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Firm efficiency and the investment anomalies

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Abstract

Purpose – The purpose of this paper is to investigate whether firm efficiency can explain the investment anomaly. The investment anomaly refers to the persistent negative relation between firm growth and future risk-adjusted returns. When firms grow by investing heavily, the market often takes the growth as positive news initially but will correct prices downward subsequently if the firms lack skills to materialize value from the investments.

Design/methodology/approach – The author conducts portfolio sorting and Fama–Macbeth regression analyses with three different measures of efficiency and four variables for firm investment: net stock issuance (NSI), total asset growth (dAA), fixed asset and inventory growth (IA) and net operating assets (NOA).

Findings – The author finds that the NSI, dAA and IA anomalies are concentrated in firms with low overall efficiency. In addition, there is strong evidence that manager-driven efficiency is closely related to the NSI anomaly and limited evidence that NOA efficiency plays a role in the NSI, IA and NOA anomalies.

Originality/value – The research contributes to the literature by employing advanced efficiency measures developed by Demerjian *et al.* (2012) to resolve extant asset pricing puzzles. Also, the findings offer important implications for corporate managers and investors by demonstrating the effect of firm investments and efficiency on future profitability of stocks.

Keywords Investment anomaly, Firm efficiency, Mispricing, Managerial ability, Net stock issuance, Market efficiency, Behavioral finance

Paper type Research paper

1. Introduction

The investment anomaly refers to the negative cross-sectional relation between corporate investments and future stock returns. Public firms that experience growth by undertaking investments earn lower stock returns that cannot be attributed to standard risk factors. This anomaly is a well-known, persistent phenomenon in both the US and international stock markets, and yet the source of the return predictability is still debatable.

This research advances the understanding of the underlying cause of the investment anomaly by investigating the role of firm efficiency in the cross-sectional variation in the anomaly. To properly measure the level of firm efficiency, this research employs advanced efficiency measures, developed by Demerjian *et al.* (2012). The main result, in short, is that the investment anomaly is concentrated among inefficient firms. This supports the mispricing hypothesis that an average stock investor misreacts to the information of firms undertaking excessive investments. That is, when inefficient firms undertake large investments, they are prone to mismanaging the resources, and their stocks are likely to underperform in the future.

While numerous existing studies attribute the investment anomalies to mispricing, we have yet to identify a specific source of the mispricing, which the extant literature lacks. This paper contributes to the literature by presenting the evidence that market irrationality and investors' failure to adequately process investment-related information play a role.

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2. Literature review

2.1 Investment anomalies

In efforts to explain various asset pricing anomalies, studies in behavioral finance propose to relax the assumption that effects of irrational noise traders are not completely driven away by the acts of rational, sophisticated investors (De Long *et al.*, 1990; Shleifer and Vishny, 1997; Barberis *et al.*, 2015). Overreaction and underreaction to information are some of the underlying behavioral causes of the investment anomalies, cited by previous literature [1]. When investors overreact to corporate investments or underreact to overinvestments (Jensen, 1986), firms could experience subsequent stock underperformance as the market corrects prices. Titman *et al.* (2004) find that increases in capital investments lead to lower stock returns, supporting investor underreaction to managerial empire building. Similarly, Chan *et al.* (2008) find that the negative return predictability of firm growth is stronger in firms facing high agency costs, which indicates that managers facing agency costs tend to overexpand. Overconfidence is also a documented behavior that would cause managers to undertake excessive investments (Malmendier and Tate, 2005), contributing to stock underperformance later. This paper seeks to understand the persistence of this pervasive underperformance of stocks following excessive growth.

This paper examines four variables of investments that are known to predict the cross section of future stock returns: net stock issuance (NSI), asset growth (dAA), investment to assets (IA) and net operating assets to assets (NOA). Loughran and Ritter (1995), Fama and French (2008) and Pontiff and Woodgate (2008) find that the increase in NSI, measured with the number of split-adjusted shares outstanding, is a strong negative predictor of returns in cross sections. Loughran and Ritter attribute this puzzle to firms investing in negative net-present-value projects with the new issues, which the market fails to bet against fully. Lyandres *et al.* (2008) document that net issuers make larger investments than nonissuers, so the NSI effect is closely connected to firm investments. The relation between share issuance and returns has also been documented at the market level (Baker and Wurgler, 2000).

Relatedly, Cooper *et al.* (2008) show that the growth of total assets on balance sheets (dAA) inversely predicts the cross section of stock returns. During the period from January 1966 to December 2015, the highest asset-growth decile of stocks underperformed the lowest decile by 7.3% per year in the USA. The asset-growth effects are persistent in international markets as well (Gray and Johnson, 2011; Watanabe *et al.*, 2013; and Titman *et al.*, 2013). Lakonishok *et al.* (1994) and Cooper *et al.* suggest that investors' systematic overreaction to the past asset growth is most likely the source of the anomaly.

