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ORIGINAL RESEARCH

Does CEO managerial ability matter? Evidence from corporate investment efficiency

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Abstract This study investigates how higher ability CEOs behave differently from lower ability CEOs in making investment decisions and, particularly, whether CEO managerial ability contributes to improved investment efficiency. I show evidence that more able CEOs make more efficient investment decisions. Specifically, talented CEOs increase (decrease) capital expenditures, acquisition expenditures, and total investments when their firms operate in settings more prone to under-investment (over-investment). These results suggest that high managerial ability helps with overcoming the two sources of investment inefficiency: over- and under-investment. I also find that the positive impact of CEO managerial ability on investment efficiency generally persists across different levels of board monitoring, whereas it gets weaker as the CEOs are overly exposed to equity risk. Robustness tests of using alternative measures of CEO managerial ability and controlling for potential endogeneity issues generate consistent results. Overall, the findings suggest that higher managerial ability leads to more efficient investment decision-making.

Keywords Managerial ability · Corporate investment · Investment efficiency · Managerial incentives · Board monitoring

JEL Classification G31 · G34 · M41

1 Introduction

This study examines how the variation in CEO managerial ability impacts firms' investment efficiency. Specifically, I investigate whether higher managerial ability contributes to improved investment practices when firms operate in an environment where under-investment or over-investment is very likely. Existing literature (Jensen 1986; Shleifer and

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Vishny 1989; Morck et al. 1990; Bertrand and Schoar 2003) suggests that CEOs' individual attributes influence corporate investment practices and outcomes. Bertrand and Schoar (2003), for instance, find that a significant part of the heterogeneity in firms' investment practices can be explained by unobserved manager-fixed effects, supporting the upper echelons theory in Hambrick and Mason (1984).[1] Managers with different abilities view future prospects differently (Trueman 1986), and their differing views affect their judgments, confidence, and risk preferences. Moreover, managers with different levels of ability possess various skill sets, which in turn affect their perceptions and evaluations of potential investment opportunities. Therefore, I first predict that more able and less able CEOs behave differently in their investment practices.

Further, I examine whether more able CEOs make more efficient investment decisions. Higher ability CEOs are perceived to have better knowledge and judgment than their peers, which enables them to better anticipate future changes (Trueman 1986). As a result, they are more likely to identify favorable investment opportunities. Consistent with this argument, Jian and Lee (2011) provide empirical evidence that investment decisions made by more reputable CEOs lead to better post-investment performance. This study takes another angle by examining how more able CEOs respond to an operating environment with a pre-existing high likelihood of over-investment or under-investment. Holding other things constant, if CEO managerial ability contributes to improved investment efficiency, more able CEOs are expected to be associated with a decreased propensity for under-investment and/or over-investment.

Prior studies (e.g., Scharfstein and Stein 1990) suggest that less able CEOs may ignore their own private information about payoffs and copy the decisions of previous managers, because they are afraid that they may be punished for their investment decisions by shareholders and markets. Such ignorance and herd behavior can lead to firms' under-investment or over-investment. In addition, without sufficient knowledge and capability, less able CEOs may fail to accurately anticipate future changes and employ inappropriate strategic views and poor evaluation techniques that lead to inefficient investment decisions. In contrast, more able CEOs pinpoint potential investment opportunities and make investment decisions that best fit their firms' operating characteristics and strategic plans (Copeland et al. 1994). Further, with their private information, superior knowledge about business operations (i.e., firms' cost structures and revenue drivers), and other skill sets, high ability CEOs are likely to arrive at more accurate estimates and evaluations of investments. This discussion suggests that, ceteris paribus, more able CEOs are likely to make more efficient investment decisions, which leads to less over- and/or under-investment.

In this study, I utilize the CEO managerial ability measure developed by Demerjian et al. (2012) to examine the above predictions. A CEO's ability can be indicated by the efficiency with which he or she operates a firm, i.e., the degree to which a CEO generates more outputs by consuming fewer resources (Demerjian et al. 2012). Building on this idea, Demerjian et al. (2012) develop a measure of managerial ability that captures CEOs' efficiency in generating more revenue given the same levels of inputs. As described in Demerjian et al. (2012), there are two stages in the variable construction process. In the first stage, they apply the Data Envelopment Analysis statistical procedure to generate firm efficiency scores by maximizing the output—the revenue—while minimizing the inputs,

[1] Upper echelons theory (Hambrick and Mason 1984) states that behavioral factors are influential in complex decisions in a corporate context. Generally speaking, strategic decisions and organizational outcomes are predicted, to some degree, by CEO managerial characteristics (Hambrick and Mason 1984).

including the cost of inventory, general and administrative expenses, operating leases, research and development expenditures (R&Ds, hereafter), fixed assets, and intangible assets. In the second stage, they regress the firm efficiency score on firm size, market share, firm age, free cash flow, business segments, a foreign currency indicator, and year dummies to extract managerial factors from firm characteristics. Managerial ability scores are the residuals from the estimation of the second-stage regression model.[2] Managerial ability measure constructed in this way essentially represent managerial efficiency that contributes to firms' productivity and operating efficiency. Given that investments are critical inputs to support firms' long-term growth and that investment efficiency relates to the utilization of resources and firms' productivity, CEOs who have higher managerial efficiency should make more efficient investment decisions. From this perspective, the managerial ability measure developed by Demerjian et al. (2012) is a comprehensive and direct proxy indicating CEOs' operating efficiency, which I believe is an appropriate proxy for managerial ability considering the research question and setting of this study.[3]

Consistent with my predictions, I find evidence that higher ability CEOs are associated with higher levels of capital expenditures and total investments. More interestingly, the results show that a high ability CEO increases (decreases) capital expenditures, acquisition expenditures, and total investments when the firm is more prone to under-investment (over-investment). I do not, however, find such a pattern for R&Ds. In the additional analyses section, I analyze how CEO managerial ability impacts investment efficiency by taking the factors of incentive mechanism and monitoring level into consideration. In addition to managerial ability, how CEOs are being incentivized and monitored is a critical aspect affecting decision-making. In the absence of proper incentive and monitoring mechanisms, CEOs may not necessarily make investment decisions in the best interests of shareholders even if their ability could have enabled them to do so. I show that while high managerial ability is generally associated with improved investment efficiency across different levels of monitoring, this positive impact is weakened when CEOs are exposed to excessive equity risk. Specifically, for CEOs whose yearly compensation flows have high equity-based compensation and options proportions (e.g., above median), high managerial ability does not significantly improve over-investment situations; for CEOs whose equity incentives are highly sensitive to stock returns and stock volatility (e.g., above-median delta and vega), high managerial ability does not effectively mitigate either under-investing or over-

[2] Demerjian et al. (2012) confirm the validity of the measure of managerial ability and demonstrate that it contains less noise and better captures the manager-specific component of ability. In addition, they show that their proposed measures outperform existing ability measures, including past abnormal performance, CEO tenure, and media mentions. However, as Demerjian et al. (2012) acknowledge in their study, the managerial ability measures still have some limitations. For example, there could be measurement errors in some accounting variables that are used in the process of estimating firms' efficiency scores and managerial efficiency scores; the regression processes may omit some factors that affect firm efficiency and managerial ability due to unavailable data; and residuals, which are used as the measure of managerial ability, may contain some factors that are not attributable to managerial ability.

[3] The managerial ability measure developed by Demerjian et al. (2012) reflects managerial efficiency and productivity, which undoubtedly result from CEOs' past (and unobservable) experiences, psychological traits, values, etc. In this sense, this measure is a summary proxy for CEO managerial ability that directly speaks to the research question and setting of this study. I acknowledge the merits of alternative managerial quality measures used by other studies, such as Chemmanur et al. (2001) and Chemmanur and Paeglis (2005), which use composite measures for managerial quality by taking management team size, knowledge and education, tenure, CEO dominance, and reputation into account. However, given that this study investigates how managerial ability impacts investment efficiency, these measures can be incomplete and less direct compared to the ability (efficiency) measure developed by Demerjian et al. (2012).

investing propensities. These results suggest that an appropriate incentive system is necessary to maximize managerial ability's utility in enhancing investment efficiency.

This study makes the following contributions. First, by systematically and comprehensively examining how CEO managerial ability impacts firms' investment practices, it shows how CEOs' ability influences corporate-level investment decisions and outcomes, building evidence to support the upper echelons theory in Hambrick and Mason (1984) and the existing manager-effect literature. Using various proxies for managerial ability, prior research has demonstrated that better CEOs are associated with larger IPO offer sizes, stronger post-IPO operating performance, greater long-term stock returns (Chemmanur and Paeglis 2005), better firm performance (Chang et al. 2010), and higher quality accounting information (Francis et al. 2008; Demerjian et al. 2013). In a similar vein, Jian and Lee (2011) show that a CEO's reputation is positively related to post-investment performance. Extending this stream of literature, this study adopts a new perspective and shows the impact of a CEO's managerial ability on overcoming the two sources of investment inefficiency: over- and under-investment.

Second, a firm's investment level and investment efficiency generally capture both firm- and manager-specific efficiency drivers. Therefore, investment practices at the firm level are likely to under- or over-represent manager-specific factors (e.g., CEO managerial ability), depending on the drivers of firm-specific efficiency. To address this concern, I use direct and summary measures of managerial ability that economically capture significant manager-specific components of ability. Prior studies examining manager-effect and investment practices (e.g., Bertrand and Schoar 2003; Barker and Mueller 2002; Jian and Lee 2011; Goodman et al. 2013) generally rely on single or indirect measures, such as reputation, education, career path, tenure, and management forecast quality, as surrogates for managerial ability. However, using these measures to examine managerial ability's impacts on corporate practices raises concerns about induced measurement errors, because they may not be exhaustive in terms of measuring management ability and can be contaminated by firm-specific factors that are beyond management's control (Demerjian et al. 2012). Bertrand and Schoar (2003) substantiate that manager-fixed effects play a significant role in core strategic operational decisions and that the magnitude of managers' influence is great for high profile strategic decisions like acquisitions. However, the presence of manager-fixed effects does not inform us which specific managerial characteristics and whether managerial abilities influence managers' investment decisions. The question of how a firm's investment efficiency can be attributed to the manager-specific ability remains largely unexplored; the present study addresses this research gap.

