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Indexing Mergers and Acquisitions

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Indexing Mergers and Acquisitions

By* GANG JIANHUA, GUO JIE AND LI XI

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Abstract

This paper introduces an index to measure the efficiency of mergers and acquisitions. The Merger and Acquisition Index is able to evaluate and forecast merger outcomes for acquiring firms. It is calculated for each takeover deal based on the stochastic frontier analysis. The value of the M&A index is standardized between 0 and 1, and a deal with a higher index encompasses higher efficiency. Empirical results suggest takeover bids with higher M&A indices are more likely to succeed. Moreover, M&A index shows strong and positive relation with acquirers' short-run stock performance and long-run operating performance. After constructing three portfolios under a buy-and-hold strategy, efficient portfolios with the highest indices earn higher equity returns and monthly alphas than inefficient portfolios with the lowest indices.

JEL Classification: G34, G11

Key words: Mergers and Acquisitions; Stochastic Frontier Analysis (SFA); Efficiency

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1. Introduction

Does an acquirer efficiently take over the target? Does the efficiency of acquisition imply any significant post-acquisition performance in the short-run or in the long-run, and how? Questions as such have strong economic and trading implications. It is therefore a necessity to re-evaluate acquisition from a bird's eye view. 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] (such as probability of deal completion, bid premium, announcement return) 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 on the subject of takeover quality[4].

Consolidating and simplifying information from a complex process into a certain composite index is a superior approach when researchers are to standardize diverse empirical results so as to do comparisons. Therefore, the approach of indexing to analyse economic behaviour 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 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 own 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.

In general, as one of the largest corporate investment behaviours, M&A deals tend to exert strong and long-lasting influence on firms' operating and financial performance. Recent academic studies and financial practices tend to focus on understanding deal characteristics as well as corporate fundamentals, and pay closer attention to market reaction in order to predict possible outcomes both in the short run and long run. However, documented empirical results in this field are mixed due to the complication of takeover activities. Therefore, an indicator, which is able to accurately gauge an overall takeover quality, is needed to effectively evaluate and forecast financial consequences of acquisitions. This study is among very few studies that try to fulfil this task and hence enrich literature in this field.

We start the M&A indexing by firstly introducing the concept of "takeover

[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.

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 public. In a market of strong-form efficiency (Fama, 1965), stock price on announcement day reflects market reaction and expectation to the takeover transaction. Higher announcement return indicates market is optimistic towards the deal. Acquisition is an efficient and quick tactic for acquirers to develop and expand their business. Acquirers 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 get good feedback from the market, which is an optimal and maximized announcement return of bidders. However, the actual announcement return is sometimes less than the optimal gain due to various factors of inefficiencies, including agency problem 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 takeover efficiency suggests the actual announcement return is closer to optimal market reaction, implying that acquirers can gain better post-acquisition performance. Accordingly, the M&A index is developed in order to directly and quantitatively scoring the degree of efficiency of each takeover deal. By design, the M&A index is forward-looking and includes information of the probability of deal completion, announcement return in the short run and post-acquisition operating performance in the long run.

To build the M&A index, the stochastic frontier analysis (SFA) approach[8] is adopted. In this paper, the SFA is implemented to measure the deviation from an optimal market reaction to acquirers' takeover announcement. Hence, the SFA provides a benchmark of takeover efficiency. In our SFA approach, the acquirer's announcement return is examined as an output to quantify possible acquisition impact. Specifically, market optimism towards the takeover 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. This paper only considers 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 a technical efficiency[9] of frontier models and can be regarded 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 any of the

[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] The reason why we adopt acquirers' announcement return rather than target's or combined firms' return is that acquirer generally has much larger size than target. 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.

[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]See Aigner et al., 1977; Meeusen and van denkBroeck, 1977.