Lyandres *et al.* (2008) find that increases in fixed assets and inventory (IA) predict future returns inversely, which subsumes the effect of the new issues anomaly (NSI). They find that long in low IA stocks and short in high IA stocks earns a significant average return of 0.57% per month. The authors bring forth the risk argument, rather than mispricing, to explain the NSI puzzle with their IA factor.

Lastly, Hirshleifer *et al.* (2004) document the NOA anomaly and attribute it to mispricing, but Wu *et al.* (2010) suggest the possibility of a rational force generating the effect in the framework of the *Q*-theory of investment. Hirshleifer *et al.* find high and significant portfolio returns (up to 1.24% monthly) on long low-NOA and short high-NOA.

In sum, the behavioral mispricing argument attributes the investment anomaly to the systematic biases of either investors and managers or both. This research aims to investigate this argument by bringing firm efficiency into the picture.

2.2 Firm efficiency

While this paper examines the role of firm efficiency in the asset pricing context, previous studies have applied it to various other areas as well. For example, Leverty and Qian (2011) examine the effect of firm efficiency on the aftermath of mergers and acquisitions; Koesker *et al.* (2017) investigate the role of managerial efficiency in corporate tax avoidance. Hence, it is meaningful to have a reliable, high-quality measure of firm efficiency for financial research. However, multidimensionality of efficiency makes it challenging to quantify without introducing noise [2]. Previous studies have relied on rather ad-hoc or unidimensional proxies for firm skill, such as firm size, labor productivity, past profitability, past stock returns, compensation and manager fixed effects (Fee and Hadlock, 2003; Milbourn, 2003; Bertrand and Schoar, 2003; Rajgopal *et al.*, 2006).

This paper defines efficiency based on the firm's or manager's ability to deploy its resources to maximize output based on a selection of inputs. To measure this specific aspect of firm skill, we employ advanced efficiency measures developed by Demerjian *et al.* (2012): FirmEFF for overall firm efficiency and ManagerEFF for manager-driven efficiency.

A heterogeneity in management skills, which may stem from the manager's personal attributes, organizational structure and behavior of the firm, has been useful for investigating cross-sectional differences in firm-level productivity, profitability and survival rates (Bloom and Van Reenen, 2007). Demerjian *et al.* demonstrate that their efficiency measure is significantly associated with major attributes of managerial ability, such as stock price performance, executive compensation and investment opportunities, and that it outperforms other performance measures in explaining market reactions to CEO turnover. Also, they demonstrate that the negative relation between NSI and subsequent stock returns (NSI anomaly) to be weaker in firms with higher managerial efficiency. This finding is consistent with the view that issuing firms that are more likely to misallocate funds from new issues will underperform subsequently.

This research expands upon Demerjian *et al.*'s quick investigation on the NSI anomaly by experimenting with the overall firm efficiency as well (not just managerial efficiency) and additional investment variables, in order to enhance our understanding of the investment anomaly in its entirety. That is, we test whether the dAA, IA and NOA anomalies, in addition to the NSI anomaly, also interact similarly with measures of total firm efficiency and managerial efficiency in driving future stock returns. Such additional batch of tests serves as an important and meaningful extension for the purpose of examining a potentially more prevalent role of firm efficiency in the investment anomalies, not just for the NSI. This would allow us to draw a more robust conclusion on the mispricing hypothesis.

3. Hypothesis

The key to testing the role of firm skill as a source of behavioral mispricing in the investment anomaly is to be able to differentiate legitimate investments by skilled firms from overinvestments by unskilled firms. Large investments will only lead to stock underperformance for unskilled firms that would most likely invest beyond the optimal point and/or mismanage resources, subsequently failing to meet performance expectations. Skilled firms need not underperform following growth. The more efficient a firm is, the "better" quality investment it makes, and the less likely it is that the market will penalize that firm for investing a large amount. This intuition leads to the following hypothesis:

H1. The investment anomaly is concentrated in firms with low efficiency.

More specifically, in a group of inefficient firms, high-investing firms would underperform low-investing firms. No such significant differential would be observed in a group of more efficient firms.

4. Data and variable

4.1 Data

I obtain the stock market data from the Center for Research in Security Prices (CRSP) and the accounting data from Compustat annual file. The sample includes firms listed on the NYSE, AMEX and NASDAQ stock exchanges and only the common shares (with share code of 10 or 11). To identify a firm's industry, I use the 49 industry classification provided by Fama and French (1997). Each month, the four-digit SIC code determines its assignment in one of the 49 industries. Because I leave out utility and financial firms (SIC Code from 4,900 to 4,999 and 6,000–6,999), the sample firms are classified into 43 industries. Firms with missing observations for any variable are omitted from the sample. To mitigate survivorship bias, all firms need to have existed in Compustat for at least two years. Accounting data are assumed to be published four months after the end of the fiscal year. The majority of firms in the sample end their fiscal year in December, so their financial statements would be observable by the end of the next April. Hence, the annual rebalancing month is set to April for the portfolio analysis.