Finally, this study contributes to the corporate investment literature by examining the impacts of managerial attributes contingent on certain agency issues. In addition to managerial ability, how management is incentivized and monitored affects decision-making (e.g., Jensen 1986; Shleifer and Vishny 1989; Morck et al. 1990; Core and Guay 1999; Coles et al. 2006; Bebchuk et al. 2009; Biddle et al. 2009). By investigating the association between CEO managerial ability and investment efficiency given various levels of incentives and monitoring, this study provides evidence on how managerial ability, interacting with managerial incentives and the monitoring environment, shapes corporate investment practices and influences investment efficiency.

The remainder of this paper is organized as follows. In Sect. 2, I discuss related prior literature and develop the study's hypotheses. I discuss the research design in Sect. 3 and the empirical results in Sect. 4. In Sects. 5 and 6, I present additional analyses and robustness tests. I conclude the paper in Sect. 7.

2 Literature review and hypotheses development

2.1 CEO individual attributes and corporate investment

Complex decisions are largely the result of behavioral factors, and decisions usually reflect the idiosyncrasies of decision-makers to some degree (Hambrick and Mason 1984). When making a decision, the decision-maker usually brings in a cognitive base and his/her own values. This cognitive base influences the decision-maker's anticipation of future events, insights about alternatives, and estimates of consequences related to those alternatives (March and Simon 1958; Hambrick and Mason 1984). Elaborating on the relation between upper echelon managers' characteristics and firms' strategic choices, Hambrick and Mason (1984) state that both psychological aspects, such as cognitive base values, and observable background characteristics (i.e., age, education, and financial position), can affect the decision-maker's strategic choices on product innovation, potential acquisition opportunities, capital intensity, and forward integration.

A stream of prior studies provides empirical evidence on how CEO managerial characteristics influence firms' investment practices. Barker and Mueller (2002), for example, show that CEO characteristics explain significant variance in firm R&D practices. Specifically, they find that the level of R&Ds is negatively related to CEO age while positively associated with career experience, advanced science-related degrees, and tenure. Bertrand and Schoar (2003) find that unobserved manager-fixed effects account for a significant part of the heterogeneity in firms' investment practices. In addition, they document that older generations of managers act more conservatively, while managers with an MBA degree adopt more aggressive strategies. Malmendier and Tate (2005) reveal that overconfident CEOs tend to over-invest when they have excess internal funds, whereas they trim down investment when they have to resort to outside financing. Hirshleifer et al. (2012) show evidence that overconfident CEOs invest more in innovation and possess more patents and patent citations for given R&Ds. In a similar vein, Doukas and Petmezas (2007), Malmendier and Tate (2008), and Ferris et al. (2013) all substantiate that the frequency, the characteristics, and the quality of mergers and acquisitions (M&As, hereafter) are partly attributable to CEO overconfidence. Graham et al. (2013) demonstrate that CEOs who are more risk-tolerant are more likely to pursue M&As. Huang-Meier et al. (2016) find that managers who are more optimistic tend to reserve cash for capital expenditure and acquisitions. Finally, Yung and Chen (2017) show that high ability managers are more receptive to risk-taking relative to low ability managers. For instance, the authors find that high ability managers tend to spend more on R&Ds and less on capital expenditures, whereas low ability managers significantly reduce investments in capital expenditures and R&Ds.

2.2 Hypotheses development

Various corporate practices across firms can arise from differences in CEOs' preferences, extent of risk aversion, skill levels, and opinions (Bertrand and Schoar 2003). As discussed above, CEOs' managerial characteristics to some extent account for firms' heterogeneous practices on investment policies. Therefore, I argue that managerial ability plays a role in shaping firms' investment decisions and practices. Managers with different abilities view future prospects differently (Trueman 1986). This may affect CEOs' judgments, confidence, and risk preferences. Moreover, managers with different levels of ability possess

various skill sets, which in turn affect their evaluations and perceptions of potential investment opportunities. For instance, more able CEOs may behave differently than less able CEOs in making investment decisions, by following more aggressive investment strategies while not bypassing positive NPV projects with high risk. Therefore, I posit the following hypothesis in the null form:

Hypothesis 1 (H1) High ability CEOs behave differently from less able CEOs in making investment decisions.

Investment decision-making and implementation can signal a CEO's managerial ability. First of all, less able CEOs may under-invest or over-invest because of their greater career and reputation concerns. They may be eager to inform investors about their ability through investments that are observable to investors, which results in over-investment and value-decreasing investment decisions (Stein 2003). Alternatively, low ability CEOs may ignore their own private information about payoffs and copy the decisions of previous managers, because they are afraid to be punished for their investment decisions by shareholders and markets (Scharfstein and Stein 1990). This may also lead to inefficient decision-making. Second, lacking sufficient knowledge and capability, less able CEOs may fail to accurately anticipate changes in the firm, the industry, and the whole economic environment; therefore they may fail to accurately evaluate the value of investment opportunities and identify investments that best fit their firms' needs. In other words, inappropriate strategic views and poor evaluation techniques can lead to inefficient investment decisions. In contrast, because their reputations are at stake, more able CEOs are likely to consider each investment decision more seriously. Moreover, with their ability to anticipate trends and movements in the industry and in the macro-economic environment, their knowledge of corporate operations, and their expertise in estimating and evaluating investment opportunities, more able CEOs are expected to positively impact the efficiency of corporate investment decisions. Indeed, Goodman et al. (2013) show that the higher a CEO's ability to foresee and evaluate the future payoffs from the new assets and research inputs, the more efficient that CEO's investment decisions are likely to be.

According to Copeland et al. (1994), a qualified CEO usually possesses a value-oriented view of investment activities that well matches the firm's business strategy and responds to investment opportunities that can create incremental value for the firm, through internal and/or external potential growth. In a similar vein, Jian and Lee (2011) show that stock markets react more positively to announcements of capital investments made by CEOs with better reputations. Demerjian et al. (2012) suggest that CEOs' ability to operate a firm efficiently is reflected in their ability to generate more revenue while consuming fewer resources than their peers in the same industry. Such efficiency indicates a manager's ability to create, manage, and enhance the firm's value by increasing the firm's productivity. Building on these discussions, I conjecture that higher ability CEOs make more efficient investment decisions. I depict the second hypothesis in the following alternate form:

Hypothesis 2 (H2) Ceteris paribus, more able CEOs make more efficient decisions on investments than less able CEOs.

3 Research design

3.1 Sample and data

The sample period of this study is from 1991 to 2013. I collect firms' financial data from the COMPUSTAT database. For the managerial ability measure, I utilize the dataset published on Dr. Sarah McVay's website.[4] The dataset contains managerial ability scores and managerial ability rankings. For the succinct purpose. I use the ability score as the independent variable of interest in the main tests of this study, and report the results of employing the ability ranking as an alternative independent variable of interest in one of the robustness check tables in Sect. 6. After merging the dataset from COMPUSTAT with the managerial ability dataset, I have an initial sample of 22,531 firm-year observations. I then delete observations with missing values in the required variables and exclude firms in the financial services industries (with SIC codes between 6000 and 6999), leaving 20,323 firm-year observations as the final sample.

3.2 Empirical model

The first hypothesis predicts that CEOs with various levels of managerial ability behave differently in making investment decisions. Following Biddle et al. (2009), I estimate the following Model (1) to test the association between managerial ability and investment levels. A lagged model is employed because firms generally prepare investment budgets ahead of a new fiscal year. The model controls for both industry- and year-fixed effects to account for unobserved heterogeneity across industries and years. Standard errors are clustered at both firm and fiscal-year levels.

$$\begin{aligned} INVT_{i,t+1} = {} & \beta_0 + \beta_1 ABILITY_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 MTOB_{i,t} + \beta_4 LOSS_{i,t} + \beta_5 SALE\_VOL_i \\ & + \beta_6 INVT\_VOL_{i,t} + \beta_7 CFO\_SALE_{i,t} + \beta_8 CFO\_VOL_{i,t} + \beta_9 SLACK_{i,t} + \beta_{10} DIV_{i,t} \\ & + \beta_{11} ZSCORE_{i,t} + \beta_{12} TANGIBILITY_{i,t} + \beta_{13} KSTRUCTURE_{i,t} + \beta_{14} IND\_KSTRUCTURE_{i,t} \\ & + \beta_{15} CASH_{i,t} + \beta_{16} LEV_{i,t} + \beta_{17} AQ_{i,t} + \beta_{18} EINDEX_{i,t} + Industry\ Fixed\ Effects \\ & + Year\ Fixed\ Effects + e_{i,t+1}, \end{aligned} \tag{1}$$

where

INVT = *INVT_TOT*, the level of total investments, equal to the sum of capital expenditures, R&Ds, and acquisition expenditures less cash receipts from the sale of property, plant, and equipment (PPE) scaled by lagged total assets, multiplied by 100; or *CAPX*, the level of capital expenditures, scaled by lagged total assets, multiplied by 100; or *R&D*, the level of R&Ds scaled by lagged total assets, multiplied by 100; or *ACQ*, the level of acquisition expenditures scaled by lagged total assets, multiplied by 100;
ABILITY = *ABILITY_SCORE*, CEO managerial ability scores developed by Demerjian et al. (2012);
SIZE = natural log of total assets;
MTOB = the ratio of the market value of total assets to book value of total assets;

[4] This managerial ability dataset is constructed according to the methodology in Demerjian et al. (2012). It is available on the website http://faculty.washington.edu/pdemerj/data.html.