[9]Technical efficiency in SFA is measured as firm's actual output over maximum output value.

inefficiency factors. The value of the M&A index ranges from 0 to 1[10]. 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 the M&A index accurately measures the takeover efficiency and forecasts the post-acquisition performance. Particularly, the spectrum of its prediction includes the probability of deal completion and duration of the deal. Surprisingly, the M&A index positively correlates with the completion rate, signalling deals with higher indices are more likely to be successful. Additionally, deals with higher M&A indices tend to have better post-acquisition performance 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: A. Portfolio of most efficient deals; B. Portfolio of least efficient deals; C. Portfolio of the deals of moderate efficiency. Results show that acquirers in Portfolio A earn much higher returns and monthly alphas than the ones in Portfolio B. This superior performance is significant and also robust to different asset pricing models[11]. Specifically, Portfolio A earns 7% higher than Portfolio B for one to six-month holding periods. Monthly alpha of Portfolio A also dominates B 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 very first one to develop a methodology to score the efficiency for takeovers. The M&A index may also be used to forecast merger outcomes, and thereby financial practitioners can evaluate acquisitions in a much simpler way and researchers can treat the M&A index as a factor of measuring the impact of acquisitions in asset pricing models.

The contribution of this paper is four-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, the index may be useful to create trading strategies based on anticipations of M&A outcomes; fourth, 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 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

[10]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 'optimalannouncement return is larger than the actual announcement return. Therefore, M&A index which equals to $\frac{acquirer\ s'actual\ \ announcement\ \ \ return}{acquirer\ s'optiamal\ \ announcement\ \ \ return}$, is limited to 1.

[11] 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.

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 before and 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 higher probability of dealcompletion.

Olson and Pagano (2005) illustrate that short-term stock reaction reflect 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 announcement, which shows market response to acquisition between acquirers and targets. 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 more cumulative abnormal return than the firms with lower indices in the short term after acquisition.

Andrade et al. (2001) indicate that post-merger operating performance reflects whether acquirers eventually obtain expected gain at announcement. Therefore, long-run operating performance signifies the takeover quality and synergy gain to acquirers. Deals with higher M&A index represent that market participants are 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 information is released. Therefore, acquirers' stock prices[12] on the announcement day would reflect the market reaction and expectation to the acquisition, including the probability of deal completion and the post-acquisition performance.

Higher acquirers' announcement returns suggest that market is optimistic towards

[12]The reason why acquirers' stock performance is considered not combined firms is that 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.

the merger outcomes. Takeover is an efficient investment strategy for acquirers to grow business and enhance competiveness. 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, which is the optimal announcement return for bidding firms. However, the actual 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, agency problem in acquirers, resistance from targets' management and overpayment for the target[13]. A smaller difference between the actual and optimal announcement returns indicates less agency problems in takeover transactions, and therefore implies a better merger quality.

In this paper, we define the takeover efficiency as that acquisition maximizes the acquirers' announcement return. High-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.

3.1.2 Constructing a benchmark for takeover efficiency

To estimate the takeover efficiency, we start with an optimal acquirers' announcement return, which is obtained by the production function in the stochastic frontier analysis (SFA) (Aigner et al., 1977).The optimal acquirers' announcement return can be estimated as follows:

$$ACQ\_RET_i = f(\mathrm{X}_i\ , \beta)\exp(\varepsilon_i) \tag{1}$$

whereACQ_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.β is a vector of the estimated coefficients.$\varepsilon_i$is a composite error component.

$$ACQ\_RET_i = \frac{Ret_i}{E(R_{it})} \tag{2}$$

$$E(R_{it}) = \beta_0 + \beta_i R_{mt} + \xi_i \tag{3}$$

where$E(R_{it})$is the expectation of return calculated by the market model(Brown and Warner, 1985).$R_{it}$is the rate ofreturn for thei^{th}ith.Firm on day *t* from CRSP, R_{mt} is the market value-weighted excess return on day *t* from CRSP. We obtain the abnormal return by subtracting the estimated return from the actual rate of return for firm *i*on day *t*.

Herein, ACQ_RET_i[14]is the output of production frontier, computed as a ratio of the acquirer's return on announcement day over the predicted return. 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 market return over estimation period to obtain coefficients. Next, we select a vector of inputs which affects the acquirers' announcement return to consider different characteristics of acquisition partners and acquisition transactions. These inputs are often included in the previous M&A literatures as control variables. Definitions of our input variables are listed in

[13]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.

[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.

the Appendix A. We then take a logarithmic transformation[15] of equation (1) and include dummy variables to characterize deals.

