1.03) | (1.19) | (0.61) | (0.73) |
| Hostile takeover | -0.0053 | -0.0056* | -0.0058* | -0.0056* |
| | (-1.62) | (-1.71) | (-1.91) | (-1.82) |
| Tender offer | -0.0008 | -0.0010 | -0.0012 | -0.0010 |
| | (-0.58) | (-0.68) | (-0.86) | (-0.71) |
| Pure Cash deal | 0.0025** | 0.0023* | 0.0025* | 0.0023* |
| | (2.11) | (1.81) | (1.87) | (1.70) |
| Competing bid | -0.0011 | -0.0014 | -0.00144 | -0.0014 |
| | (-0.39) | (-0.48) | (-0.50) | (-0.49) |
| Diversification | -0.0033** | -0.0037** | -0.0036** | -0.0037** |
| | (-2.31) | (-2.53) | (-2.33) | (-2.38) |
| Constant | -0.1681*** | -0.1892*** | -0.1860* | -0.1892* |
| | (-3.67) | (-4.09) | (-1.68) | (-1.71) |
| Year-fixed-effects | No | Yes | Yes | Yes |
| Industry-fixed-effects | No | Yes | No | Yes |
| Firm clustering | No | No | Yes | Yes |
| Observations | 6254 | 6254 | 6254 | 6254 |
| Adjust R2 | 0.004 | 0.009 | 0.009 | 0.009 |

## Table 6 long-run operating performance

Table 6 reports the relation between M&A Index and long-run operating performance after acquisitions. The dependent variable is average industry-adjusted ROA of acquirers for three years post-acquisition (IAROA). IAROA is bidder's return on assets, deducting median ROA in the industry with the same first two digits SIC code as acquirers'. The independent variable is the M&A Index calculated by stochastic frontier analysis (SFA). We also control the firm and deal characteristics. Definitions of variables are listed in the Appendix A. T-values are showed in the table. Fixed effects are considered in model 2, including industry and year fixed effects. Model 3 and model 4 incorporates acquirer clustering. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

| Average 3-year IAROA | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| M&A index | 1.4712*** | 1.2641*** | 1.2724*** | 1.2641*** |
| | (3.18) | (2.72) | (3.60) | (3.57) |
| Acquirer Tobin's Q | -0.0001 | 0.0001 | 0.0000 | 0.0001 |
| | (-0.14) | (0.49) | (1.00) | (1.33) |
| Acquirer Price To Earnings | -0.0001 | -0.0001 | 0.0000 | 0.0000 |
| | (-0.47) | (-0.45) | (-0.69) | (-0.77) |
| Acquirer Leverage | 0.0546** | 0.0591** | 0.0632** | 0.0591* |
| | (2.33) | (2.42) | (2.16) | (1.85) |
| Acquirer Cash Flow To Asset | 0.3650*** | 0.3586*** | 0.3519*** | 0.3586*** |
| | (6.74) | (6.49) | (4.55) | (4.69) |
| Target Tobin's Q | -0.0001 | 0.0001 | 0.0001 | 0.0001 |
| | (-0.02) | (0.21) | (0.11) | (0.22) |
| Target Price To Earnings | 0.0001 | 0.0002 | 0.0000 | 0.0000 |
| | (0.38) | (0.30) | (0.78) | (0.68) |
| Target Leverage | 0.0207 | 0.0236 | 0.0241* | 0.0236 |
| | (1.06) | (1.20) | (1.73) | (1.48) |
| Target Cash Flow To Asset | 0.0665** | 0.0765** | 0.0707** | 0.0765** |
| | (2.07) | (2.31) | (2.02) | (2.25) |
| Relative deal size | -0.0091 | -0.0073 | -0.0092* | -0.0073 |
| | (-1.37) | (-1.09) | (-1.85) | (-1.45) |
| Hostile takeover | 0.0048 | 0.0011 | 0.0000 | 0.0011 |
| | (0.15) | (0.03) | (-0.00) | (0.11) |
| Tender offer | 0.0118 | 0.0114 | 0.0094 | 0.0114 |
| | (0.85) | (0.80) | (0.78) | (0.84) |
| Pure Cash deal | 0.0149 | 0.0215* | 0.02175** | 0.0215*** |
| | (1.31) | (1.72) | (2.37) | (2.77) |
| Competing bid | 0.0110 | 0.0102 | 0.0112 | 0.0102 |
| | (0.39) | (0.36) | (0.78) | (0.71) |
| Diversification | 0.0051 | 0.0062 | 0.0057 | 0.0062 |
| | (0.37) | (0.44) | (0.73) | (0.86) |
| Constant | -2.153*** | -1.9785*** | -1.9812*** | -1.9785*** |
| | (-4.75) | (-4.33) | (-5.61) | (-5.60) |
| Year-fixed-effects | No | Yes | Yes | Yes |
| Industry-fixed-effects | No | Yes | No | Yes |
| Firm clustering | No | No | Yes | Yes |
| Observations | 6254 | 6254 | 6254 | 6254 |
| Adjust R2 | 0.016 | 0.026 | 0.024 | 0.026 |