LOSS = an indicator variable equal to 1 if net income before extraordinary items is negative, and 0 otherwise;
SALE_VOL = standard deviation of sales, scaled by average total assets over the previous 5 years;
INVT_VOL = *INVT_TOT_VOL*, the standard deviation of total investments over the previous 5 years; or *CAPX_VOL*, the standard deviation of capital expenditures over the previous 5 years; or *R&D_VOL*, the standard deviation of R&D over the previous 5 years; or *ACQ_VOL*, the standard deviation of acquisition expenditures over the previous 5 years;
CFO_SALE = operating cash flows divided by sales;
CFO_VOL = standard deviation of the cash flow from operations, scaled by the average total assets over the previous 5 years;
SLACK = the ratio of cash to PPE;
DIV = an indicator variable equal to 1 if the firm paid dividends, and 0 otherwise;
ZSCORE = 0.033*earnings before extraordinary item/total assets + sales/total assets + 0.014*retained earnings/total assets + 0.012*(working capital/total assets) + 0.006*(market value of common stock/total liabilities);
TANGIBILITY = PPE divided by total assets;
KSTRUCTURE = long-term debt divided by the sum of long-term debt and the market value of equity;
IND_KSTRUCTURE = mean K-structure for firms in the same SIC3-digit industry;
CASH = cash divided by lagged total assets;
LEV = long-term liability divided by total assets;
AQ = abnormal accruals to proxy for accounting quality, estimated by the modified Jones model; and
EINDEX = the entrenchment index constructed according to Bebchuk et al. (2009).

To test the second hypothesis, I following the practice in Biddle et al. (2009) by dividing the sample into two categories: the group more likely to over-invest and the group more likely to under-invest, using cash and leverage as criteria. The underlying theory is that the level of free cash flow and leverage together indicate the severity of agency problems, which may lead to over-investment or under-investment (Jensen 1986; Myers and Majluf 1984). Thus, I examine whether high managerial ability is able to improve investment efficiency when managers have a tendency to over-invest (under-invest) by incorporating the variable *OVERI*, which indicates the likelihood of over-investment or under-investment, and the interaction between *OVERI* and managerial ability to Model (1) (see Model 2 below).[5]

$$\begin{aligned} INVT_{i,t+1}\left(or\, ABN\_INVT_{i,t+1}\right) &= \beta_0 + \beta_1 ABILITY_{i,t} + \beta_2 OVERI_{i,t} \\ &+ \beta_3 OVERI_{i,t} * ABILITY_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 MTOB_{i,t} + \beta_6 LOSS_{i,t} \\ &+ \beta_7 SALE\_VOL_{i,t} + \beta_8 INVT\_VOL_{i,t} + \beta_9 CFO\_SALE_{i,t} \\ &+ \beta_{10} CFO\_VOL_{i,t} + \beta_{11} SLACK_{i,t} + \beta_{12} DIV_{i,t} + \beta_{13} ZSCORE_{i,t} \\ &+ \beta_{14} TANGIBILITY_{i,t} + \beta_{15} KSTRUCTURE_{i,t} + \beta_{16} IND\_KSTRUCTURE_{i,t} \\ &+ \beta_{17} AQ_{i,t} + \beta_{18} EINDEX_{i,t} + e_{i,t+1}, \end{aligned} \tag{2}$$

[5] I exclude the cash and leverage variables in Model (2) because the *OVERI* variable captures information about cash and leverage.

where

INVT = *INVT_TOT*, the level of total investments, equal to the sum of capital expenditures, R&Ds, and acquisition expenditures less cash receipts from the sale of PPE scaled by lagged total assets, multiplied by 100; or *CAPX*, the level of capital expenditures scaled by lagged total assets, multiplied by 100; or *R&D*, the level of R&Ds scaled by lagged total assets, multiplied by 100; or *ACQ*, the level of acquisition expenditures scaled by lagged total assets, multiplied by 100;
ABN_INVT = *ABN_TOT*, the abnormal level of total investments; or *ABN_CAPX*, the abnormal level of capital expenditure; or *ABN_R&D*, the abnormal level of R&Ds; or *ABN_ACQ*, the abnormal level of acquisition expenditure;
ABILITY = *ABILITY_SCORE*, CEO managerial ability scores developed by Demerjian et al. (2012);
OVERI = a composite score measure created to indicate the likelihood of over- and under-investment based on the ranking of cash and leverage levels.

All other variables are defined as in Model (1).

OVERI is a rank variable used to suggest a tendency towards over-investment or under-investment. As in Biddle et al. (2009), I rank firms into deciles according to their cash and leverage levels. Leverage is multiplied by − 1 before ranking, so that it can be interpreted in the same direction as cash balance. Deciles constructed in this way are re-scaled to range from 0 to 1. I then create a composite score measure (*OVERI*) equaling the mean of the ranked values of the two partitioning variables. The *OVERI* variable is increasing with the trend of over-investment. In Model (2), β_1 indicates the effect of managerial ability on investment level when under-investment is most likely, i.e., when *OVERI* is 0, and β_3 measures the effect of managerial ability on the association of likelihood of over-investing and actual investment levels. If more able CEOs make more efficient investment decisions, I expect to observe a positive β_1 and a negative β_3.

Following Biddle and Hilary (2006) and Biddle et al. (2009), I include several control variables, including firm size (*SIZE*), market-to-book ratio (*MTOB*), return on assets (*ROA*), loss (*LOSS*), sales volatility (*SALE_VOL*), investment volatility (*INVT_VOL*), cash flow to sales ratio (*CFO_SALE*), cash flow volatility (*CFO_VOL*), cash to PPE ratio (*SLACK*), dividend (*DIV*), the possibility of bankruptcy measured as in Altman (1968) (*ZSCORE*), the ratio of PPE to total assets (*TANGIBILIT*), capital structure (*KSTRUCTURE*), and leverage (*IND_STRUCTURE*). Sales volatility, return on assets, and loss indicate firm performance and profitability. Both firm size and market-to-book ratio represent growth opportunities. Cash flow to sales ratio, cash flow volatility, and cash to PPE ratio, dividend and the possibility of bankruptcy, and capital structure suggest free cash availability, the degree of financial constraint, and the magnitude of agency problems, respectively. In addition, as Biddle et al. (2009) reveal, financial reporting quality and corporate governance can affect investment efficiency. Therefore, I control for financial reporting quality (*AQ*), proxied by abnormal discretionary accruals estimated using the modified Jones model, and the management entrenchment index (*EINDEX*) constructed according to Bebchuk et al. (2009).[6]

[6] Before running regressions, I calculate variance inflation factors (VIF, hereafter) for the independent variables. The mean VIF is 1.50, and the independent variable with the highest VIF is capital structure (*KSTRUCTURE*), 2.79.

Table 1 Sample distribution

Year	# of obs.	% of sample	Cumulative percent
Panel A: by year			
1991	708	3.48	3.48
1992	710	3.49	6.98
1993	821	4.04	11.02
1994	781	3.84	14.86
1995	852	4.19	19.05
1996	747	3.68	22.73
1997	705	3.47	26.2
1998	1034	5.09	31.28
1999	925	4.55	35.84
2000	957	4.71	40.55
2001	926	4.56	45.10
2002	1194	5.88	50.98
2003	1092	5.37	56.35
2004	1151	5.66	62.01
2005	967	4.76	66.77
2006	993	4.89	71.66
2007	779	3.83	75.49
2008	822	4.04	79.54
2009	824	4.05	83.59
2010	834	4.10	87.69
2011	869	4.28	91.97
2012	871	4.29	96.26
2013	761	3.74	100.00
Total	20,323	100.00	

	2-digit SIC	# of obs.	% of sample	Cum. %
Panel B: by industry				
Metal mining	10	115	0.57	0.57
Oil and gas	13	783	3.85	4.42
Food, beverage	20	728	3.58	8.00
Textile mill products	22	193	0.95	8.95
Apparel and other fabrics finished products	23	241	1.19	10.14
Lumber and wood products, except furniture	24	115	0.57	10.70
Furniture and fixtures	25	234	1.15	11.85
Paper and allied products	26	442	2.17	14.03
Printing, publishing, and allied industries	27	393	1.93	15.96
Chemicals and allied products	28	1885	9.28	25.24
Petroleum refining and related industries	29	284	1.40	26.63
Rubber	30	268	1.32	27.95
Leather and leather products	31	100	0.49	28.45
Stone, clay, glass, and concrete products	32	220	1.08	29.53
Primary metal industries	33	481	2.37	31.89

Table 1 continued

	2-digit SIC	# of obs.	% of sample	Cum. %
Fabricated metal products	34	430	2.12	34.01
Industrial machinery and computer equipment	35	1749	8.61	42.62
Electronic and other electric equipment	36	1773	8.72	51.34
Transportation equipment	37	663	3.26	54.60
Instruments and related products	38	1267	6.23	60.84
Miscellaneous manufacturing	39	217	1.07	61.91
Railroad transportation	40	118	0.58	62.49
Motor freight transportation and warehousing	42	146	0.72	63.20
Transportation by air	45	177	0.87	64.08
Communication	48	643	3.16	67.24
Wholesale—durable goods	50	579	2.85	70.09
Wholesale—non-durable goods	51	289	1.42	71.51
General merchandise store	53	305	1.50	73.01
Food stores	54	189	0.93	73.94
Automotive dealers and gasoline stations	55	134	0.66	74.60
Apparel and accessory stores	56	369	1.82	76.42
Furniture and home furnishings stores	57	130	0.64	77.06
Eating and drinking	58	399	1.96	79.02
Miscellaneous retail	59	417	2.05	81.07
Personal services	72	119	0.59	81.66
Business services	73	2093	10.30	91.95
Health services	80	353	1.74	93.69
Educational services	82	102	0.50	94.19
Engineering and management services	87	286	1.41	95.60
Others[a]		894	4.40	100.00
		20,323	100.00	

[a]Industries with observations less than 100 are aggregated to this category

4 Results

4.1 Descriptive statistics and univariate analysis

Table 1 summarizes the sample distribution by year and by two-digit SIC code industry.