The advanced measures of firm efficiency (FirmEFF) and managerial ability (ManagerEFF), developed by Demerjian *et al.* (2012), are made available online publicly from 1980 to 2016 [3]. After merging with the CRSP and Compustat databases and filtering out firms with missing observations for any variable, the average number of firms per year is 2,164.

4.2 Investment variables construction

I employ four investment variables that negatively predict average future stock returns. First, NSI is calculated as the log of the percent change in split-adjusted shares outstanding (Loughran and Ritter, 1995; Fama and French, 2008; Pontiff and Woodgate, 2008). Split-adjusted shares are calculated as the product of shares outstanding (SHROUT) and split-adjustment factor (CFACSHR) provided by Compustat.

Total assets growth (dAA) is calculated as the percent change in total assets (AT) from year $t-2$ to $t-1$, following Cooper *et al.* (2008). IA, following Lyandres *et al.* (2008), is calculated as the change in gross property, plant and equipment (PPEGT) plus the change in inventories (INVT) divided by lagged total assets (AT). The change in PPEGT represents the long-term investments, and the change in IVT represents the short-term investments.

NOA to total assets is calculated as NOA scaled by lagged total assets, following Hirshleifer *et al.* (2004). NOA is the net operating assets, calculated as the difference between operating assets (OA) and operating liabilities (OL), where OA = AT – cash and short-term investments (CHE), and OL = AT – debt in current liabilities (DLC) – long-term debt (DLTT) – minority interest (MIB) – preferred stock (PSTK) – common equity (CEQ).

4.3 Efficiency measures

Testing the hypothesis requires a reliable measure of firm skill, or more specifically, a measure of capability to pursue profitable investment opportunities and materialize profits for shareholders. Demerjian *et al.* describe the procedure and rationale in detail in their original paper. To explain briefly, they estimate frontier efficiency using a mathematical programming approach called data envelopment analysis (DEA) to maximize the output variable given a set of inputs. In contrast to a regression approach, which is another method for estimating frontier efficiency, the DEA approach does not require any assumptions regarding the production function, such as Cobb–Douglas, and error-term distribution [4].

The authors characterize an able management team as "one that generates the highest level of revenue from a given set of inputs." Hence, they set the firm revenue (Sales) as the output variable [5]. The input variables represent their choice of accounting measures that "contribute to the generation of revenue and are affected by managerial ability." The firm efficiency measure, FirmEFF, is the result from solving the optimization problem as follows [6]:

$$\max_v \theta = (\text{Sales}) \cdot (v_1\text{COGS} + v_2\text{SG\&A} + v_3\text{PPE} + v_4\text{OpsLease} + v_5\text{R\&D} + v_6\text{Goodwill} + v_7\text{OtherIntan})^{-1}.$$

Because FirmEFF is a manifestation of both firm-specific and managerial aspects, the authors extract out the firm-specific drivers to produce a measure focused on managerial efficiency (ManagerEFF) by estimating the following Tobit regression by industry:

$$\begin{aligned}\text{FirmEFF}_i = {} & \alpha + \beta_1 \ln(\text{Total Assets}_i) + \beta_2 \text{Market share}_i + \beta_3 \text{Free Cash Flow Indicator}_i \\ & + \beta_4 \ln(\text{Age}_i) + \beta_5 \text{Business Segment Concentration}_i \\ & + \beta_6 \text{Foreign Currency Indicator}_i + \text{Year}_i + \varepsilon_i\end{aligned}$$

The residual from this estimation is the measure of managerial efficiency, ManagerEFF.

In addition to FirmEFF and ManagerEFF, another efficiency measure used in this paper is the industry-adjusted asset turnover (AssetEFF), computed as sales (SALE) to NOA to measure operating-asset efficiency. Deflating SALE by NOA instead of total assets (AT) helps us focus on the operating activities that mainly drive firm value, instead of the financing activities (Nissim and Penman, 2001; Esplin *et al.*, 2014). The industry adjustment extracts firm-specific skills, which is critical because asset turnover is largely a function of industry membership (Soliman, 2004). Soliman documents that higher AssetEFF is associated with higher future profitability and stock performance on average and can be a valuable piece of information for market participants.

5. Summary statistics

Tables 1 and 2 present the descriptive statistics and correlation matrix, respectively, for the full sample of firms. The figures represent time-series averages of cross-sectional statistics. All variables are winsorized at 1% and 99% annually.