## Table 7 Trading strategy

Table 7 shows the holding period return in panel A and monthly alpha for a trading strategy in panel B for trading strategy on M&A Index. The full sample is split into three portfolios on the basis of M&A Index of each deal. Portfolio 1 is the group with lowest indices which is the portfolio with inefficient deals. Portfolio 3 is the group with highest indices which is portfolio with efficient deals. Portfolio 2 is the group of those having neutral indices. To avoid the large movement in acquirers stocks due to the takeover announcement, we exclude the date announced and start to hold stocks from the day after the takeover announcement. Panel A reports the average holding period return over 1 to 6 months after announced day and the mean difference between each two portfolios. To calculate the monthly alpha, we adopt four models for benchmarking, including CAPM, Fama-French 3 factors, Fama-French 4 factors and Fama-French 5 factors. Panel B shows the monthly alpha for portfolios over different holding periods and the difference between each two groups. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

**Panel A: Holding period return**

| **Holding Period Return** | Portfolio (least efficient) (I) | Portfolio (II) | Portfolio (most efficient) (III) | Difference (II)-(I) | Difference (III)-(II) | Difference (III)- (I) |
|---|---|---|---|---|---|---|
| Holding 1 month | -0.0184*** | 0.0207*** | 0.0604*** | 0.0391*** | 0.0397*** | 0.0789*** |
| Holding 2 months | -0.0082*** | 0.0308*** | 0.0676*** | 0.0390*** | 0.0369*** | 0.0759*** |
| Holding 3 months | 0.0067*** | 0.0446*** | 0.0797*** | 0.0380*** | 0.0351*** | 0.0731*** |
| Holding 4 months | 0.0067*** | 0.0510*** | 0.0864*** | 0.0442*** | 0.0354*** | 0.0796*** |
| Holding 5 months | 0.0299*** | 0.0736*** | 0.0969*** | 0.0437*** | 0.0233*** | 0.0670*** |
| Holding 6 months | 0.0365*** | 0.0839*** | 0.1057*** | 0.0474*** | 0.0217** | 0.0692*** |
| Observation | 2085 | 2085 | 2084 | | | |