Panel A of Table 1 shows that the sample observations generally are distributed evenly across years. As Panel B shows, the industry with the highest frequency in the sample is Business Services (10.30 percent, SIC code 73), followed by Chemicals and Allied Products (9.28 percent, SIC code 28) and Electronic and Other Electric Equipment (8.72 percent, SIC code 36).

Descriptive statistics and correlations among selected variables appear in Table 2. All continuous variables are winsorized at the 1st and 99th percentiles in each year to minimize the effects of outliers.

In Panel A of Table 2, the mean (median) of total investments, *INVT_TOT*, is 12.903 percent (9.405 percent) of the previous year's total assets. Regarding the specific types of investments, the mean (median) of capital expenditures, *CAPX*, is 6.196 percent (4.362

Table 2 Descriptive statistics

Variable	N	Mean	SD	25 percentile	Median	75 percentile
Panel A: full sample						
$INVT\_TOT_{t+1}$	20,323	12.903	12.385	5.011	9.405	16.465
$CAPX_{t+1}$	20,323	6.196	5.844	2.418	4.362	7.813
$R\&D_{t+1}$	20,323	3.531	5.914	0.000	0.463	4.671
ACQ_{t+1}	20,323	3.275	8.517	0.000	0.000	2.147
ABILITY_SCORE	20,323	0.010	0.132	− 0.073	0.001	0.083
ABILITY_RANKING	20,323	0.583	0.268	0.400	0.600	0.800
OVERI	20,323	0.550	0.243	0.350	0.500	0.750
SIZE	20,323	7.266	1.465	6.208	7.101	8.185
MTOB	20,323	1.959	1.233	1.221	1.579	2.238
LOSS	20,323	0.176	0.381	0.000	0.000	0.000
SALE_VOL	20,323	0.152	0.133	0.064	0.112	0.192
INVT_VOL	20,323	0.065	0.063	0.023	0.044	0.084
CAPX_VOL	20,323	0.024	0.025	0.008	0.016	0.030
R&D_VOL	20,323	0.009	0.023	0.000	0.001	0.007
ACQ_VOL	20,323	0.043	0.060	0.000	0.020	0.059
CFO_SALE	20,323	0.106	0.199	0.050	0.098	0.162
CFO_VOL	20,323	0.051	0.042	0.024	0.040	0.063
SLACK	20,323	1.492	3.440	0.076	0.317	1.234
DIV	20,323	0.587	0.492	0.000	1.000	1.000
ZSCORE	20,323	1.209	0.717	0.725	1.060	1.500
TANGIBILITY	20,323	0.294	0.214	0.127	0.238	0.409
KSTRUCTURE	20,323	0.180	0.188	0.021	0.129	0.274
IND_KSTRUCTURE	20,323	0.180	0.122	0.085	0.146	0.248
AQ	20,323	− 0.887	3.261	− 0.547	− 0.129	− 0.049
EINDEX	20,323	2.303	1.333	1.000	2.000	3.000

Table 2 continued

	Low ability			High ability			Difference tests	
	N	Mean	Median	N	Mean	Median	*t* test (p values)	Wilcoxon (p values)
Panel B: by low versus high ability								
$INVT\_TOT_{t+1}$	10,161	12.230	8.932	10,162	13.577	9.961	0.000	0.000
$CAPX_{t+1}$	10,161	5.534	4.047	10,162	6.859	4.777	0.000	0.000
$R\&D_{t+1}$	10,161	3.790	0.726	10162	3.272	0.000	0.000	0.000
ACQ_{t+1}	10,161	3.004	0.000	10,162	3.546	0.000	0.000	0.023
INVT_VOL	10,161	0.068	0.046	10,162	0.062	0.042	0.000	0.000
CAPX_VOL	10,161	0.025	0.016	10,162	0.024	0.015	0.000	0.000
R&D_VOL	10,161	0.010	0.001	10,162	0.007	0.000	0.000	0.000
ACQ_VOL	10,161	0.044	0.022	10,162	0.041	0.018	0.000	0.000

	(1)	(3)	(4)	(5)	(6)
Panel C: correlations among selected variables					
1. *ABILITY_SCORE*		0.091***	0.113***	− 0.005	0.054***
3. $INVT\_TOT_{t+1}$	0.070***		0.417***	0.493***	0.718***
4. $CAPX_{t+1}$	0.100***	0.486***		− 0.091***	− 0.028***
5. $R\&D_{t+1}$	− 0.071***	0.454***	− 0.155***		0.048***
6. ACQ_{t+1}	0.036***	0.363***	− 0.078***	0.048***	

In Panel B, the samples are partitioned into low versus high groups based on the median values of CEO managerial ability scores

All variables are defined in "Appendix"

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

Table 3 The unconditional association between managerial ability and investment levels (N = 20,323)

	(1) *INVT_TOT* Coefficient (t-stat)	(2) *CAPX* Coefficient (t-stat)	(3) *R&D* Coefficient (t-stat)	(4) *ACQ* Coefficient (t-stat)
ABILITY_SCORE	3.996***	2.564***	0.328	1.102
	(2.94)	(5.53)	(0.48)	(1.44)
SIZE	− 0.465***	− 0.044	0.002	− 0.330***
	(− 3.36)	(− 0.87)	(0.03)	(− 5.51)
MTOB	1.515***	0.656***	0.575***	− 0.037
	(9.40)	(11.04)	(6.19)	(− 0.54)
LOSS	− 1.492***	− 0.866***	1.038***	− 1.877***
	(− 4.77)	(− 7.22)	(6.82)	(− 8.30)
SALE_VOL	− 3.411***	− 0.723**	− 3.532***	0.255
	(− 3.63)	(− 2.07)	(− 8.94)	(0.45)
INVT_VOL	17.538***	29.467***	86.122***	12.630***
	(7.26)	(6.47)	(5.57)	(6.22)
CFO_SALE	− 0.482	1.026	− 0.665	1.103***
	(− 0.56)	(1.55)	(− 1.46)	(2.60)
CFO_VOL	18.576***	2.862**	3.146	− 3.451
	(5.53)	(2.46)	(1.59)	(− 1.51)
SLACK	− 0.000	− 0.065***	− 0.129***	0.142***
	(− 0.00)	(− 4.08)	(− 2.91)	(5.06)
DIV	− 2.582***	− 0.826***	− 1.234***	− 0.209
	(− 8.70)	(− 6.99)	(− 7.10)	(− 1.36)
ZSCORE	− 0.678**	0.420***	− 0.214	− 0.133
	(− 2.21)	(3.31)	(− 1.27)	(− 1.02)
TANGIBILITY	12.902***	13.898***	− 0.205	− 1.841***
	(13.28)	(20.25)	(− 0.51)	(− 3.22)
KSTRUCTURE	− 9.877***	− 3.825***	− 2.304***	− 2.340***
	(− 9.19)	(− 8.30)	(− 4.63)	(− 3.49)
IND_KSTRUCTURE	− 1.849	− 0.627	− 0.640	− 0.120
	(− 1.63)	(− 1.08)	(− 1.16)	(− 0.17)
CASH	8.411***	− 0.494	8.856***	− 1.390*
	(5.47)	(− 1.03)	(8.89)	(− 1.76)
LEV	1.417	0.094	0.755	0.080
	(1.55)	(0.29)	(1.32)	(0.14)
AQ	0.035**	− 0.012	0.047***	− 0.015
	(2.13)	(− 0.97)	(3.60)	(− 1.00)
EINDEX	0.186**	− 0.002	0.024	0.150***
	(2.16)	(− 0.05)	(0.56)	(2.93)
INTERCEPT	7.735**	0.720	2.904	4.501***
	(2.44)	(0.96)	(1.46)	(2.97)
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes

Table 3 continued

	(1) *INVT_TOT* Coefficient (t-stat)	(2) *CAPX* Coefficient (t-stat)	(3) *R&D* Coefficient (t-stat)	(4) *ACQ* Coefficient (t-stat)
R-sq	0.232	0.557	0.596	0.057

INVT_TOT is the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment; *CAPX* is the level of capital expenditures; *R&D* is the level of R&D expenditure; *ACQ* is acquisition expenditures; *ABILITY_SCORE* is CEO managerial ability scores. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

percent) of the previous year's total assets; the mean of *R&D* is 3.531 percent of the previous year's total assets; and the mean of acquisition expenditures, *ACQ*, is 3.275 percent of the previous year's total assets. The mean and median values of the managerial ability score, *ABILITY_SCORE*, are 0.010 and 0.001, respectively. The firms' financial data are as follows. The average firm size is 7.266. The sample firms in the study have an average market-to-book ratio of 1.959, an average sales volatility of 0.152, and a mean operating cash flow volatility of 0.051. An average of 17.6 percent of the firm-year observations report losses. The average volatility of total investments is 0.065. The ratio of operating cash flow to sales has a mean of 0.106 and a median of 0.098. The ratio of cash to PPE, *SLACK*, has a mean of 1.492, and the Z-score to indicate bankruptcy risk has an average of 1.209. Finally, the ratio of PPE to total assets, *TANGIBILITY*, has a mean of 0.294, and the capital structure has an average of 0.180.