All efficiency measures exhibit sufficient variation: FirmEFF ranges from 0 to 1 by construction with the mean of 0.32 and standard deviation of 0.16; ManagerEFF has the mean

	Mean	Std Dev	Min	Max
FirmEFF	0.32	0.16	0.04	1
ManagerEFF	0.00	0.12	−0.3	0.64
AssetEFF	0.59	2.38	−8.7	23.38
NSI	0.03	0.12	−0.43	0.94
dAA	0.13	0.34	−0.56	4.77
IA	0.07	0.15	−0.46	1.12
NOA	0.64	0.28	0.03	2.53
ROA	0.89	1.07	−2.02	11.6
Q	1.79	1.25	0.46	14.16
ab_SG	0.048	0.34	−2.09	2.85
ACC	−0.04	0.09	−0.4	0.51
OP	0.34	0.35	−1.03	4.5
Size	19.63	2.15	12.85	26.99

Note(s): The sample period covers January 1981 through December 2018. Firms must have at least two years of Compustat data and have no missing observations to be included in the sample. All variables are winsorized at 1% and 99%

Table 1.
Descriptive statistics

Table 2.
Correlation matrix

	FirmEFF	ManagerEFF	AssetEFF	ROA	*Q*	ab_SG	dAA	IA	NOA	NSI	ACC	OP	Size
FirmEFF	1	0.872	0.112	0.256	0.197	0.019	0.114	0.065	−0.070	−0.088	0.027	0.284	0.551
ManagerEFF	0.872	1	0.175	0.362	0.262	0.041	0.140	0.087	−0.091	−0.009	0.095	0.194	0.213
AssetEFF	0.112	0.175	1	0.665	0.122	0.028	−0.039	−0.104	−0.462	−0.053	−0.077	0.086	−0.058
ROA	0.256	0.362	0.665	1	0.296	0.012	0.017	−0.087	−0.433	−0.058	−0.033	0.173	−0.025
Q	0.197	0.262	0.122	0.296	1	0.103	0.233	0.118	−0.111	0.162	0.103	0.139	0.229
ab_SG	0.057	0.094	0.028	0.012	0.103	1	0.451	0.259	0.395	0.162	0.059	−0.001	0.002
dAA	0.114	0.140	−0.039	0.017	0.233	0.212	1	0.635	0.546	0.295	0.258	0.046	0.109
IA	0.065	0.087	−0.104	−0.087	0.118	0.173	0.635	1	0.563	0.288	0.206	0.063	0.094
NOA	−0.070	−0.091	−0.462	−0.433	−0.111	0.090	0.546	0.563	1	0.253	0.239	0.030	0.030
NSI	−0.088	−0.009	−0.053	−0.058	0.162	0.162	0.595	0.288	0.253	1	0.089	−0.203	−0.104
ACC	0.027	0.095	−0.077	−0.033	0.103	0.059	0.258	0.206	0.239	0.089	1	−0.005	−0.003
OP	0.284	0.194	0.086	0.173	0.139	−0.001	0.046	0.063	0.030	−0.203	−0.005	1	0.242
Size	0.551	0.213	−0.058	−0.025	0.229	0.002	0.109	0.094	0.030	−0.104	−0.003	0.242	1

Note(s): The table presents the time-series averages of cross-sectional pairwise correlations of 0 by construction and standard deviation of 0.12; and AssetEFF has the mean of 0.59 with standard deviation of 2.38.

In Table 2, efficiency measures are correlated with some of alternative firm-ability measures, the return on assets (ROA), Tobin's *Q* and industry-adjusted sales growth (ab_SG). First, as noted by Demerjian *et al.*, FirmEFF and ManagerEFF are highly correlated with each other, which is reasonable since managerial ability is a component of total firm efficiency. FirmEFF, ManagerEFF and AssetEFF are all highly correlated with ROA (statistically significant at 5%, 0.256, 0.362 and 0.665, respectively), which is not surprising as firms that are more efficient in generating revenues are more likely to produce higher net earnings. All three are positively correlated with Tobin's *Q* (statistically significant at 5%, 0.197, 0.262 and 0.122, respectively), which proxy for investment opportunities. ManagerEFF is more strongly associated with higher Tobin's *Q* than other efficiency measures, suggesting that efficient managers are more capable of attracting investment opportunities and are better situated to improve firm prospects. The efficiency measures exhibit a low correlation with the industry-adjusted sales growth (ab_SG), indicating that the efficiency measures clearly contain distinct information from the historical growth in revenue. FirmEFF is 55% correlated with firm size (Size) but ManagerEFF, which is the result of taking out the firm size effect, is still 21.3% significantly correlated with Size. In interpretation, larger firms are more likely to not only operate more efficiently but also hire and retain more capable managers.

6. Methodology

At the end of every April, stocks are assigned to one of two subsamples based on the median level of efficiency and then into an investment quintile within the subsample. For portfolio analyses, I examine the presence of the return predictability by going long lowest-quintile and short highest-quintile. This position is held for 12 months and rebalanced annually. The excess monthly portfolio return (%) is computed as the time-series average of value-weighted stock returns over the risk-free rate. The risk-adjusted portfolio return is the estimated intercept (α) from the Carhart four-factor model:

$$R_t = \alpha + \beta_1 \mathrm{MKTRF}_t + \beta_2 \mathrm{SMB}_t + \beta_3 \mathrm{HML}_t + \beta_4 \mathrm{UMD}_t + \varepsilon_t \quad (1)$$

where R_t is the monthly excess return on the low–high strategy over the risk-free rate; MKTRF, SMB, HML and UMD are monthly returns on the market, size, book-to-market and momentum factors, respectively (Fama and French, 1997; Carhart, 1997).

