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Managerial ability and corporate investment opportunity

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ABSTRACT

This study examines whether firms operated by superior managers can obtain more favorable investment opportunities using data on U.S. industrial firms during 1988–2015. The empirical results disclose that there exists a positive relationship between managerial ability and investment opportunity, and that the relation is only significant in financially unconstrained firms or firms in a strong financial position. Overall, our findings support that firms having managers with superior ability could gain more economic profits via better investment opportunity. Through our research, policy makers and investors can pay more attention on managerial ability.

1. Introduction

Managerial ability has been proven to play an important determinant in tax avoidance, earnings quality, goodwill impairment, and other corporate policies. However, the relationship between investment opportunity and managerial ability has remained unclear for a long time, likely due to difficulty in measurement and other data limitations. This study focuses on how superior managerial ability affects investment opportunity for the following two reasons. First, as a crucial role in corporate finance, investment opportunity impacts a firm's capital structure, dividend policy, and future growth (Smith and Watts (1992), Kallapur and Trombley (1999)). Second, because investment opportunity is unobservable by outsiders, it would be helpful if we could link investment opportunity to other firm characteristics and managerial ability.

We argue that superior managers can understand industrial trends better, predict product demand more accurately, and invest in more value-creating projects, therefore associating themselves with better investment opportunity. Although the hypothesis we propose is somehow intuitive, a recent study in behavior corporate finance also shows that managers with a good reputation and compensation package may engage in more risk-averse and time preference projects that can harm investment opportunities (Graham, Campbell, and Manju (2013)). Moreover, we aim to find out whether the relation between managerial ability and investment opportunity varies under different financial conditions and economic environments. Rather than extrapolate the ability from managers' characteristics, education background, personality traits, and working experience, we examine the relation by adopting the newly developed measure of managerial ability introduced by Demerjian, Lev, and McVay (2012) - namely, the MA-score (henceforth, we use MA-score to represent managerial ability). This measure follows a two-step procedure composed of data envelopment analysis and multivariate regression to quantify managers' efficiency in generating revenue. Prior research shows that the MA-score can reflect management-specific factors more precisely through several valid tests and is thus a better measure of managerial ability.

The empirical evidence strongly supports our hypothesis, because our results document a significantly positive relation between managerial ability and investment opportunity, even after we control for firm fixed effects, year fixed effects, and other control variables. The empirical results indicate that managers with superior ability are related to more outstanding investment opportunities, as expected. In addition, we conduct a subsample test to look at how managerial ability's impact on investment opportunity operates in different financial conditions and find that the result is more pronounced for firms with a low Kaplan-Zingales Index and a high Altman *Z*-score. Lastly, we interact the MA-score with the HHI dummy and Recession dummy to examine theirs correlations under different industrial and economic conditions and show that superior ability can mitigate the adverse effect of industry competition and financial crisis. For robustness, we conduct many different tests. First, we adopt Tobin's q and the capital expenditure rate as alternative proxies for investment opportunity. Second, we use another methodology, first difference, to confirm the baseline regression. Third, we select the subsample of positive MA-scores to re-run analysis. Fourth, we use 2SLS with instrumental variables, system simultaneous equations model (SEM), and Granger Causality to solve the endogenous problem.[1] All results are still consistent with our expectation. Overall, we find that managerial ability is

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[1] Please see E. Robustness test.

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an important determinant of investment opportunity, and that firms in better financial condition can benefit more from exceptional managers.

This study contributes to the literature in several ways. First, our results shed light on the effect of managerial ability on investment opportunity and fill the gap in existing studies. Second, we identify which kind of firms can gain more economic benefits when employing extraordinary managers. Third, we adopt a new proxy for investment opportunity - namely, Total q - which has not been looked at by any studies. Fourth, our finding derives several economic implications for boards of directors, investors, and policy makers.

The remainder of this paper is organized as follows. Section II presents the relevant literature and our hypothesis development. Section III illustrates the process of sample construction and the main variables that we employ. Section IV documents the empirical results in this study. Finally, Section V offers some concluding remarks.