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

$$\ln(ACQ\_RET_i) = \beta_0 + \beta_1 \ln(Acquirer\ M/B_i) + \beta_2 \ln(Acquirer\ leverage_i) + \beta_3 \ln(Acquirer\ MV_i) + \beta_4 \ln(Target\ M/B_i) + +\beta_5 \ln(Target\ leverage_i) + \beta_6 \ln(TransactionValue_i) + \beta_7\ Hostile + \beta_8\ Tender + \beta_9\ Toehold + \beta_{10}\ Stock + \beta_{11} Competing + \beta_{12}\ Diversification + \varepsilon_i \quad (4)$$

$$\varepsilon_i = v_i - \mu_i \quad (5)$$

Where ε_i is error term, v_i isthe idiosyncratic component for the i^{th} deal, u_i is a one-side error with one-side distribution for inefficiency in the i^{th} deal. v_i is systematically distributed with Gaussian $v_i \sim N(0, \sigma_v^2)$. In SFA, error term ε_i is decomposed 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 andcan be reduced or even eliminated. In this paper, we assume an 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, such as acquirers' hubris CEO, empire building[16], and overpayment etc. 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 by maximum likelihood estimation (MLE) and ordinary least square (OLS). A likelihood-ratio test is then conducted to examine whether inefficiency exists in the takeover transactions.

Table 1 Estimation of M&A index

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)

[15]In SFA, log transformation is commonlyapplied due to the concern of skewness in the sample.

[16] 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.

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

Note: 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 stochastic frontier analysis (SFA). The variables are same in the ordinary least square (OLS). M/B is a ratio of market value over book value of firms' asset (Lang et al., 1989). Leverage ratio is total debt, which is the sum of long-term debt and short-term debt, divided by firm's total asset. Transaction value ($million) is total value that acquirers pay for the deal, deducting expenses and fees (Thomson One). Hostile is a dummy variable that equals 1 when the deal attitude is hostile (Thomson One). Tender offer is a dummy variable that equals 1 when the acquisition is tender offer (Thomson One). Toehold is a dummy variable that equals 1 when bidder owns target shares before takeover transaction. Stock is a dummy variable that equals to 1 when the deal is paid 100% with stocks. Competing is a dummy variable that equals 1 when acquisition is involved with multiple bidders. Diversification is a dummy variable that equals 1 when the first-two digits of acquirer SIC are different from the first-two digits of target SIC. T-values are showed in the table. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

Table 1 tabulates coefficients of the independent variables for the production function. We also include estimation 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 exit. A series of likelihood-ratio tests are then conducted to examine the existence of any inefficiency. The null hypothesis that inefficiency does not exist is rejected at 1% level. Moreover, a ratio of lambda,$\lambda = \sigma_u/\sigma_v$,is calculated standing forthe standard deviation of inefficiency against the standard deviation of a random shock. Herein, *lambda* λ 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 of 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 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:

$$\text{M\&A Index} = \exp\{-u_i\} = \frac{E(\,ACQ\_RET_i|\widehat{\mu_i}\ ,\ X_i\,)}{E(\,ACQ\_RET_i{}^*|\widehat{\mu_i}=0,\ X_i\,)} = \frac{ACQ\_RET_i}{ACQ\_RET_i{}^*}$$

whereu_i represents a one-side error for inefficiency in thei^{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，ceteris paribus. 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 collected 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 are 28,065 including both successful and failed transactions. We drop the takeover deals worth less than $1 million. We also require that acquirer take over control of targets (own more than 50% of targets' stake) after acquisitions. And it leaves us with14,706 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.

Table 2 descriptive data

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

Note: Table 2 lists the descriptive data for M&A index. Specifically, 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.

We then estimate the M&A index for each takeover deals. 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 [17] indicates that acquisitions are usually quite efficient. This could be explained bythe 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.

Panel B shows M&A index and the number of acquisition distributed by year. In general, the difference of the M&A index is little among deals for each year. There is a merger"boom"between1994 and2000, 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) are generally much lower, indicating that acquisitions driven by the merger boom are less efficient due to more irrational decision made by acquirers. Moreover, takeover efficiency is negatively affected by financial crisis. Lower M&A indices are very frequently around the year 2008.