Panel B of Table 2 reports descriptive statistics and difference tests by low versus high managerial ability score, using the median of the managerial ability score as a benchmark. It shows that the high ability group has higher levels of capital expenditures, acquisition expenditures, and total investments but lower levels of R&Ds than the low ability group. In addition, the high ability group displays lower volatilities in investments. Panel C of Table 2 presents the Spearman correlations (the lower matrix) and Pearson correlations (the upper matrix) between the independent variable of interest and the dependent variables. As reported, capital expenditures, acquisition expenditures, and total investments are positively correlated with the ability score; *R&D* is negatively correlated with managerial ability score in the lower matrix.

4.2 The association of managerial ability and investments

H1 predicts that CEOs of various managerial ability levels behave differently. I thus conduct multivariate regressions to investigate the association between managerial ability and actual levels of investment by testing Model (1). The results are tabulated in Table 3.

Table 3 shows that managerial ability score, *ABILITY_SCORE*, is significantly associated with higher levels of total investments (t = 2.94) and capital expenditures (t = 5.53). These results indicate that more able CEOs are associated with higher levels of corporate investments, particularly in the form of capital expenditures.

Next, I examine the association between managerial ability and investments conditioned on firms' tendency to over- or under-invest in order to test H2, which predicts that higher

Table 4 The association between managerial ability and investment efficiency (N = 20,323)

	INVT_TOT Coefficient (t-stat)	*CAPX* Coefficient (t-stat)	*R&D* Coefficient (t-stat)	*ACQ* Coefficient (t-stat)
ABILITY_SCORE	12.292***	6.414***	− 0.185	3.689**
	(4.50)	(5.75)	(− 0.16)	(2.27)
OVERI	2.921***	0.264	2.975***	− 0.273
	(4.34)	(0.85)	(7.50)	(− 0.59)
OVERI_ABILITY	− 14.600***	− 6.543***	0.424	− 4.354*
	(− 3.27)	(− 3.97)	(0.17)	(− 1.89)
SIZE	− 0.403***	− 0.028	0.041	− 0.322***
	(− 2.98)	(− 0.58)	(0.52)	(− 5.86)
MTOB	1.782***	0.679***	0.753***	− 0.041
	(11.28)	(11.91)	(7.08)	(− 0.75)
LOSS	− 1.320***	− 0.870***	1.178***	− 1.892***
	(− 4.14)	(− 7.08)	(6.87)	(− 8.36)
SALE_VOL	− 3.258***	− 0.784**	− 3.385***	0.156
	(− 3.38)	(− 2.20)	(− 8.26)	(0.27)
INVT_VOL	16.013***	28.623***	89.344***	3.689**
	(6.43)	(6.28)	(5.63)	(2.27)
CFO_SALE	− 0.705	1.158*	− 1.093**	1.240***
	(− 0.81)	(1.76)	(− 2.27)	(3.09)
CFO_VOL	21.383***	2.709**	5.319***	− 3.860*
	(6.35)	(2.34)	(2.72)	(− 1.75)
SLACK	0.160***	− 0.074***	0.025	0.119***
	(3.21)	(− 5.00)	(0.76)	(4.54)
DIV	− 2.629***	− 0.811***	− 1.268***	− 0.191
	(− 8.93)	(− 6.89)	(− 7.00)	(− 1.23)
ZSCORE	− 0.667**	0.461***	− 0.227	− 0.092
	(− 2.30)	(3.67)	(− 1.39)	(− 0.72)
TANGIBILITY	12.500***	13.990***	− 0.566	− 1.757***
	(13.22)	(20.57)	(− 1.34)	(− 3.23)
KSTRUCTURE	− 7.460***	− 3.370***	− 0.826**	− 2.211***
	(− 8.23)	(− 8.17)	(− 2.23)	(− 3.85)
IND_KSTRUCTURE	− 1.834	− 0.498	− 0.796	− 0.010
	(− 1.62)	(− 0.85)	(− 1.43)	(− 0.01)
AQ	0.037**	− 0.011	0.048***	− 0.014
	(2.29)	(− 0.95)	(3.62)	(− 1.00)
EINDEX	0.161*	− 0.004	0.011	0.150***
	(1.85)	(− 0.11)	(0.25)	(2.92)
INTERCEPT	6.139*	0.132	1.702	4.321***
	(1.92)	(0.16)	(0.93)	(2.70)
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes

Table 4 continued

	INVT_TOT Coefficient (t-stat)	*CAPX* Coefficient (t-stat)	*R&D* Coefficient (t-stat)	*ACQ* Coefficient (t-stat)
R-sq	0.231	0.558	0.582	0.057

INVT_TOT is the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment; *CAPX* is the level of capital expenditures; *R&D* is the level of R&D expenditure; *ACQ* is acquisition expenditures; *ABILITY_SCORE* is CEO managerial ability scores; and OVERI is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

ability CEOs make more efficient investment decisions. The results are reported in Table 4.

As Table 4 shows, the coefficients for *ABILITY_SCORE* are significantly positive when the dependent variables are total investments, capital expenditures, and acquisition expenditures, which indicates that a firm with a more able CEO tends to increase its total investments, capital expenditures, and acquisition expenditures when the firm is in a setting more prone to under-investment. This suggests that having a higher ability CEO contributes to an increase in the firm's investment efficiency when the firm is very likely to under-invest. The results are economically significant. For example, Column (1) shows that a one standard deviation increase in ABILITY_SCORE results in an increase of 1.623 in total capital investments among the firms that are most likely to under-invest. Considering that the mean value of total capital investments (deflated by the previous year's total assets) is 12.903, this reflects an increase of 12.58 percent. Column (2) shows that one standard deviation increase in *ABILITY_SCORE* is associated with an increase of 0.847 in capital expenditures among the firms that are most likely to under-invest. Given that the mean of capital expenditures is 6.196, this indicates an increase of 13.67 percent. Furthermore, the significant and negative coefficients of *OVERI_ABILITY* indicate that when the ex-ante likelihood of over-investment is high, higher ability CEOs tend to reduce total investments, capital expenditures, and acquisition expenditures. This evidence suggests that talented CEOs of firms more prone to over-investment can increase investment efficiency in terms of capital expenditures, acquisition expenditures, and total investments. I do not, however, find significant results for R&Ds.

With respect to control variables, the estimated coefficients are generally consistent with the findings of prior literature (Biddle and Hilary 2006; Biddle et al. 2009). Growing firms (*MTOB*), for example, are more likely to increase investments; distributing dividends (*DIV*) negatively affects the investment level of the next period; firm size (*SIZE*), volatilities in sales (*SALE_VOL*), and a capital structure with a higher ratio of leverage (*KSTRUCTURE*) are negatively associated with investment levels; and volatilities in investments (*INVT_VOL*) are positively related to investment levels.

In sum, the conditional association tests reveal that managerial ability plays a significant role in promoting investment efficiency. Specifically, when firms are most likely to under-invest, higher ability CEOs increase capital expenditures, acquisition expenditures, and total investments. At the same time, however, more able CEOs appear to decrease capital

Table 5 The association of managerial ability and investment efficiency using abnormal investment (N = 19,787)

	(1) *ABN_TOT* Coefficient (t-stat)	(2) *ABN_CAPX* Coefficient (t-stat)	(3) *ABN_R&D* Coefficient (t-stat)	(4) *ABN_ACQ* Coefficient (t-stat)
ABILITY_SCORE	11.863***	7.077***	0.711	2.260
	(3.02)	(4.36)	(0.36)	(1.48)
OVERI	2.448*	0.536	2.297***	− 0.194
	(1.85)	(1.42)	(2.60)	(− 0.38)
OVERI_ABILITY	− 17.255***	− 8.324***	− 3.377	− 3.336
	(− 2.89)	(− 4.03)	(− 0.91)	(− 1.50)
CONTROL VARIABLES	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
R-sq	0.277	0.334	0.398	0.048

ABN_TOT is the abnormal level of total investments, proxied by the residuals from the regression of a firm's total capital investment on lagged sales growth; *ABN_CAPX* is the abnormal level of capital expenditures, proxied by the residuals from the regression of a firm's capital expenditures on lagged sales growth; *ABN_R&D* is the abnormal level of R&Ds, proxied by the residuals from the regression of a firm's R&Ds on lagged sales growth; *ABN_ACQ* is the abnormal level of acquisition expenditures, proxied by the residuals from the regression of a firm's acquisition expenditures on lagged sales growth; *ABILITY_SCORE* is CEO managerial ability scores; and *OVERI* is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

expenditures, acquisition expenditures, and total investments in order to constrain the magnitude of over-investing when firms operate in settings more prone to over-investment.

5 Additional analyses

5.1 CEO managerial ability and investment efficiency using abnormal levels of investment

In this section, I employ abnormal investment levels as alternative dependent variables to examine the association between CEO managerial ability and investment conditioning on firms' tendency to under-invest and/or over-invest. I estimate the abnormal investment level using the following model (Model 3), as in Biddle et al. (2009). Specifically, I conduct industry-year regressions by regressing a firm's total investment (or capital expenditures, R&D, and acquisition expenditures, respectively) in year t + 1 on sales growth ($\Delta SALE$) in year t.[7] Residuals from such regressions are considered abnormal investment levels.[8]

[7] I require at least 20 observations for each year and industry.