For regression analyses, I examine the slopes on the investment variable from the following the Fama–Macbeth regression (Fama and Macbeth, 1973) in a given subsample.

$$\mathrm{XRet}^i_{t+1} = b_0 + b_1 \mathrm{Investment}^i_t + b_2 \mathrm{Size}^i_t + b_3 \mathrm{BEME}^i_t + b_4 \mathrm{MOM}^i_t + b_5 \mathrm{Accrual}^i_t + b_6 \mathrm{OP}^i_t + \varepsilon^i_{t+1}. \quad (2)$$

XRet^i_{t+1} is the monthly excess return on stock$_i$ over the next period, $t+1$, multiplied by 100. The annual accounting variables are lagged at least four months to ensure that stock market participants have access to the data available at the time of portfolio formation. The monthly variables are lagged one month. The *t*-values are corrected for heteroskedasticity and serial correlation, using the Newey and West (1987) estimator with up to 12 lags. The equation includes five control variables: size (Size), book-to-market-equity ratio (BEME), past 12-month return (MOM), accrual (Accrual) and profitability (OP). MOM is the past 12-month cumulative return skipping a month before the formation date (Jegadeesh and Titman, 1993). Following Sloan (1996), accrual (ACC) is measured as the change in current assets (ACT) – cash and short-term investments (CHE) – (the change in current liabilities (LCT) – the change in debt in current liabilities (DCL) – the change in taxes payable (TXP) – depreciation and amortization expense (DP) divided by AT. OP is the operating profitability calculated as SALE – cost of goods sold (COGS) – Selling, General and Administrative Expense (XSGA) + Research and Development Expense (XRD) scaled by lagged BE.

Finally, I perform the following regression using the entire sample of firms:

$$\text{Cum1}Yr^i_{t+1} = b_0 + b_1\text{Investment}^i_t + b_2\text{Efficiency}^i_t + b_3\text{Investment}^i_t \times \text{Efficiency}^i_t + b_4\text{Size}^i_t + b_5\text{BEME}^i_t + \varepsilon^i_{t+1} \quad (3)$$

The dependent variable, $\text{Cum1}Yr^i_{t+1}$, is the one-year cumulative return on stock i over the next period, $t+1$. Investment^i_t and Efficiency^i_t will take the value of a given investment and efficiency measure, respectively, of stock i at time t. The coefficient b_3 on the interaction variable of Investment^i_t and Efficiency^i_t is the focus of interest. The hypothesized signs are negative on the investment variable (b_1); positive on the efficiency variable (b_2) as skilled firms are more likely to increase shareholders' wealth; and positive on the interaction variable (b_3), which would indicate that the negative relation between investment and the next one-year return is mitigated in firms with higher efficiency.

7. Results

First, I examine the systematic inverse relation between the firm investments and stock returns in the full sample of firms. Table 3 reports the risk-adjusted returns based on the Carhart four-factor model Eqn (1) and the Fama–Macbeth regression slopes on the investment variable Eqn (2).

All investment portfolios except for the asset growth (dAA) exhibit positive abnormal returns on the low–high portfolio. Due to the data availability of the efficiency measures, the analysis is limited to the period of 1980–2018. In the repeated analysis expanding the period to 1965–2018 (not tabulated), the economic and statistical significance of the investment anomaly is generally higher and more robust. The evidence indicates that the portfolio alpha has greatly weakened for IA or even lost its significance for dAA in the recent period. The slope regressions also suggest that the return predictability has mitigated over time; the slope

	Low	Portfolio α High	Low–high	Regression b_1
NSI	0.251***	−0.049	0.3**	−0.644**
	4.359	*−0.448*	*2.263*	*−2.44*
dAA	0.305***	0.121	0.184	−0.442***
	2.872	*1.284*	*1.235*	*−4.89*
IA	0.167**	−0.011	0.177*	−0.849***
	1.972	*−0.108*	*1.682*	*−4.19*
NOA	0.351***	−0.078	0.429***	−0.642***
	4.170	*−0.814*	*3.069*	*−3.64*

Note(s): ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 levels, respectively
The table reports the risk-adjusted returns and the regression slopes in the full sample of firms from 1980 to 2018. At the end of every April in year t, stocks are assigned to investment quintiles and rebalanced annually. The strategy of going long and short on the bottom and top quintiles, respectively, is held for 12 months. The risk-adjusted return is the intercept (α) from the Carhart four-factor model: $R_t = \alpha + \beta_1\text{MKTRF}_t + \beta_2\text{SMB}_t + \beta_3\text{HML}_t + \beta_4\text{UMD}_t + \varepsilon_t$, where R_t is the monthly return on the low–high strategy over the risk-free rate. The last column presents the results from conducting the Fama–Macbeth regression of the monthly excess returns on a given investment variable and five control variables for the fiscal year ending in calendar year $t-1$, $\text{XRet}^i_{t+1} = b_0 + b_1\text{Investment}^i_t + b_2\text{Size}^i_t + b_3\text{BEME}^i_t + b_4\text{MOM}^i_t + b_5\text{Accrual}^i_t + b_6\text{OP}^i_t + \varepsilon^i_{t+1}$

Table 3.
The investment anomaly in the full sample: portfolio and regression analyses

estimates are generally less negative and less significant in the recent data. However, we still find significant return predictability for all investment variables in the regressions and for all except dAA in the portfolio analyses, adjusting for standard risks.