In panel C, 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.

[17]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.

Table 3 Descriptive statistics

Variables	Full sample (I)		Low-efficiencydeals (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***
M/B	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***
M/B	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
Time to resolution (in days)	201.9520	325.5927	174.8626	256.4156	228.9165	380.3411	54.0539***
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		

Note: Table 3 provides the descriptive statistics of variables for takeover deals in the full sample and in 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). Market value is calculated as the number of shares outstanding multiplied by the respective stock price at 4 weeks before the official deal announcement. M/B is a ratio of market value over book value of firms' asset (Lang et al., 1989). 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 Asset (ROA) is computed as the ratio of the company's net income by the book value of total assets (Yermack, 1996) Transaction value ($million) is total value that acquirers pay for the deal, deducting expenses and fees (Thomson One). Premium is defined as the offer price, as the log percentage difference from target's share price 4 weeks before the M&A deal announcement (Baker et al. 2012). Time to resolution is the duration of deal, computed as the difference between date of deal announcement and the date when the deal completes (fails). Hostile is a dummy variable that equals 1 when the deal attitude is hostile (Thomson One). Tender offer is a dummy variable that equals to 1 when the acquisition is tender offer (Thomson One). Toehold is a dummy variable that equals to 1 when bidder owns target shares before takeover transaction. Competing bid is a dummy variable that equals 1 when acquisition is involved with multiple bidders. Diversification is a dummy variable that equals 1 when the first-two digits of acquirer SIC are different from the first-two digits of target SIC. Cash is a dummy variable that equals 1 if the M&A deal was paid entirely by cash.Stock is a dummy variable that equals 1 when the deal is paid 100% with stocks. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

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 premium than bidding firms in deals with low efficiency. Our findings suggest that the M&A index performs as a measurement for merger outcomes. 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 of 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 0.9778on 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.

Table 4 Analysis for probability of deal completion

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
M&A index	5.2729***	4.5600***
	(3.53)	(2.98)
Acquirer Tobin's Q	0.0002	0.0003
	(0.86)	(1.25)
Acquirer Price To Earnings	0.0000	0.0002
	(-0.04)	(0.44)
Acquirer Leverage	-0.0514	-0.1464
	(-0.55)	(-1.46)
Acquirer Cash Flow To Asset	0.1802	0.2475
	(0.82)	(1.13)
Target Tobin's Q	-0.0029	-0.0018
	(-1.04)	(-0.61)
Target Price To Earnings	0.0001	0.0000
	(0.24)	(0.08)
Target Leverage	0.0094	-0.0166
	(0.13)	(-0.22)

Target Cash Flow To Asset	-0.1156	-0.1013
	(-0.82)	(-0.72)
Relative deal size	-0.2465***	-0.2439***
	(-6.39)	(-6.11)
Hostile takeover	-1.6988***	-1.6977***
	(-15.96)	(-15.62)
Tender offer	0.5901***	0.6383***
	(9.03)	(9.41)
Cash	-0.2846***	-0.2833***
	(-5.94)	(-5.28)
Competing bid	-0.8927***	-0.9459***
	(-9.63)	(-9.84)
Diversification	0.0164	0.0315
	(0.29)	(0.53)
Constant	-3.7407***	-3.3872**
	(-2.56)	(-2.25)
Firm-fixed-effects	No	Yes
Year-fixed-effects	No	Yes
Industry-fixed-effects	No	Yes
Observations	6254	6254
Pseudo R2	0.132	0.170

Note: Table 4 presents analysis for 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 to 0 when the transactions is 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. Tobin's Q is computed as the ratio of market value by book value of the company's assets. Price to earnings is calculated as share price 4 weeks before announcement divided by earnings per share excluding extraordinary items. Leverage ratio is total debt, which is the sum of long-term debt and short-term debt, divided by firm's total 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. Relative deal size is computed as the transaction value divided by the market capitalization of the acquirer, 4 weeks before the official deal announcement. Hostile is a dummy variable that equals 1 when the deal attitude is hostile (Thomson One). Tender offer is a dummy variable that equals 1 when the acquisition is tender offer (Thomson One). Cash is a dummy variable that equals 1 if the M&A deal was paid entirely by cash. Competing is a dummy variable that equals 1 when acquisition is involved with multiple bidders. Diversification is a dummy variable that equals 1 when the first-two digits of acquirer SIC are different from the first-two digits of target SIC. T-values are showed in the table. Fixed effects are considered in model 2, including firm, industry and year fixed effects. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