[8] The more positive (negative) the residuals, the greater is the magnitude of over-investment (under-investment).

Table 6 Cross-sectional tests based on incentive levels

	Equity proportion		Option proportion		Delta		Vega	
	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)
ABILITY_SCORE	11.846***	8.404**	13.057***	7.802**	14.510***	7.284*	16.476***	6.521
	(3.54)	(2.38)	(3.94)	(2.08)	(4.58)	(1.83)	(4.87)	(1.56)
OVERI	2.462***	4.716***	1.711*	5.270***	3.120***	3.317***	1.806**	5.169***
	(3.05)	(4.02)	(1.67)	(4.36)	(3.19)	(3.19)	(1.98)	(4.10)
OVERI_ABILITY	− 20.218***	− 4.579	− 19.113***	− 5.249	− 18.772***	− 8.214	− 19.691***	− 7.149
	(− 3.49)	(− 0.76)	(− 3.21)	(− 0.83)	(− 3.23)	(− 1.22)	(− 3.32)	(− 0.99)
CONTROL VARIABLES	Included	Included	Included	Included	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	8490	8501	8490	8501	8089	9028	8319	8315
R-sq	0.201	0.258	0.211	0.247	0.221	0.247	0.240	0.238

The sample firms are divided into below median and above median groups based on equity proportion, option proportion, pay-for-performance sensitivity of CEOs' pay (delta), and the sensitivity of CEOs' wealth to stock return volatility (vega), respectively. The dependent variables of the regressions are *INVT_TOT*, the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment; *ABILITY_SCORE* is CEO managerial ability scores; and *OVERI* is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

$$INVT_{i,t+1} = \beta_0 + \beta_1 \Delta SALE_{i,t} + e_{i,t+1}, \quad (3)$$

where

INVT = *INVT_TOT*, the level of total investments, equal to the sum of capital expenditures, R&Ds, and acquisition expenditures less cash receipts from the sale of PPE; or *CAPX*, the level of capital expenditures; or *R&D*, the level of R&D; or *ACQ*, the level of acquisition expenditures;
$\Delta SALE$ = sales growth.

I then replace the dependent variables in Model (2) with the abnormal investment levels as estimated above and test Model (2). The results are tabulated in Table 5.

Table 5 shows that *ABILITY_SCORE* is positively associated with abnormal total investments and abnormal capital expenditures. It also shows that high ability CEOs tend to reduce abnormal total investments and abnormal capital expenditures when *OVERI* is increasing.

5.2 Association between CEO managerial ability and investment efficiency contingent on incentive and monitoring levels

In this section, I examine the association between managerial ability and investment efficiency by taking incentive levels and monitoring strength into consideration. When making investment decisions, risk-averse CEOs, unlike risk-neutral shareholders, are unwilling to engage in risky investments and hesitate to take on favorable investment opportunities. In addition, managers' personal interests, such as empire-building, particular investment preferences, long-term promotion, and job security, can also drive the disparities between the agent's actual decisions and the decisions that would maximize the welfare of the principal (Jensen 1986; Shleifer and Vishny 1989; Morck et al. 1990). Appropriately designed compensation incentives are necessary to motivate risk-averse managers to catch investment opportunities and invest in high risk and positive NPV projects (Core and Guay 1999; Coles et al. 2006), and monitoring mechanisms are vital to ensuring that managers act in their firms' best interests (e.g., Jensen 1986; Shleifer and Vishny 1989; Morck et al. 1990; Bebchuk et al. 2009; Biddle et al. 2009; Chien et al. 2016). These discussions suggest that CEOs may not necessarily make investment decisions in the best interests of shareholders even if their ability could have enabled them to do so, especially if they are not properly motivated and monitored. Hence, it is interesting to investigate how the association between managerial ability and investment efficiency varies given different levels of incentives and monitoring.[9]

Aligning managers' financial interests with those of shareholders by tying managers' wealth to stock return is necessary to encourage risk-averse managers to invest in risky but positive NPV projects and make decisions that serve the objective of maximizing shareholder value (Core and Guay 1999; Coles et al. 2006). Particularly, options are believed to be effective in cultivating management's risk incentives, because options protect managers from the down-side risk (e.g., Jensen and Mecking 1976; Hirshleifer and Suh 1992; Murphy 1999; Rajgopal and Shevlin 2002; Hayes et al. 2012). However, an overly

[9] These cross-section analyses serves two goals. First, they can further examine whether the different degrees of managerial ability's impacts on improving investment efficiency are consistent with this study's hypotheses. Second, they can provide evidence as to whether the positive effects of high managerial ability on investment efficiency still holds after controlling for CEOs' various incentives and boards' monitoring levels.

Table 7 Cross-sectional tests based on monitoring levels

	Eindex		Board independence		Inside director ownership		CEO/chair duality	
	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	No Coefficient (t-stat)	Yes Coefficient (t-stat)
ABILITY_SCORE	12.250***	11.714***	10.373***	11.116***	14.552***	7.203*	11.809***	9.529***
	(3.81)	(3.06)	(2.65)	(3.62)	(4.27)	(1.71)	(2.85)	(2.71)
OVERI	2.705***	3.375***	0.759	6.727***	3.765***	3.603***	2.702**	4.112***
	(2.89)	(3.31)	(0.66)	(7.03)	(2.73)	(2.93)	(2.32)	(4.50)
OVERI_ABILITY	− 12.232**	− 16.917***	− 11.347*	− 11.067**	− 18.962***	− 5.281	− 13.282*	− 12.135*
	(− 2.28)	(− 2.82)	(− 1.75)	(− 2.07)	(− 3.18)	(− 0.75)	(− 1.78)	(− 1.95)
CONTROL VARIABLES	Included	Included	Included	Included	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11,191	9132	6858	7525	6456	6463	7459	9658
R-sq	0.240	0.234	0.223	0.243	0.221	0.256	0.239	0.226

The sample firms are divided into below median and above median groups based on entrenchment index (Eindex), the proportion of independent board directors (Board Independence), and the value of inside director ownership (Inside Director Ownership). In addition, the sample firms are divided based on CEO/Chair duality, in which "yes" means a CEO is also the Chairman of the board and "no" otherwise. The dependent variables of the regressions are *INVT_TOT*, the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment. *ABILITY_SCORE* is CEO managerial ability scores; and *OVERI* is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

Table 8 The association of managerial ability and investment efficiency: using average ability score as an independent variable of interest (N = 17,117)

	(1) *INVT_TOT* Coefficient (t-stat)	(2) *CAPX* Coefficient (t-stat)	(3) *R&D* Coefficient (t-stat)	(4) *ACQ* Coefficient (t-stat)
AVGABILITY_SCORE	8.576***	4.938***	− 0.634	2.595
	(2.75)	(3.32)	(− 0.40)	(1.41)
OVERI	3.231***	0.112	3.166***	− 0.245
	(4.32)	(0.29)	(6.68)	(− 0.47)
OVERI_AVGABILITY_SCORE	− 11.644**	− 5.269**	0.503	− 3.683
	(− 2.11)	(− 2.53)	(0.15)	(− 1.19)
CONTROL VARIABLES	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
R-sq	0.225	0.578	0.584	0.056

INVT_TOT is the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment; *CAPX* is the level of capital expenditures; *R&D* is the level of R&D expenditure; *ACQ* is the level of acquisition expenditures; *AVGABILITY_SCORE* is the average ability score of a CEO throughout the sample years when he/she is the CEO of the firm; and *OVERI* is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels

*, **, and *** indicate significance levels at 10, 5, and 1%, respectively

incentivized compensation scheme can induce excessive risk-taking behaviors among managers, resulting in sub-optimal decision-making at the cost of shareholders' long-term benefits (e.g., Chen et al. 2006; Dong et al. 2010). Furthermore, high levels of equity ownership entrench management, leading managers to make myopic decisions that are detrimental to shareholders (e.g., Morck et al. 1988; Stulz 1988; McConnell and Servaes 1990). Last but not least, using equity incentives to align the interests of shareholders and managers requires managers stay with firms for certain length of time; if the time frames of managers and shareholders are different, a negative effect of options granting on promoting expenditures on research and development and long-term investments is very likely to occur (Bhargava 2013).

In order to examine how the association between managerial ability and investment efficiency varies with different incentive levels, I classify the sample into below-median and above-median groups based on the percentages of CEOs' overall equity-based compensation and options in their yearly compensation flows, pay-performance sensitivity (delta), and the sensitivity of CEO wealth to stock volatility (vega).[10] I then test the association between managerial ability and total investments (Model 2) across these subsamples and tabulate the results in Table 6.

As Table 6 shows, in the below-median groups, the positive impacts of managerial ability in mitigating under-investment and over-investment generally persist. However, in the above-median groups, higher ability is not shown to significantly reduce firms' tendency to over-invest. In addition, for the CEOs whose wealth is highly sensitive to stock

[10] The calculation of delta and vega follows Core and Guay (1999, 2002) and Coles et al. (2006).