**Panel B: Monthly alpha for various models**

| Monthly Alpha | Model | Portfolio (least efficient) (I) | Portfolio (II) | Portfolio (most efficient) (III) | Difference (II)-(I) | Difference (III)-(II) | Difference (III)- (I) |
|---|---|---|---|---|---|---|---|
| **Holding 1 month** | Alpha_CAPM | 0.0264*** | 0.0451*** | 0.1173*** | 0.0187*** | 0.0721*** | 0.0908*** |
| | Alpha_FF3 | 0.0205*** | 0.0459*** | 0.1141*** | 0.0254*** | 0.0682*** | 0.0936*** |
| | Alpha_FF4 | 0.0202*** | 0.0474*** | 0.1172*** | 0.0272*** | 0.0698*** | 0.0970*** |
| | Alpha_FF5 | -0.3937*** | -0.3715*** | -0.3407*** | 0.0222*** | 0.0308*** | 0.0531*** |
| **Holding 2 months** | Alpha_CAPM | 0.0131*** | 0.0203*** | 0.0444*** | 0.0072*** | 0.0241*** | 0.0313*** |
| | Alpha_FF3 | 0.0074*** | 0.0175*** | 0.0434*** | 0.0101*** | 0.0259*** | 0.0360*** |
| | Alpha_FF4 | 0.0086*** | 0.0193*** | 0.0410*** | 0.0107*** | 0.0217*** | 0.0324*** |
| | Alpha_FF5 | -0.3885*** | -0.3709*** | -0.3481*** | 0.0176*** | 0.0229*** | 0.0404*** |
| **Holding 3 months** | Alpha_CAPM | 0.0038*** | 0.0101*** | 0.0250*** | 0.0063*** | 0.0149*** | 0.0212*** |
| | Alpha_FF3 | -0.0001*** | 0.0085*** | 0.0249*** | 0.0086*** | 0.0164*** | 0.0250*** |
| | Alpha_FF4 | 0.0008*** | 0.0100*** | 0.0229*** | 0.0091*** | 0.0129*** | 0.0220*** |
| | Alpha_FF5 | -0.3851*** | -0.3708*** | -0.3497*** | 0.0142*** | 0.0212*** | 0.0354*** |
| **Holding 4 months** | Alpha_CAPM | 0.0009*** | 0.0062*** | 0.0170*** | 0.0053*** | 0.0108*** | 0.0161*** |
| | Alpha_FF3 | -0.0021*** | 0.0051*** | 0.0171*** | 0.0072*** | 0.0120*** | 0.0192*** |
| | Alpha_FF4 | -0.0013*** | 0.0063*** | 0.0154*** | 0.0077*** | 0.0091*** | 0.0167*** |
| | Alpha_FF5 | -0.3816*** | -0.3707*** | -0.3502*** | 0.0109*** | 0.0206*** | 0.0315*** |
| **Holding 5 months** | Alpha_CAPM | -0.0002*** | 0.0043*** | 0.0127*** | 0.0045*** | 0.0084*** | 0.0130*** |
| | Alpha_FF3 | -0.0027*** | 0.0035*** | 0.0129*** | 0.0062*** | 0.0094*** | 0.0156*** |
| | Alpha_FF4 | -0.0021*** | 0.0045*** | 0.0114*** | 0.0066*** | 0.0069*** | 0.0135*** |
| | Alpha_FF5 | -0.3795*** | -0.3699*** | -0.3515*** | 0.0096*** | 0.0184*** | 0.0280*** |
| **Holding 6 months** | Alpha_CAPM | -0.0007*** | 0.0032*** | 0.0101*** | 0.0039*** | 0.0069*** | 0.0109*** |
| | Alpha_FF3 | -0.0028*** | 0.0026*** | 0.0103*** | 0.0054*** | 0.0078*** | 0.0132*** |
| | Alpha_FF4 | -0.0023*** | 0.0034*** | 0.0090*** | 0.0057*** | 0.0056*** | 0.0113*** |
| | Alpha_FF5 | -0.3774*** | -0.3683*** | -0.3509*** | 0.0091*** | 0.0174*** | 0.0265*** |
| Observation | | 2085 | 2085 | 2084 | | | |

## Table 8 Trading strategy classified by industry

Table 8 shows holding period return in panel A and monthly alpha for a trading strategy in panel B for trading strategy on M&A Index, classified by industry. The full sample is split into 3 portfolios on the basis of M&A Index of each deal. Portfolio 1 is the group with lowest indices which is the portfolio with inefficient deals. Portfolio 3 is the group with highest indices which is the portfolio with efficient deals. Portfolio 2 is the group of those having neutral indices. To avoid the large movement in acquirers stocks due to the takeover announcement, we exclude the date announced and start to hold stocks from the day after the takeover announcement. Panel A reports the average holding period return over 1 to 6 months after announced day and the mean difference between each two portfolios. To calculate the monthly alpha, we adopt four models for benchmarking, including CAPM, Fama-French 3 factors, Fama-French 4 factors and Fama-French 5 factors. Panel B shows the monthly alpha for portfolios over different holding periods and the difference between each two groups. The industry classification is according to Fama-French 12 industry classification. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