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 deal is successfully completed, or zero otherwise. The independent variable is the M&A index. We also control variables for firm and deal characteristics, which are commonly used in previous M&A literatures. In panel B, coefficients on M&A index are positive and significant at 1% in model 1 and model 2, which supports findings in the univariate analysis. Therefore, 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 favourably 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 to 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 proxied by the cumulative abnormal returns (CARs) over the period from 3 days to 5 days after the announcement (ACAR (+3,+5))[†††††]. We calculate the market-model cumulative abnormal returns based on the procedure by Brown and Warner (1985). We implement the estimation period starting 220 trading days, ending 20 trading days preceding to the announcement day. Then we estimate acquirers' CARs with 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).

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

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
M&A index	0.1704***	0.1861***
	(3.64)	(3.95)
Acquirer Tobin's Q	0.0000	0.0000
	(-0.95)	(-0.92)
Acquirer Price To Earnings	0.0000	0.0000
	(0.47)	(0.31)
Acquirer Leverage	0.0002*	0.0002*

[†††††]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.

	(1.89)	(1.72)
Acquirer Cash Flow To Asset	0.0038*	0.0041*
	(1.70)	(1.80)
Target Tobin's Q	0.0001	0.0001
	(0.71)	(0.80)
Target Price To Earnings	-0.0001	-0.0001
	(-1.56)	(-1.51)
Target Leverage	-0.0002	-0.0002
	(-0.90)	(-0.93)
Target Cash Flow To Asset	-0.0003	-0.0002
	(-0.84)	(-0.76)
Relative deal size	0.0007	0.0008
	(1.03)	(1.19)
Hostile takeover	-0.0053	-0.0056*
	(-1.62)	(-1.71)
Tender offer	-0.0008	-0.0010
	(-0.58)	(-0.68)
Cash	0.0025**	0.0023*
	(2.11)	(1.81)
Competing bid	-0.0011	-0.0014
	(-0.39)	(-0.48)
Diversification	-0.0033**	-0.0037**
	(-2.31)	(-2.53)
Constant	-0.1681***	-0.1892***
	(-3.67)	(-4.09)
Firm-fixed-effects	No	Yes
Year-fixed-effects	No	Yes
Industry-fixed-effects	No	Yes
Observations	6254	6254
Adjust R2	0.004	0.009

Note: 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. PanelA 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)). ACAR(+3,+5) is calculated by market model (Brown and Warner, 1985) with value-weighted CRSP index as a benchmark for market return and a estimation period starting 200 trading days and ending 20 trading days before the M&A deal announcement. The independent variable is the M&A index calculated by stochastic frontier analysis (SFA). We also control the firm and deal characteristics. Tobin's Q is computed as the ratio of market value by book value of the company's assets. Price to earnings is calculated as share price 4 weeks before announcement divided by earnings per share excluding extraordinary items. Leverage ratio is total debt, which is the sum of long-term debt and short-term debt, divided by firm's total 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. Relative deal size is computed as the transaction value divided by the market capitalization of the acquirer, 4 weeks before the official deal announcement. Hostile is a dummy variable that equals 1 when the deal attitude is hostile (Thomson One). Tender offer is a dummy variable that equals 1 when the acquisition is tender offer (Thomson One). Cash is a dummy variable that equals 1 if the M&A

deal was paid entirely by cash. Competing is a dummy variable that equals 1 when acquisition is involved with multiple bidders. Diversification is a dummy variable that equals 1 when the first-two digits of acquirer SIC are different from the first-two digits of target SIC. T-values are showed in the table. Fixed effects are considered in model 2, including firm, industry and year fixed effects. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

In panel A, the full M&A samples are 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, 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. Panel B 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, statistically significant at 1% in all the regressions. As a measurement of takeover efficiency, M&A index measures whether acquisitions maximize acquirers' return on announcement. This objective is measurable because it is modelled as a ratio of the actual announcement return against the optimal level. A smaller deviation from the optimal announcement return leads to a higher M&A index, implying market optimism towards a given M&A activity. Acquisitions with higher indices are more close to efficiency. Our findings suggest that efficient deals perform better in the short run.