7.1 Subsampling analyses

Table 4 reports the portfolio alphas, regression slopes and differences in the alpha and the slope between the high and low subsamples of efficiency.

7.1.1 Firm efficiency (FirmEFF). If the hypothesis holds, the investment anomaly would be concentrated in firms with low efficiency. Hence, the difference in the risk-adjusted returns on the low–high investment portfolio and in the regression coefficients between the high and low efficiency subsamples must be significantly different. The predicted sign for high–low is negative for the alpha and positive for the regression coefficient. A number in the high–low column is bolded if the difference between the subsamples is statistically significant with the predicted sign.

The results in Table 4 demonstrate that firm efficiency potentially explains the empirical puzzles associated with NSI, dAA and IA. The negative relation between investment and future returns is accentuated in low FirmEFF firms and nonexistent in high FirmEFF firms. This difference is statistically significant in both portfolio and regression outputs. Except for the NOA anomaly, the results indicate that total firm efficiency matters for the future stock performance following firm growth related to investments. Inefficient firms that invest underperform other comparably inefficient firms that invest less, which is consistent with the mispricing view that the market either overreacts to investments or underreacts to overinvestments.

7.1.2 Managerial efficiency (ManagerEFF). As shown in the "Managerial Efficiency" columns of Table 4, managerial ability produces results aligned with the hypothesis only for NSI, which is consistent with Demerjian *et al.*'s finding. In interpretation, issuing firms with superior managers need not underperform nonissuing firms, as skilled managers are more likely to select and implement positive NPV investments. However, ManagerEFF does not explain other investment anomalies, dAA, IA and NOA. It appears that stock issuance captures distinct corporate activity, distinguished from overall firm growth (dAA), fixed assets and inventory growth (IA) and growth in NOA. In light of the results, the NSI anomaly is specifically linked to managerial ability to pursue valuable investments following new issues, whereas other investment anomalies, except NOA, are more closely linked to firm-specific drivers of efficiency.

7.1.3 Net-operating-asset efficiency (AssetEFF). The AssetEFF is sales divided by net operating assets, adjusted for industry, following Nissim and Penman and Esplin *et al.* The accounting literature has utilized this measure as an incremental and useful form of information about the operating characteristics of a firm and as potential predictors of future profitability of firms (Soliman, 2004, 2008). The results in the last three columns of Table 4 show limited evidence that the NSI and IA anomalies are associated with AssetEFF, but the results are not as robust as with Demerjian *et al.*'s efficiency measures. It can be interpreted that FirmEFF and ManagerEFF by Demerjian *et al.* dominate the simple accounting measure AssetEFF in gauging the level of firm efficiency.

7.2 Overall regression

This section explains the results from the regression analyses using the full sample of firms. The regression specification follows Demerjian *et al.*'s setup in analyzing the net issues puzzle. The dependent variable is cumulative one-year returns on individual stocks, and the independent variables include an investment variable, efficiency measure, interaction variable of the investment and efficiency and the control variables (size and book-to-market

Table 4. The investment anomaly in the subsamples split by a given efficiency measure: portfolio and regression analyses

		Firm efficiency			Managerial efficiency			Asset efficiency		
		High	Low	High–low	High	Low	High–low	High	Low	High–low
NSI	α	0.23	0.599***	*−0.443***	−0.06	0.477***	*−0.537****	−0.204	0.282*	*−0.486***
		1.624	3.119	*−1.963*	−0.354	3.186	*−2.641*	−1.037	1.758	*−2.054*
	b_1	−0.32	−0.949***	*0.629***	−0.23	−1.098***	*0.868****	−0.456	−0.48**	0.024
		−1.100	−2.800	*2.192*	−0.780	−3.330	*2.571*	−1.330	−2.210	0.081
dAA	α	0.199	0.547**	*−0.348***	0.126	0.234	−0.108	0.257	0.34*	−0.082
		1.221	2.276	*−1.819*	0.679	1.239	−0.470	1.088	1.769	−0.291
	b_1	−0.272**	−0.61***	*0.338***	−0.297**	−0.408***	0.111	−0.303**	−0.34***	0.0337
		−2.290	−3.880	*1.993*	−2.530	−2.840	0.592	−2.120	−3.310	0.225
IA	α	0.092	0.626***	*−0.534***	−0.043	0.272	−0.314	0.081	0.211	−0.13
		0.637	3.267	*−2.439*	−0.241	1.650	−1.424	0.428	1.145	−0.512
	b_1	−0.632*	−0.992***	*0.359**	−0.724**	−0.703***	0.0206	−0.173	−1.043***	*0.870****
		−1.920	−3.750	*1.692*	−2.160	−2.810	0.056	−0.660	−3.900	*2.546*
NOA	α	0.44***	0.122	0.318	0.495**	0.135	0.359	0.181	0.232	−0.051
		2.778	0.522	1.336	2.362	0.847	1.476	0.917	1.394	−0.187
	b_1	−0.708***	−0.533**	−0.174	−0.796***	−0.48**	−0.316	−0.558**	−0.659***	0.101
		−4.120	−1.990	−0.952	−4.090	−2.370	−1.629	−1.960	−3.470	0.496