**Panel A: Holding period return**

| **Holding Period Return for Industry** | Portfolio (least efficient) (I) | Portfolio (II) | Portfolio (most efficient) (III) | Difference (II)-(I) | Difference (III)-(II) | Difference (III)- (I) |
|---|---|---|---|---|---|---|
| **Telephone and Television** | -0.0607*** | 0.0254*** | 0.0731*** | 0.0861*** | 0.0477 | 0.1338*** |
| observation | 78 | 77 | 75 | | | |
| **Oil, Gas, and Coal** | -0.0843*** | 0.0350*** | 0.0500*** | 0.1193*** | 0.015 | 0.1343*** |
| observation | 84 | 82 | 81 | | | |
| **Consumer Durables** | -0.0184*** | 0.0207*** | 0.0604*** | 0.0288 | 0.0732** | 0.1020*** |
| observation | 54 | 52 | 58 | | | |
| **Business Equipment** | -0.0333*** | 0.0165*** | 0.0639*** | 0.0498*** | 0.0475*** | 0.0972*** |
| observation | 388 | 380 | 381 | | | |
| **Manufacturing** | -0.0115*** | 0.0244*** | 0.0612*** | 0.0359*** | 0.0369*** | 0.0727*** |
| observation | 173 | 172 | 170 | | | |
| **Chemicals Products** | -0.0264*** | 0.0189*** | 0.0618*** | 0.0453** | 0.0429** | 0.0882*** |
| observation | 70 | 68 | 73 | | | |
| **Consumer Non-Durables** | -0.0071*** | 0.0201*** | 0.0734*** | 0.0273 | 0.0533*** | 0.0805*** |
| observation | 103 | 99 | 105 | | | |
| **Healthcare** | -0.0284*** | 0.0173*** | 0.0584*** | 0.0457*** | 0.0411*** | 0.0868*** |
| observation | 168 | 174 | 165 | | | |
| **Wholesale and retail** | 0.0057*** | 0.0278*** | 0.0821*** | 0.022 | 0.0544*** | 0.0764*** |
| observation | 163 | 166 | 164 | | | |
| **Finance** | -0.0058*** | 0.0170*** | 0.0440*** | 0.0228*** | 0.0271*** | 0.0498*** |
| observation | 576 | 589 | 594 | | | |
| **Utilities** | -0.0094*** | 0.0154*** | 0.0294*** | 0.0249 | 0.014 | 0.0389** |
| observation | 51 | 59 | 57 | | | |
| **Other** | -0.0174*** | 0.0322*** | 0.0868*** | 0.0497*** | 0.0546*** | 0.1042*** |
| observation | 177 | 179 | 181 | | | |

**Panel B: Monthly alpha**

| **Monthly alpha for Industry** | Portfolio (least efficient) (I) | Portfolio (II) | Portfolio (most efficient) (III) | Difference (II)-(I) | Difference (III)-(II) | Difference (III)- (I) |
|---|---|---|---|---|---|---|
| **Telephone and Television** | -0.2987*** | 0.0806*** | 0.0306*** | 0.3794*** | -0.0501*** | 0.3293*** |
| observation | 78 | 77 | 75 | | | |
| **Oil, Gas, and Coal** | -0.1771*** | 0.0296*** | -0.1111*** | 0.2067*** | -0.1406*** | 0.0661*** |
| observation | 84 | 82 | 81 | | | |
| **Consumer Durables** | 0.0097*** | -0.0522*** | 0.0251*** | -0.0619*** | 0.0773*** | 0.0154** |
| observation | 54 | 52 | 58 | | | |
| **Business Equipment** | 0.0547*** | 0.0795*** | 0.1231*** | 0.0248*** | 0.0435*** | 0.0683*** |
| observation | 388 | 380 | 381 | | | |
| **Manufacturing** | -0.0194*** | 0.0191*** | 0.1379*** | 0.0385*** | 0.1188*** | 0.1573*** |
| observation | 173 | 172 | 170 | | | |
| **Chemicals Products** | 0.0102*** | 0.0765*** | 0.0942*** | 0.0663*** | 0.0177*** | 0.0840*** |
| observation | 70 | 68 | 73 | | | |
| **Consumer Non-Durables** | -0.0628*** | -0.0531*** | 0.1320*** | 0.0097** | 0.1851*** | 0.1948*** |
| observation | 103 | 99 | 105 | | | |
| **Healthcare** | -0.0056*** | 0.0456*** | 0.1530*** | 0.0512*** | 0.1075*** | 0.1587*** |
| observation | 168 | 174 | 165 | | | |
| **Wholesale and retail** | -0.0312*** | 0.0049*** | 0.1757*** | 0.0361*** | 0.0544*** | 0.2068*** |
| observation | 163 | 166 | 164 | | | |
| **Finance** | 0.0970*** | 0.0662*** | 0.1315*** | -0.0309*** | 0.0654*** | 0.0345*** |
| observation | 576 | 589 | 594 | | | |
| **Utilities** | 0.0999*** | 0.0154*** | -0.0569*** | 0.0383*** | -0.1952*** | -0.1568*** |
| observation | 51 | 59 | 57 | | | |
| **Other** | 0.0056*** | 0.0270*** | 0.1137*** | 0.0214*** | 0.0867*** | 0.1081*** |
| observation | 177 | 179 | 181 | | | |