5.3 post-acquisition operating performance

According to Andrade et al. (2001), the expected gains on takeover announcements are realized in a 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.

Table 6 long-run operating performance

Average 3-year IAROA	Model 1	Model 2
M&A index	1.4712***	1.2641***
	(3.18)	(2.72)
Acquirer Tobin's Q	0.0000	0.0000
	(-0.14)	(0.49)
Acquirer Price To Earnings	0.0000	0.0000
	(-0.47)	(-0.45)
Acquirer Leverage	0.0546**	0.0591**
	(2.33)	(2.42)
Acquirer Cash Flow To Asset	0.3650***	0.3586***
	(6.74)	(6.49)
Target Tobin's Q	-0.0001	0.0001

	(-0.02)	(0.21)
Target Price To Earnings	0.0001	0.0002
	(0.38)	(0.30)
Target Leverage	0.0207	0.0236
	(1.06)	(1.20)
Target Cash Flow To Asset	0.0665**	0.0765**
	(2.07)	(2.31)
Relative deal size	-0.0091	-0.0073
	(-1.37)	(-1.09)
Hostile takeover	0.0048	0.0011
	(0.15)	(0.03)
Tender offer	0.0118	0.0114
	(0.85)	(0.80)
Pure Cash deal	0.0149	0.0215*
	(1.31)	(1.72)
Competing bid	0.0110	0.0102
	(0.39)	(0.36)
Diversification	0.0051	0.0062
	(0.37)	(0.44)
Constant	-2.153***	-1.9785***
	(-4.75)	(-4.33)
Firm-fixed-effects	No	Yes
Year-fixed-effects	No	Yes
Industry-fixed-effects	No	Yes
Observations	6254	6254
Adjust R2	0.016	0.026

Note: 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 3 years post-acquisition (IAROA). IAROA is bidder's return on assets, deducting median ROA in the industry with the same first-2 digit 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. Tobin's Q is computed as the ratio of market value by book value of the company's assets. Price to earnings is calculated as share price 4 weeks before announcement divided by earnings per share excluding extraordinary items. Leverage ratio is total debt, which is the sum of long-term debt and short-term debt, divided by firm's total 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. Relative deal size is computed as the transaction value divided by the market capitalization of the acquirer, 4 weeks before the official deal announcement. Hostile is a dummy variable that equals 1 when the deal attitude is hostile (Thomson One). Tender offer is a dummy variable that equals 1 when the acquisition is tender offer (Thomson One). Cash is a dummy variable that equals 1 if the M&A deal was paid entirely by cash. Competing is a dummy variable that equals 1 when acquisition is involved with multiple bidders. Diversification is a dummy variable that equals 1 when the first-two digits of acquirer SIC are different from the first-two digits of target SIC. T-values are showed in the table. Fixed effects are considered in model 2, including firm, industry and year fixed effects. ***, ** and * represents significant at 1%, 5% and 10%, respectively.

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 firm, year and industry in model 2. In table 6, coefficients of the M&A index are positive‡‡‡‡‡ and statistically significant at 1%. These findings indicate deals with higher levels of efficiency perform better in terms of 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 acquirer.

Moreover, industry-adjusted ROA is improved if acquirers have higher leverage ratio (Cai and Sevilir, 2012). Post-merger operating performance is also positively affected by acquirers' and targets' operating cash flows, deflated by firms' total assets.

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 values of the M&A indices. Specifically, the full ordered-sample[§§§§§] is divided into three subsamples (portfolios) by three quantiles (tertiles) based on the averaged M&A index. Portfolio 1 includes deals with the lowest 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 1, 2, 3, 4, 5, and 6 months, respectively[******].

The return, r_{it},for thei^{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).

Table 7Trading strategy

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			

‡‡‡‡‡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.

§§§§§Here, order stands for the ranking of the values of the M&A index from the minimum to maximum.