Table 9 The association of managerial ability and investment efficiency: using ability ranking as an independent variable of interest

	(1) *INVT_TOT* Coefficient (t-stat)	(2) *CAPX* Coefficient (t-stat)	(3) *R&D* Coefficient (t-stat)	(4) *ACQ* Coefficient (t-stat)
Panel A: the unconditional association between managerial ability and investment levels				
ABILITY_RANKING	1.208**	1.164***	− 0.018	0.199
	(2.14)	(6.16)	(− 0.07)	(0.57)
CONTROL VARIABLES	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
N	20,323	20,323	20,323	20,323
R-sq	0.232	0.557	0.596	0.056
Panel B: the association between managerial ability and investment efficiency				
ABILITY_RANKING	4.108***	2.261***	− 0.049	1.292**
	(3.98)	(5.01)	(− 0.10)	(1.99)
OVERI	5.867***	1.286**	3.110***	0.778
	(5.05)	(2.26)	(4.33)	(1.15)
OVERI_ABILITY	− 5.348***	− 1.906***	− 0.207	− 1.877*
	(− 2.97)	(− 2.70)	(− 0.20)	(− 1.94)
CONTROL VARIABLES	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
N	20,323	20,323	20,323	20,323
R-sq	0.229	0.557	0.582	0.056

Table 9 continued

	(1) *ABN_TOT* Coefficient (t-stat)	(2) *ABN_CAPX* Coefficient (t-stat)	(3) *ABN_R&D* Coefficient (t-stat)	(4) *ABN_ACQ* Coefficient (t-stat)
Panel C: the association of managerial ability and investment efficiency using abnormal investment				
ABILITY_RANKING	2.722*	2.281***	− 0.845	0.886
	(1.85)	(3.91)	(− 1.06)	(1.36)
OVERI	4.715**	1.762**	2.158*	0.744
	(2.27)	(2.52)	(1.68)	(0.88)
OVERI_ABILITY	− 4.378*	− 2.311***	0.070	− 1.656
	(− 1.73)	(− 2.87)	(0.05)	(− 1.56)
CONTROL VARIABLES	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
N	19,787	19,787	19,787	19,787
R-sq	0.276	0.333	0.398	0.048

	Equity proportion		Option proportion		Delta		Vega	
	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)
Panel D: cross-sectional tests based on incentive levels								
ABILITY_RANKING	3.900***	3.098**	4.286***	3.155**	5.285***	2.530	6.559***	1.673
	(2.94)	(2.01)	(3.27)	(1.97)	(3.82)	(1.49)	(4.52)	(0.90)
OVERI	6.529***	5.736***	5.830***	6.433***	7.033***	5.626***	6.537***	6.391***
	(3.62)	(3.27)	(2.96)	(3.45)	(4.23)	(2.88)	(3.80)	(2.78)
OVERI_ABILITY	− 7.467***	− 1.753	− 7.509***	− 2.058	− 6.956***	− 4.101	− 8.438***	− 2.358
	(− 3.02)	(− 0.65)	(− 3.08)	(− 0.76)	(− 2.71)	(− 1.42)	(− 3.43)	(− 0.74)

Table 9 continued

	Equity proportion		Option proportion		Delta		Vega	
	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)
CONTROL VARIABLES	Included	Included	Included	Included	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	8490	8501	8490	8501	8089	9028	8319	8315
R-sq	0.200	0.257	0.209	0.247	0.220	0.246	0.239	0.238

	Eindex		Board independence		Inside director ownership		CEO/chair duality	
	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	No Coefficient (t-stat)	Yes Coefficient (t-stat)
Panel E: cross-sectional tests based on monitoring levels								
ABILITY_RANKING	3.805***	4.092***	3.287**	3.982***	4.831***	2.150	4.521**	3.232**
	(2.93)	(2.99)	(2.04)	(3.41)	(3.49)	(1.23)	(2.54)	(2.29)
OVERI	4.736***	7.221***	2.983	8.896***	7.419***	4.831**	5.792***	6.772***
	(3.00)	(4.00)	(1.61)	(6.81)	(4.46)	(2.03)	(2.77)	(3.66)
OVERI_ABILITY	− 3.796*	− 6.863***	− 4.202	− 3.937*	− 6.421**	− 2.313	− 5.651*	− 4.776*
	(− 1.67)	(− 2.92)	(− 1.53)	(− 1.84)	(− 2.48)	(− 0.76)	(− 1.78)	(− 1.87)
CONTROL VARIABLES	Included	Included	Included	Included	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11,191	9132	6858	7525	6456	6463	7459	9658

Table 9 continued

	Eindex		Board independence		Inside director ownership		CEO/chair duality	
	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	Below median Coefficient (t-stat)	Above median Coefficient (t-stat)	No Coefficient (t-stat)	Yes Coefficient (t-stat)
R-sq	0.238	0.233	0.222	0.241	0.220	0.255	0.238	0.225

INVT_TOT is the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment; *CAPX* is the level of capital expenditures; *R&D* is the level of R&Ds; *ACQ* is acquisition expenditures; *ABN_TOT* is the abnormal level of total investments, proxied by the residuals from the regression of a firm's total capital investment on lagged sales growth; *ABN_CAPX* is the abnormal level of capital expenditures, proxied by the residuals from the regression of a firm's capital expenditures on lagged sales growth; ABN_R&D is the abnormal level of R&D expenditures, proxied by the residuals from the regression of a firm's R&Ds on lagged sales growth; *ABN_ACQ* is the abnormal level of acquisition expenditures, proxied by the residuals from the regression of a firm's acquisition expenditures on lagged sales growth; *ABILITY_RANKING* is CEO managerial ability rankings; and *OVERI* is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". In Panel D, the sample firms are divided into below median and above median groups based on equity proportion, option proportion, pay-for-performance sensitivity of CEOs' pay (delta), and the sensitivity of CEOs' wealth to stock return volatility (vega), respectively. In Panel E, the sample firms are divided into below median and above median groups based on entrenchment index (Eindex), the proportion of independent board directors (Board Independence), and the value of inside director ownership (Inside Director Ownership), respectively. In addition, the sample firms are divided based on CEO/Chair duality, in which "yes" means a CEO is also the Chairman of the board and "no" otherwise. The dependent variable in Panels D and E is *INVT_TOT*, the level of total investment. All standard errors are adjusted by a two-dimensional cluster at the firm and year levels *, **, and *** indicate significance levels at 10, 5, and 1%, respectively

return (i.e., high delta) and stock volatility (i.e., high vega), managerial ability is not shown to effectively improve under-investment situations either. Perhaps being overly exposed to financial risk makes management act extremely conservatively. Together, these results suggest that although high managerial ability is associated with improved investment efficiency, the incentive system also plays a role in magnifying or weakening that association—the impacts of high managerial ability on improved investment efficiency can depend on how CEOs are incentivized.

Next, I investigate the patterns of managerial ability's impacts on investment efficiency in strong and weak monitoring contexts. I employ four proxies to measure the monitoring level from the board: the entrenchment index developed by Bebchuk et al. (2009), board independence, inside director ownership, and CEO/Chair duality. According to prior studies (e.g., Shleifer and Vishny 1989; McConnell and Servaes 1990; Hermalin and Weisbach 1991; Ashbaugh-Skaife et al. 2006; Bebchuk et al. 2009), a board's monitoring function is weakened if the management is entrenched, the board has high inside director ownership, and the CEO is also the chairman of the board; while it is strengthened if the board has more independent directors. I split the sample based on the median of each of the four proxies, and estimate the association between managerial ability and total investments with the sub-samples. The results are tabulated in Table 7.

Table 7 shows a significantly positive coefficient for *ABILITY_SCORE* and a significantly negative coefficient for the interaction between *OVERI* and *ABILITY_SCORE* across the subsamples. These results suggest that generally speaking, high managerial ability enhances investment efficiency by increasing investment when firms are most likely to under-invest and decreasing investments when they are likely to over-invest, and this association is not significantly affected by different levels of board monitoring.[11]

6 Robustness tests

In this section, I perform several robustness tests to provide further support for the main findings. *First*, I replace the yearly ability score in Model (2) with the average ability score of a CEO over the sample years when he/she is the CEO of the firm. Using yearly ability data allows the ability to vary across years for the same CEO and enables to test how a CEO's changing ability influences investment efficiency. However, this practice might induce a mechanical relation between CEO ability and investment efficiency given the way the ability measure is generated as described in Demerjian et al. (2012). To address this issue, I use the average ability score of a CEO throughout the sample years when he/she is the CEO of the firm as the independent variable of interest to provide robust tests.[12] The results are reported in Table 8.

[11] There is one exception: the above-median group using inside director ownership as the proxy. For firms that have CEOs with above-median inside director ownership, the effects of CEO managerial ability on improving investment efficiency are not significant (or very marginal).

[12] I thank an anonymous reviewer for this suggestion.

Table 8 reports that CEOs' average abilities are positively (negatively) associated with total investments and capital expenditures when under-investment (over-investment) is more likely. Hence, Table 8 provides consistent results that when firms operate in settings more prone to under-investment (over-investment), CEOs with higher ability tend to improve investment efficiency by increasing (reducing) total investments and capital expenditures.[13]

Second, I replace managerial ability score in Model (2) with a binary variable that indicates low versus high managerial ability, using the median of the managerial ability score as a benchmark. The results (untabulated) are similar to those reported in Table 4.

Third, I use managerial ability ranking as an alternative independent variable of interest and replicate the analyses in Tables 3, 4, 5, 6, 7. Managerial ability scores are ranked in deciles by year and industry to generate ability rankings to ensure comparability across time and industries and to mitigate the influence of extreme observations (Demerjian et al. 2012, 2013). The results are tabulated in Table 9.

The results in Panels A through E of Table 9 are generally consistent with those reported in Tables 3, 4, 5, 6, 7. Specifically, Panel A of Table 9 shows that *ABILITY_RANKING* is positively associated with the levels of total investments and capital expenditures. Panel B shows that higher *ABILITY_RANKING* is able to increase (decrease) the levels of total capital investments, capital expenditures, and acquisition expenditures when firms are most likely to under-invest (over-invest).[14] Panel C of Table 9 reports similar patterns when using abnormal investment levels as dependent variables. The results in Panel D suggest that when considering CEOs' financial incentive levels, high *ABILITY_RANKING* generally mitigates under-investment and over-investment in the below median groups; however, in the groups that have high delta and high vega, high *ABILITY_RANKING* is not shown to effectively improve either under-investment situation or over-investment situation. Finally, Panel E of Table 9 provides evidence that high *ABILITY_RANKING* promotes investment efficiency across different levels of board monitoring, consistent with the results reported in Table 7.