## Table 9 Trading strategy classified by year

Table 9 shows holding period return in panel A and monthly alpha for a trading strategy in panel B for trading strategy on M&A Index, classified by industry. The full sample is split into 3 portfolios on the basis of M&A Index of each deal. Portfolio 1 is the group with lowest indices which is the portfolio with inefficient deals. Portfolio 3 is the group with highest indices which is the portfolio with efficient deals. Portfolio 2 is the group of those having neutral indices. To avoid the large movement in acquirers stocks due to the takeover announcement, we exclude the date announced and start to hold stocks from the day after the takeover announcement. Panel A reports the average holding period return over 1 to 6 months after announced day and the mean difference between each two portfolios. To calculate the monthly alpha, we adopt four models for benchmarking, including CAPM, Fama-French 3 factors, Fama-French 4 factors and Fama-French 5 factors. Panel B shows the monthly alpha for portfolios over different holding periods and the difference between each two groups. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

**Panel A: Holding period return**

| **Holding Period Return for year** | Portfolio (least efficient) | Portfolio | Portfolio (most efficient) | Difference | Difference | Difference |
|---|---|---|---|---|---|---|
| | (I) | (II) | (III) | (II)-(I) | (III)-(II) | (III)- (I) |
| **1980-1984** | -0.0215*** | -0.0095*** | 0.0732*** | 0.0121 | 0.0826*** | 0.0947*** |
| observation | 98 | 93 | 85 | | | |
| **1985-1989** | -0.0262*** | 0.0246*** | 0.0702*** | 0.0508*** | 0.0456*** | 0.0964*** |
| observation | 204 | 202 | 206 | | | |
| **1990-1994** | -0.0104*** | 0.0107*** | 0.0624*** | 0.0211* | 0.0517*** | 0.0728*** |
| observation | 273 | 264 | 263 | | | |
| **1995-1999** | -0.0112*** | 0.0248*** | 0.0556*** | 0.0360*** | 0.0308*** | 0.0668*** |
| observation | 621 | 636 | 626 | | | |
| **2000-2004** | -0.0202*** | 0.0344*** | 0.0644*** | 0.0546 | 0.0300*** | 0.0846*** |
| observation | 441 | 440 | 448 | | | |
| **2005-2009** | -0.0333*** | 0.0059*** | 0.0489*** | 0.0386*** | 0.0430*** | 0.0816*** |
| observation | 289 | 295 | 293 | | | |
| **2010-2012** | -0.0148*** | 0.0191*** | 0.0642*** | 0.0339*** | 0.0450*** | 0.0789*** |
| observation | 159 | 154 | 163 | | | |