2. Literature review and hypotheses' development

In the research areas of corporate finance and accounting, whether and how an executive manager affects corporate behavior and performance have been considered important issues for a long time. Bertrand and Schoar (2003) find that managers with different styles, like experience and ability, tend to adopt different policies and strategies when making operating decisions. Koester, Shevlin, and Wangerin (2016) state that managers with a higher ability engage in more tax avoidance activities, such as tax planning and income shifting. Bonsall IV (2016) document that higher managerial ability is associated with lower variability in future earnings and stock returns and lower bond offering credit spreads. There are also studies that examine managers' impact on acquisition quality (Goodman, Neamtiu, Shroff, and White (2013)), earnings quality (Demerjian, Lev, and McVay (2012)), abnormal returns (Hayes & Schaefer, 1999), and goodwill impairment (Sun (2016)).

Managers' abilities also play an important role in corporate investments since they usually require a huge cash flow amount and a long time horizon. Chemmanur, Imants, and Karen (2009) present evidence showing that better managers are more capable of identifying high NPV projects, and therefore the scale of investment will also be larger. Lin, Lin, Song, and Li (2011) show that chief executive officer (CEO) characteristics such as professional background and education level have significant effects on a corporate's research and development (R&D) input and output. Andreou, Ehrlich, Karasamani, and Louca (2016) investigate corporate investment during the 2008 financial crisis period and find that it is positively related to pre-crisis managerial ability, because of finance security. However, exiting studies mostly focus on the level of investment, but not investment opportunity.

According to Myers (1977), the market value of a firm is composed of the value of assets on hand and the value of investment opportunity, which is unobservable and depends on future investments. There are four common proxies for investment opportunity: market-to-book, market-to-equity, the earnings-price ratio, and the ratio of capital expenditure over the net value of plant, property, and equipment. Adam and Goyal (2008) show that the market-to-book ratio, or the closely related measure used in a great deal of studies, Tobin's q,[2] contains the highest information content with regard to investment opportunity. We adopt the new measure proposed by Peters and Taylor (2017), Total q, to be our proxy for investment opportunities. The main improvement of Total q is that it considers both physical and intangible assets and is gaining importance in the recent development of service and high-tech industries. Peters and Taylor (2017) prove that Total q is a better measure with respect to investment opportunity than Tobin's q and other existing proxies. Taken together, we expect that firms with superior managers should be associated with higher investment opportunities, since they can more efficiently manage their resources and implement new projects better. We propose our first hypothesis as follows.

Hypothesis 1. *Managerial ability is positively related to a firm's investment opportunities*.

Aside from Hypothesis 1, we argue that the relationship between managerial ability and investment opportunity can vary across industry, firm circumstances, and time periods. Holcomb, Holmes, and Connelly (2009) find that managerial ability affects resource productivity, but the relationship is mitigated by an increase in the human resource quality of the company. Cornaggia, Krishnan, and Wang (2016) find that the relationship between managerial ability and credit rating is significant only in the subsample consisting of firms above the median distress level. Andreou et al. (2016) show that the positive relation between managerial ability and investment during a crisis period is significant only with firms operated by CEOs with general managerial skills. Since managers need enough financial flexibility to capture investment opportunities and realize growth, we propose our second hypothesis as follows.

Hypothesis 2. *The relationship between managerial ability and investment opportunity is more pronounced in firms with a good financial position*.

3. Research design

3.1. Data and sample construction

To examine the relationship between investment opportunity and managerial ability, we adopt unbalanced firm-level panel data for the period 1988–2015. Our study begins in 1987, because it is the first fiscal year when financial data are available in our database, and end in 2015, because of the availability of MA-score data. We obtain accounting data from COMPUSTAT to construct the financial ratio as a control variable and a measure of financial constraint. All variables are winsorized at the 5th and 95th percentiles. The measurement of managerial ability we adopt in this study is provided by Peter Demerjian on his website.[3] Total q is acquired from WRDS as our measure of investment opportunities. After we exclude the utility sector (SIC code: 490–499) and financial industry (SIC code: 600–699), since these companies are more regulated and may show different patterns in investment opportunities, we obtain a final sample of 159,448 firm-year observations.

3.2. Measurement

3.2.1. Managerial ability

We employ the managerial ability (*MA-score*) measure developed by Demerjian, Lev, Lewis, and McVay (2012), which captures the efficiency of a firm's managers to generate revenue through certain inputs. According to their theory, higher ability managers should be able to generate higher revenues from a given set of resources than their counterparts in the same industry. They introduce a two-step approach to evaluate firm efficiency, from which the managerial ability score is extracted.[4]

We believe that the MA-score measure is an appropriate proxy for managerial ability since it has been proven by several valid tests in prior studies (Demerjian, Lev, and McVay (2012); Cornaggia et al. (2016)). The Ma-score enables us to study the effect of managerial

[2] The most commonly used proxy for investment opportunity is Tobin's q, which shows the ratio of a firm's market value over the book value of assets in place (Modigliani and Miller (1958)). One disadvantage of Tobin's q is that it can be affected by measurement error, as shown in Erickson and Whited (2000).