Fourth, to address the potential endogeneity problems that could exist in this research setting, I test model (2) by controlling for firm- and year-fixed effects and clustering

[13] As another robustness test, the average ability score of a CEO prior to joining the current firm is also employed as an alternative independent variable of interest to test Model (2). To construct this measure, I require the sample to have 1) CEO turnover and 2) the CEO's ability data from both the current firm and the prior firm. These restrictions reduce sample size to 498 observations. The regression results (not tabulated) have not shown significant, even though the signs of the coefficients are generally consistent with those in Table 4. The insignificant results can be due to small sample size.

[14] Using the average ability ranking of a CEO over the sample years when he/she is the CEO of the firm as an alternative independent variable of interest generates consistent evidence (untabulated): CEOs with higher average ability rankings tend to reduce (increase) total investments and capital expenditures when firms are likely to over-invest (under-invest).

[15] The two instrumental variables have passed the overidentification and underidentification tests.

[16] Although the study employs several ways to mitigate potential endogeneity problems in this research setting (e.g., using lagged models, robustness tests controlling firm- and year-fixed effects, and using 2SLS regressions with instrumental variables), endogeneity issues may still exist. For example, there might still be

Table 10 The association of managerial ability and investment efficiency: using tenure as a proxy for managerial ability (N = 17,120)

	(1) *INVT_TOT* Coefficient (t-stat)	(2) *CAPX* Coefficient (t-stat)	(3) *R&D* Coefficient (t-stat)	(4) *ACQ* Coefficient (t-stat)
TENURE	0.054*	0.029*	− 0.004	0.019
	(1.65)	(1.71)	(− 0.23)	(0.93)
OVERI	4.239***	0.298	3.168***	0.571
	(4.54)	(0.72)	(5.69)	(0.81)
OVERI_TENURE	− 0.148**	− 0.044	0.003	− 0.096**
	(− 2.49)	(− 1.58)	(0.08)	(− 2.47)
CONTROL VARIABLES	Included	Included	Included	Included
Industry-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
R-sq	0.226	0.577	0.584	0.057

INVT_TOT is the level of total investment, measured as the capital expenditures + R&Ds + acquisition expenditures − cash receipts from sale of property, plant, and equipment; *CAPX* is the level of capital expenditures; *R&D* is the level of R&Ds; *TENURE* is CEO tenure, indicated by the number of years a CEO is in the position; and *OVERI* is a composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels. All other variables are defined in "Appendix". Standard errors are adjusted by a two-dimensional cluster at the firm and year levels. *, **, and *** indicate significance levels at 10, 5, and 1%, respectively

standard errors at firm levels. In addition, I conduct Two-Stage Least Squares (2SLS) regression analyses with two instrumental variables: industry median of managerial ability ranking and the CEO ability score of the closest matched firm based on market-to-book ratio.[15] Untabulated results provide consistent support for the main findings.[16]

Finally, I employ CEO tenure as an alternative proxy for CEO managerial ability and re-examine Model (2), as tenure can be a measure of a CEO's ability to operate the firm and influence the board's decisions (e.g., Lambert et al. 1991; Hill and Phan 1991; Ryan and Wiggins 2001; Milbourn 2003).[17] I tabulate the results in Table 10.

The results in Table 10 show that when firms face a high likelihood of over-investment, CEOs with higher ability, as indicated by longer tenure, tend to reduce total investments and acquisition expenditures; when firms operate in an environment where under-investment is most likely, CEOs with longer tenure increase total investments and capital expenditures. These results provide additional support for the hypothesis that higher ability CEOs make more efficient investment decisions.

Footnote 16 continued
omitted variables affecting managerial ability and investment relation or firms' hiring and investment policies. I acknowledge this as one of the limitations of this study.

[17] Meanwhile, prior literature maintains that tenure also indicates a potential entrenchment problem. The longer a CEO remains in that position, the more likely the CEO is to be entrenched (e.g., Mace 1971; Finkelstein and Hambrick 1989; Hill and Phan 1991).

7 Conclusion

Corporate investments are decisions and activities crucial to firms' continuing growth and long-term development. To maintain growth and preserve a competitive status in industries, risk-neutral shareholders motivate risk-averse managers to engage in certain levels of investments and take advantage of favorable investment opportunities (Core and Guay 1999; Coles et al. 2006). Relying on the managerial ability measure developed by Demerjian et al. (2012), I examine whether and how CEO managerial ability affects corporate investment practices by improving investment efficiency. I predict that more able CEOs are likely to make more efficient corporate investment decisions due to their greater ability to anticipate changes in their firms' underlying economy, to identify favorable investment opportunities to support the internal and external growth of their firms, and to perform accurate and sufficient evaluation work.

Consistent with this prediction, I show that high ability CEOs increase (decrease) capital expenditures, acquisition expenditures, and total investments when the firm is more likely to under-invest (over-invest). This is not the case, however, for R&Ds. These results provide evidence that higher ability CEOs can improve investment efficiency when the firm has a tendency to under-invest and/or over-invest. Additional analyses show that the positive impact of CEO managerial ability on investment efficiency generally persists across different levels of monitoring strength, while it gets weaker as CEOs are overly exposed to equity risk. Overall, the findings of this study suggest that CEO managerial ability plays a significant role in improving investment decision-making. This is in line with the notion that individual-level factors affect investment practices and outcomes, highlighting the importance of managerial ability in the corporate investment context.

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Appendix

See Table 11.

Table 11 Variable definitions

Variables	Definitions
Dependent variables	
Total investments (*INVT_TOT*)	The level of total investment, measured as the capital expenditures + R&D + acquisition expenditures − cash receipts from sale of property, plant, and equipment, scaled by lagged total assets, multiplied by 100
Capital expenditures (*CAPX*)	The level of capital expenditures scaled by lagged total assets, multiplied by 100
Research and development expenditures (*R&D*)	The level of R&D expenditures scaled by lagged total assets, multiplied by 100
Acquisition expenditures (*ACQ*)	The level of acquisition expenditures scaled by lagged total assets, multiplied by 100
Abnormal total investment (*ABN_TOT*)	The abnormal level of total investments, proxied by the residuals from the regression of a firm's total capital investment on lagged sales growth.
Abnormal capital expenditures (*ABN_CAPX*)	The abnormal level of capital expenditures, proxied by the residuals from the regression of a firm's capital expenditures on lagged sales growth
Abnormal research and development expenditures (*ABN_R&D*)	The abnormal level of R&D expenditures, proxied by the residuals from the regression of a firm's R&D expenditures on lagged sales growth
Abnormal acquisition expenditures (*ABN_ACQ*)	The abnormal level of acquisition expenditures, proxied by the residuals from the regression of a firm's acquisition expenditures on lagged sales growth
Independent variables of interest	
ABILITY_SCORE	CEO managerial ability scores, continuous data
ABILITY_RANKING	CEO managerial ability rankings, non-negative values
AVGABILITY_SCORE	Average ability score of a CEO throughout the sample years when he/she is the CEO of the firm
TENURE	The number of years a CEO has been in that position for
Control variables	
OVERI	A composite score measure created to indicate the likelihood of over-investment and under-investment based on the ranking of cash and leverage levels
Firm size (*SIZE*)	Natural log of total assets
Market to book ratio (*MTOB*)	The ratio of the market value of total assets to book value of total assets
LOSS	A dummy variable equal to 1 if net income before extraordinary items is negative, and 0 otherwise
Sales volatility (*SALE_VOL*)	Standard deviation of the sales deflated by average total assets over previous 5 years

Table 11 continued

Variables	Definitions
Total investment volatility (*INVT_TOT_VOL*)	The standard deviation of total investments over previous 5 years; or *R&D_VOL*, the standard deviation of R&D over previous 5 years; or *ACQ_VOL*, the standard deviation of acquisition expenditures over previous 5 years
Capital expenditures volatility (*CAPX_VOL*)	The standard deviation of capital expenditures over previous 5 years
R&D volatility (*R&D_VOL*)	The standard deviation of R&D over previous 5 years
CFO_SALE	Operating cash flows divided by sales
Operating cash flow volatility (*CFO_VOL*)	Standard deviation of the cash flow from operations deflated by average total assets over previous 5 years
SLACK	The ratio of cash to PPE
Dividend (*DIV*)	A dummy variable equal to 1 if the firm paid dividends, and 0 otherwise.
Bankruptcy risk (*ZSCORE*)	0.033*earnings before extraordinary item/total assets + sales/total assets + 0.014*retained earnings/total assets + 0.012*(working capital/total assets) + 0.006*(market value of common stock/total liabilities)
TANGIBILITY	PPE divided by total assets
Capital structure (*KSTRUCTURE*)	Long-term debt divided by the sum of long-term debt and the market value of equity
Industry capital structure (*IND_STRUCTURE*)	Mean K-structure for firms in the same SIC3-digit industry
Financial reporting quality (*AQ*)	Abnormal accruals to proxy for accounting quality, estimated by the modified Jones Model.
Entrenchment index (EINDEX)	The entrenchment index constructed according to Bebchuk et al. (2009)
Cash (*CASH*)	The level of cash, deflated by total assets
Leverage ratio (*LEV*)	Long-term debt divided by total assets

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