**Panel B: Monthly alpha**

| **Monthly alpha for year** | Portfolio (least efficient) | Portfolio | Portfolio (most efficient) | Difference | Difference | Difference |
|---|---|---|---|---|---|---|
| | (I) | (II) | (III) | (II)-(I) | (III)-(II) | (III)- (I) |
| **1980-1984** | -0.0384*** | 0.0521*** | 0.1448*** | 0.0906*** | 0.0927*** | 0.1833*** |
| observation | 98 | 93 | 85 | | | |
| **1985-1989** | 0.0159*** | 0.0198*** | 0.1199*** | 0.0039 | 0.1001*** | 0.1040*** |
| observation | 204 | 202 | 206 | | | |
| **1990-1994** | 0.0422*** | 0.0642*** | 0.1716*** | 0.0220*** | 0.1074*** | 0.1294*** |
| observation | 273 | 264 | 263 | | | |
| **1995-1999** | 0.0367*** | 0.0375*** | 0.0900*** | 0.0009 | 0.0525*** | 0.0533*** |
| observation | 621 | 636 | 626 | | | |
| **2000-2004** | 0.0518*** | 0.1128*** | 0.1719*** | 0.0610*** | 0.0591*** | 0.1210*** |
| observation | 441 | 440 | 448 | | | |
| **2005-2009** | -0.0624*** | 0.0229*** | 0.0353*** | 0.0852*** | 0.0124*** | 0.0976*** |
| observation | 289 | 295 | 293 | | | |
| **2010-2012** | 0.0287*** | -0.0129*** | 0.1168*** | -0.0416*** | 0.1297*** | 0.0881*** |
| observation | 159 | 154 | 163 | | | |

**Appendix A**

| Variables | Definitions |
|---|---|
| | Panel A: Key independent variables |
| M&A Index | M&A Index is the measurement of takeover efficiency, calculated as a ratio of actual acquirers' announcement return over optimal acquirers' announcement return (estimated by Stochastic Frontier Analysis). |
| | Panel B: Post-acquisition performance |
| ACAR(+3,+5) | ACAR (+3, +5) refers to the cumulative abnormal return for acquirers over the period 3 days to 5 days after announcement day. This variable is calculated by the market model (Brown and Warner, 1985) with value-weighted CRSP index as a benchmark for market return and an estimation period starting 200 trading days and ending 20 trading days before the M&A deal announcement. |
| Industry-adjusted Return on Asset of acquirer (A_IAROA) | A_ IAROA is bidder's return on assets (ROA), deducting median ROA in the industry with the same first 2-digit SIC code as acquirers'. |
| | Panel C: Firm characteristics |
| Tobin's Q | Tobin's Q is computed as the ratio of market value to book value of the company's assets. |
| Market Value (MV) | The market value is calculated as the number of shares outstanding multiplied by the respective stock price at 4 weeks before the official deal announcement. |
| Leverage | Leverage ratio is total debt, which is the sum of long-term debt and short-term debt, divided by firm's total asset. |
| Return on Assets (ROA) | ROA is computed as the ratio of the company's net income by the book value of total assets. |
| Price to earnings | Price to earnings is calculated as share price four weeks before announcement divided by earnings per share excluding extraordinary items. |
| Cash flow to asset | Cash flow to asset is a ratio of cash flow over total assets. Cash flow is operating income before extraordinary items, adding depreciation and subtracting dividends paid to shareholders. |
| | Panel D: Deal characteristics |
| Transaction value ($millions) | Transaction value refers to the total value of consideration paid by the acquirer in order to obtain the target. We report the total dollar value as reported by Thomson One. |
| Premium (%) | Premium is defined as the offer price, as the log percentage difference from target's share price four weeks before the M&A deal announcement (Baker et al. 2012). |

| | |
|---|---|
| Relative deal size | Relative deal size is computed as the transaction value divided by the market capitalization of the acquirer, four weeks before the official deal announcement. |
| Hostile takeover | Dummy variable that equals 1 if the M&A deal is reported as hostile. |
| Tender offer | Dummy variable that equals 1 when the acquisition is reported as tender offer |
| Toehold | Dummy variable that equals 1 when bidder owns target shares before takeover transaction |
| Competing bid | Dummy variable that equals 1 if the M&A deal involves multiple bidders. |
| Cash | Dummy variable that equals 1 if the M&A deal is paid entirely by cash. |
| Stock | Dummy variable that equals 1 if the M&A deal is paid entirely by stocks. |
| Diversification | Dummy variable that equals 1 when the first two digits of acquirer SIC are different from the first two digits of target SIC. |