[3] The MA-score data are available at: http://faculty.washington.edu/pdemerj/data.html

[4] For a detailed construction of the MA-score, please refer to Appendix C.

ability aside from other noise factors across a wide cross-section of samples.

3.2.2. Investment opportunity

Peters and Taylor (2017) find that intangible investment fits the neoclassical theory even better than physical investment. Therefore, they propose an improved Tobin's q measure that includes intangible capital in the denominator, i.e., in the replacement cost of firms' capital. They estimate the replacement cost of firms' intangible capital by accumulating past investments in R&D and SG&A plus external purchased intangible capital. We employ the new measure for two main reasons. First, Peters and Taylor (2017) show that Total q is a superior proxy for investment opportunity in this era of increasing intangible economies. Second, since our proxy of managerial ability includes the efficiency measures of R&D, SG&A, and Goodwill, it is appropriate to take intangible capital into consideration in our proxy for investment opportunity.

3.2.3. Control variables

In addition to managerial abilities, we expect some characteristics to affect investment opportunity, namely Total q, and therefore we include them in our regression as control variables. We control firm size (*SIZE*), which is measured by the nature logarithm of a firm's market value, since it has been found to be positive related to firm investment (+). Leverage (*LEV*) is included, because it is a constraint (negative effect) on investment and can be regarded as a function of investment opportunity (Frank and Goyal (2003)); on the contrary, Anderson and Prezas (1999) show firms find out good investment projects and they will raise debt financing exogenously to exercise investment opportunity (ambiguous).[5,6] Simutin (2010) shows that a firm's cash holdings (*CASH*) are a proxy for risky growth opportunity, and that firms with large cash balances invest more compared to their peers (+). Since the Q ratio also proxies for many other variables such as firm valuation and firm performance (Adam and Goyal (2008)), we control for the market to book ratio of equity (*MBE*) as a proxy for firm valuation and expect *MBE* has positive effect on firms' investment (+). The regression model includes (*ROE*), which is the ratio of operating income before tax to total assets to control for firm performance and higher *ROE* will result in high investment (+). We also notice that our measure of investment opportunities, namely Total q, could be influenced by merger and acquisition activities performed by our samples and if firms do merger and acquisition activities will have lower chance in good investment opportunity; therefore, we include acquisitions divided by lagged property, plant, and equipment (*ACQ*) in our model to cope with the effect (−). Ikenberry & andVermaelen, 1996 view stock repurchase (*REP*) indicate firms abandon their investment opportunity which could increase firms' value and focus on stock price increasing (−).

3.3. Methodology

This section explains the model we construct to examine the relation between Total q and managerial ability. To test for this association, we estimate the following panel regression model by following Bonsall IV (2016).[7]

$$\text{Total } q_{i,t} = \beta_0 + \beta_1 * \text{MA-score}_{i,t} + \beta_2 * \text{SIZE}_{i,t} + \beta_3 * \text{LEV}_{i,t} + \beta_4 * \text{CASH}_{i,t} + \beta_5 * \text{MBE}_{i,t} + \beta_6 * \text{ROA}_{i,t} + \beta_7 * \text{ACQ}_{i,t} + \beta_8 * \text{REP}_{i,t} + \beta_9 * \text{STD}_{i,t} + \beta_{10} * \text{LTD}_{i,t} + \textit{Year Fixed Effects} + \text{Firm Fixed Effects} + \varepsilon_t \quad (1)$$

As an alternative to firm fixed effects, we transform Eq. (1) into first differences. This specification should also remove time-invariant firm effects. Specifically, we estimate the following regression model in the robustness section:

$$\Delta\text{Total } q_{i,t} = \beta_0 + \beta_1{}^*\Delta\text{MA-score}_{i,t} + \beta_2{}^*\Delta\text{SIZE}_{i,t} + \beta_3{}^*\Delta\text{LEV}_{i,t} + \beta_4{}^*\Delta\text{CASH}_{i,t} + \beta_5{}^*\Delta\text{MBE}_{i,t} + \beta_6{}^*\Delta\text{ROA}_{i,t} + \beta_7{}^*\Delta\text{ACQ}_{i,t} + \beta_8{}^*\Delta\text{REP}_{i,t} + \beta_9{}^*\Delta\text{STD}_{i,t} + \beta_{10}{}^*\Delta\text{LTD}_{i,t} + \textit{Year Fixed Effects} + \varepsilon_t \quad (2)$$