Note(s): ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 levels, respectively
The table reports the risk-adjusted returns and the regression slopes in the subsamples of firms split by a given efficiency measure. The numbers in the high–low column are bolded if the differences are statistically significant in the hypothesized direction (− for and + for). The risk-adjusted return is the intercept from the Carhart four-factor model. To obtain we conduct the following Fama–Macbeth regression of the monthly excess returns on individual stocks on a given investment variable and five control variables for the fiscal year ending in calendar year t−1

equity). The hypothesized signs are negative on the investment variable, positive on the efficiency variable and positive on the interaction variable.

The results in Table 5 are largely consistent with the analyses in the previous section. First, investment variables generally take on significantly negative coefficients as expected. The efficiency measures carry significantly positive coefficients in 11 out of 12 specifications, indicating value-increasing effects of higher efficiency.

For FirmEFF, we observe significantly positive coefficients on the interaction variable for NSI, dAA and IA. The economic significance is notable; for an average firm with dAA of 0.13

	Predicted sign	Investment variables NSI	dAA	IA	NOA
Investment	−	−0.149***	−0.134***	−0.177***	−0.085**
		−3.890	−4.130	−4.310	−2.400
FirmEFF	+	0.143***	0.145***	0.145***	0.154***
		4.880	4.380	4.650	3.690
Investment*FirmEFF	+	*0.099**	*0.127***	*0.123**	−0.045
		1.829	*2.010*	*1.791*	−0.580
Size	−	−0.0274***	−0.0268***	−0.027***	−0.026***
		−4.460	−4.320	−4.230	−4.080
BEME	+	0.033***	0.0302**	0.032***	0.038***
		2.750	2.450	2.580	3.270
Intercept		0.611***	0.605***	0.607***	0.642***
		4.740	4.620	4.520	4.430
Adj RSQ		0.037	0.040	0.036	0.037
Investment	−	−0.130***	−0.091***	−0.137***	−0.100***
		−3.400	−5.110	−3.700	−3.970
ManagerEFF	+	0.099***	0.113***	0.112***	0.206***
		3.870	3.730	3.660	2.960
Investment*ManagerEFF	+	*0.253****	0.109	0.037	−0.203**
		2.880	1.150	0.240	−2.020
Size	−	−0.023***	−0.0217***	−0.022***	−0.022***
		−3.840	−3.620	−3.550	−3.600
BEME	+	0.036***	0.0327***	0.035***	0.039***
		3.080	2.670	2.810	3.420
Intercept		0.550***	0.551***	0.551***	0.603***
		4.210	4.260	4.180	4.460
Adj RSQ		0.037	0.040	0.035	0.037
Investment	−	−0.188***	−0.0859***	−0.132***	−0.091***
		−2.970	−4.780	−3.490	−2.800
AssetEFF	+	0.008***	0.008***	0.006***	−0.004*
		3.970	3.650	3.160	−1.780
Investment*AssetEFF	+	0.008	0.005	*0.026****	*0.019***
		0.980	1.350	*2.900*	*2.200*
Size	−	−0.021***	−0.019***	−0.020***	−0.020***
		−3.640	−3.370	−3.340	−3.450
BEME	+	0.041***	0.035***	0.036***	0.039***
		3.020	2.680	2.830	3.180
Intercept		0.517***	0.494***	0.510***	0.568***
		4.220	4.030	3.990	4.310
Adj RSQ		0.037	0.036	0.036	0.037

Note(s): ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 levels, respectively

The table reports the results from the full-sample regression of the following specification: $\text{Cum1}Yr^i_{t+1} = b_0 + b_1\text{Investment}^i_t + b_2\text{Efficiency}^i_t + b_3\text{Investment}^i_t \times \text{Efficiency}^i_t + b_4\text{Size}^i_t + b_5\text{BEME}^i_t + \varepsilon^i_{t+1}$. The coefficients on the interaction variables are bolded if statistically significant with the predicted sign

Table 5. Full-sample regressions

and FirmEFF of 0.32, an increase in FirmEFF by one standard deviation of 0.16 will improve the next year's return by 2.58% with all else constant. For ManagerEFF, the significantly positive coefficient on the interaction variable is only observed for NSI, which is consistent with the previous finding in the sorting analysis and with Demerjian *et al.*'s conclusion that issuing firms with capable managers do not underperform nonissuing firms.