******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.

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			

Note: Table 7 shows the holding period return in panel A and monthly alpha for trading strategy in panel B for trading strategy on M&A index. The full sample is split into 3 portfolios on the basis of M&A index of each deal. The portfolio 1 is the group with lowest indices which is portfolio with inefficient deals. The portfolio 3 is the group with highest indices which is portfolio with efficient deals. The 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 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.

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 1 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% (6-month holding) to 3.97% (1 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. The alpha in Portfolio 3 is significantly larger than the one in the rest two portfolios, and the difference is statistically significant at 1%. On average, holding an acquirer's stock for 1 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 1 month, bidders in Portfolio 3 keep outperforming the firms in Portfolio 2 and Portfolio 1.We further expand the holding period to 12, 24 and 36 months, respectively. Results[††††††] show limited consistency and confirm that the trading strategy is much more effective when the holding period is within 6 months after the takeover announcement.

Table 8 Trading strategy classified by industry

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**

[††††††]Due to the limited length of paper, we do not show the tables for 12 months, 24 months and 36 months.

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			

Note: Table 8 shows holding period return in panel A and monthly alpha for 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. The portfolio 1 is the group with lowest indices which is portfolio with inefficient deals. The portfolio 3 is the group with highest indices which is portfolio with efficient deals. The 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 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.

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 11examinesthe acquirer's return and monthly alpha over 1 month after the announcement. In most industries, M&A indices are positively associated to holding period returns. Investors can profit over 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 portfolio with the lowest

indices).

Table 9 Trading strategy classified by year

Panel A: Holding period return

Holding Period Return for year	Portfolio (least efficient) (I)	Portfolio (II)	Portfolio (most efficient) (III)	Difference (II)-(I)	Difference (III)-(II)	Difference (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) (I)	Portfolio (II)	Portfolio (most efficient) (III)	Difference (II)-(I)	Difference (III)-(II)	Difference (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			

Table 9 shows holding period return in panel A and monthly alpha for 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. The portfolio 1 is the group with lowest indices which is portfolio with inefficient deals. The portfolio 3 is the group with highest indices which is portfolio with efficient deals. The 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 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.

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 more efficient portfolios and less efficient one 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 1-month return is 4.89% and monthly alpha is 3.53% in the most efficient deals. 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 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.[‡‡‡‡‡‡] In addition, the bootstrapping confirms that the M&A index is significantly different from 0 and 1. The full sample is further divided into 3 groups according to different values of the index. 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 of the takeover efficiency, the M&A index indicates a technical efficiency on the production frontier, and its value is standardizedbetween0 and1. The reason for choosing acquirers' announcement returns as the output of the SFA is that they reflect 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, a deal with 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 cumulative abnormal

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

returns for acquirers. In the long term, acquirers with higher M&A index perform better in terms of 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 6-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 1 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 1 month after the takeover announcement, and this result is robust to different models.

In sum, this study suggests that the M&A index is an accurate measurement for acquisition efficiency. The M&A index can effectively forecast the likelihood of deal completion and post-acquisition performance in the short run and in the long run. Trading strategies based on the M&A index are effective and profitable during the post-acquisition period. Therefore, market participants could benefit from this composite indicator by evaluating takeover deals in an outright and very simple way. Due to the strong predicating power, the M&A index can be used for investors and analysts to forecast firm performance and design trading strategies. Moreover, academic research could include M&A index in regression models to gauge the impact of acquisitions.

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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 market model (Brown and Warner, 1985) with value-weighted CRSP index as a benchmark for market return and a 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 by 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 (Yermack, 1996).
Price to earnings	Price to earnings is calculated as share price 4 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 4 weeks before the M&A deal announcement (Baker et al. 2012).
Time to resolution	Time to resolution is the duration of deal, computed as the difference between date of deal announcement and the date when the deal completes (fails).

Relative deal size	Relative deal size is computed as the transaction value divided by the market capitalization of the acquirer, 4 weeks before the official deal announcement.
Hostile takeover	Dummy variable that equals 1 if the M&A deal was 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 was paid entirely by cash.
Stock	Dummy variable that equals 1 if the M&A deal was 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.