Here, Total q is a proxy for investment opportunity, and MA-score is our key explanatory variable. If the difference in managerial ability can affect corporate investment opportunities as we predict in Hypothesis 1, then we should find a significantly positive coefficient on the MA-score. All variables in regression (1) are defined in Appendix B, and continuous variables are winsorized at the 5th and 95th percentiles.

Even though we already control several characteristics that have been found to be associated with the q ratio in other studies, we are still concerned about unobservable individual effects or missing variables in our regression.[8] In addition to the baseline specifications described above, we include dummy variables and interaction terms to investigate the importance of managerial ability in different circumstances.

4. Empirical results

4.1. Descriptive statistics and correlation analysis

Table 1 presents the summary statistics for the dependent variables, independent variables, and control variables employed in this study. The sample firms have a mean MA-score of −0.0008, which is close to zero, since it is residual value from a regression. The standard deviation of MA-score is 0.1197. The mean values of Total q and Tobin's q of our dataset are respectively 1.1678 and 1.9777. We use Tobin's q as another measurement of investment opportunity in our robust test. In regards to control variables, firms in our sample keep 14.29% of their assets in cash and earn 9.48% ROE on average. Measured by the debt to asset ratio, LEV has a mean value of 0.332, indicating that on average one-third of a firm's capital structure comes from liabilities in our sample. The mean values of both STD and LTD are positive, showing that firms expand through debt financing during the sample period.

In Table 2 the Pearson correlation coefficient shows some preliminary relationships between our variables. Most importantly, Total q is positively correlated to MA-score, which is consistent with our hypothesis that firms with superior managers can seize better investment opportunities. Because Total q is a proxy for firm valuation and is proven to be significantly correlated with other variables, it is important to control these firm characteristics in our regression analysis. MA-score is positively correlated to *CASH*, *SIZE*, and *ROE* and negatively correlated to *LEV*, conforming to our expectation and the results documented in a previous study (Cornaggia et al. (2016)). The correlation coefficients between all independent variables and control

[5] In this paper, we also consider other two debt financing variables, short term debt financing (*STD*) and long term debt financing (*LTD*). We regard these two variables to be the proxy of Leverage (*LEV*). Anderson and Prezas (1999) show how debt (*STD, LTD*) affects a firm's decision to allocate resources and increasing debt financing exogenously may increase investment opportunity. On the other side, we also think firms with too much short term and long term debt will decrease investment opportunity, because interest repayment could be the limitation to do investment (ambiguous).

[6] The correlations among LEV, STD, and LED are approximately 0.13277–0.16837. Here, we put these three variables together into the baseline regression model. In addition, we also run the regression by separating STD, LTD, and LEV, and the results are still consistent with our Hypothesis 1.

[7] They adopt the same period between dependent variables and independent variables (including control variables). To avoid reverse causality, we take lag one period of all independent variables to run the regression again and find the results are still consistent with the main hypothesis (see Table 3(b)).

[8] In the paper, we consider fixed effect panel data analysis which could cope with cross-sectional individual firm heterogeneity to be our main specification. In addition, we perform pooled ordinary least square method which used in most other studies. The results of pooled ordinary least square are requested upon authors.

Table 1
Descriptive statistics.
This table reports descriptive statistics for the dependent variables, independent variables, control variables, and financial constraint indices. Panel A reports descriptive information for the full sample consisting of 159,448 firm-years from 1987 to 2015. All variables are defined in Appendix B and winsorized at the 5th and 95th percentiles.