For AssetEFF, we observe some differences from the subsampling results in the previous section. The interaction variables carry significantly positive coefficients forIA and NOA, indicating that firms with higher operating asset efficiency mitigate negative predictability of IA and NOA for future returns. That is, investing firms with higher efficiency in managing operating assets do not underperform less-investing firms. The coefficients are also economically significant: for an average firm with IA of 0.07 and AssetEFF of 0.59, an increase in AssetEFF by one standard deviation of 2.38 will improve the next one-year return by approximately 2%, holding all else constant. The results for IA are consistent with the previous result, but the new result is that AssetEFF potentially explains the NOA anomaly as well. In fact, it is reasonable to expect that firms increasing their NOA base do not perform well when they lack NOA efficiency.

8. Conclusion

The source of the investment anomaly remains open to question. This study evaluates the mispricing hypothesis by examining the role of firm efficiency in the persistent stock underperformance associated with the NSI, total asset growth, IA and NOA. This research probes into the simple intuition that overinvesting firms will not perform well, especially if the market initially fails to fully process the negative information of the suboptimal growth. The measure of firm efficiency is used to distinguish excessive growth from legitimate growth.

This study employs three measures of efficiency, including two advanced measures developed by Demerjian *et al.* (2012). These measures are not perfect, as they contain noise due to measurement errors in the inputs and some accounting variables and, therefore, are limited in capturing the full spectrum of firm skills. However, Demerjian *et al.*'s measures are most up-to-date measures containing less noise than previously existing proxies. This paper is the first one to utilize these measures for evaluating the mispricing argument for the investment anomalies.

The paper concludes that the return predictability of firm investments is associated with the degree of firm efficiency; investing firms that are inefficient underperform less-investing firms with the comparable level of inefficiency, while investing firms that are efficient need not underperform less-investing firms with the comparable level of efficiency. In short, the investment anomaly is concentrated in inefficient firms. Specifically, the NSI, asset growth and IA anomalies appear in firms with *overall* firm inefficiency. There is strong evidence that the net issuance anomaly is driven by firms with *managerial* inefficiency; and limited evidence that the NOA efficiency potentially explains the IA, NSI and NOA anomalies.

This research offers several implications for corporate finance and investment management. First, firms should be equipped to marshal resources efficiently when undertaking investments in order to deliver value to shareholders. Firm skill is highly relevant, for an effective corporate strategy should balance growth with capability to maintain that growth. Second, firms should hire and retain managers who are capable of harnessing firm resources efficiently, especially if they expect to issue new shares for expansion. Unskilled managers will most likely exceed the optimal level of firm growth, misallocate firm resources and detract from shareholders' wealth. Lastly, investors should be cautious of firms making large investments and growing fast. Investors are advised to research whether growth arises from legitimate investments, not overinvestments by inefficient firms or managers.

Notes

1. To focus on the behavioral mispricing argument, this research abstracts away from the details of rational, risk-based explanations. For literatures related to the nonbehavioral argument, see Cochrane (1991) and Li and Zhang (2010). The findings in support for the mispricing explanation do not necessarily preclude the potential role of rational forces in producing the anomalies. In fact, mispricing and rational effects may coexist (Lam and Wei, 2011).
2. Some of the applied-economics researches have attempted to see how much of the residual from estimating the Cobb–Douglas production function can be accounted for as the managerial skill measure. However, it has not been successful to attribute the error term to managerial quality alone. Bloom and Van Reenen (2007) recognize that it is most likely an amalgamation of numerous firm qualities; hence, they produce survey-based managerial measures. However, this method leads to a sample of only 290 US observations.
3. http://faculty.washington.edu/pdemerj/data.html
4. Banker and Natarajan (2008) show that DEA procedures generally outperform regression methods and are less susceptible to specification errors. Leverty and Qian (2011) and Koesker *et al.* (2017) endorse this approach for investigating research questions associated with managerial skills in M&A and corporate tax avoidance, respectively.
5. Demerjian *et al.* argue against net income as an output variable because it is the aggregation of their inputs and output (revenue less expense) and against the market value of equity because it is affected by market factors beyond the firm's control.
6. The input variables (SG&A = Selling, general, and administrative expenses; PPE = Net Property, Plant, and Equipment; OpsLease = Net Operating Lease; R&D = Net Research and Development; OtherIntan = Other Intangible Assets) are measured at the beginning of year *t*, and the flow variables (Sales = Revenue; COGS = Cost of Inventory) are measured over year *t*. The authors explain the motivation for including each input variable in Section 4 of their paper. For instance, they include acquired tangible and intangible assets, R&D and goodwill as a more capable management is expected to make more efficient purchasing decisions and pursue more promising R&D projects.

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