Panel A	N	MEAN	MEDIAN	Std. Dev	Q1	Q3
Dependent variable						
Total q	149,302	1.1678	0.6718	1.4511	0.2536	1.4309
Tobin's q	145,005	1.9777	1.4408	1.4223	1.0483	2.2939
CAPX rate	156,383	0.3491	0.2206	0.3565	0.1144	0.4330
Independent variable						
MA-score	159,448	−0.0008	−0.0164	0.1197	−0.0703	0.0418
MA-score-rank	159,448	0.5515	0.6000	0.2847	0.3000	0.8000
Control variable						
CASH	155,817	0.1429	0.0704	0.1765	0.0204	0.1915
SIZE	150,386	4.9482	4.8953	2.2997	3.1881	6.6553
MBE	150,154	2.3081	1.7773	6.1266	0.9494	3.2715
LEV	158,459	0.3320	0.2753	0.3134	0.0283	0.5259
ROE	159,142	0.0948	0.1426	0.4652	−0.0660	0.3167
ACQ	152,129	0.1533	0.0000	0.3988	0.0000	0.0245
REP	147,731	0.0606	0.0000	0.1550	0.0000	0.0114
STD	158,169	0.0475	0.0000	0.4340	−0.0319	0.0602
LTD	157,989	0.1082	0.0000	0.6255	−0.0737	0.1164

variables are < 0.5, and therefore collinearity is not a serious issue that we should consider.

4.2. Relationship between managerial ability and investment opportunity

In Table 3 (a) we provide the multivariate regression result of Eq. (3) using the full sample to examine the relationship between managerial ability and investment opportunity. Because of unobservable characteristics that might affect a corporate's investment opportunities, we estimate our baseline model specification with fixed-effects model and random-effects model. The regression estimates for all three models show that MA-score, the main explanatory variable of our study, is positively related to Total q, and the relation is significant at the 0.01 level. These findings support our main hypothesis that firms with superior managers should be associated with better investment opportunities. Since Hausman and Taylor (1981) argue that the fixed-effects model can represent an unbiased method of controlling for unobserved variables in a panel dataset and the result of the Hausman specification test also shows that the fixed-effects model is appropriate, we adopt the fixed-effects model instead of the random-effects model in the rest of this study.

Besides, we also separate *LEV*, *STD*, and *LTD* in column 1 and 2 to deal with similar proxy for corporate debt financing. Basically, we still find firms with superior managers should be associated with better investment opportunities. As for control variables, the coefficients estimated are mostly significant except for *MBE* and *STD* in column 3 of Table 3 (a). Corporate cash holdings (*CASH*), size (*SIZE*), and earnings performance (*ROE*) are positively related to investment opportunity as showed in previous studies. Corporate merger & acquisition (*ACQ*) and stock repurchase (*REP*) have a negative impact on investment opportunity, which may result from the reduction of cash and other resources on hand. The effect of debt on corporate investment opportunity is somehow ambiguous. Although Lang, Ofek, and Stulz (1996) document a negative relationship between leverage (*LEV*) and future growth for firms with low investment opportunities, further research is needed to investigate the relationship between leverage and investment opportunity.

We realize our regression model that includes firms' size and cash holdings could result in some *multicollinearity* problem, because computing MA-score also controls these firms' characteristics in Eqs. (3) and (4) (see Appendix C). Hence, we remove corporate cash holdings (*CASH*) and size (*SIZE*) from the baseline regression (see column 1 of Table 4) and then separately include size (*SIZE*) and cash holdings (*CASH*) in columns 2 and 3 of Table 4. In sum, the results here are still consistent with our Hypothesis 1.

Investment opportunities may vary significantly for different activities and for separate operations of different industries. For example, such opportunities exist in the option to explore, develop, and extract a mineral vein for firms in the mining industry, while in manufacturing the key investment opportunity is R&D. This section examines the relationship between managerial ability and investment opportunity across different sectors, defined by the two-digit SIC code. The results in Table 5 show that managerial ability is positively related to investment opportunity in most industries after controlling for firm fixed effects and year fixed effects, especially in Agriculture, Forestry & Fishing, Construction, Manufacturing, and Service. Among Mining and Transportation & Communications, higher managerial ability results in better investment opportunities, but the estimated coefficients are relatively smaller than the others. The coefficient of Wholesale Trade is negative, and the coefficient of Retail Trade is insignificant. Rather than managerial ability does not matter at all in those industries, we think the result should be interpreted as the q ratio is not a good proxy for investment opportunity in the Retail and Wholesale Trade industry due to its low possession of either physical or intangible assets.

4.3. The relationship in different financial conditions

Recent studies report strong evidence of a link between investment and financing decisions (De, Verbeek, & Verwijmeren, 2012). Therefore, we conduct a further discussion on subsamples to review the relationship between managerial ability and investment opportunity for firms in different financial conditions. In Panel A of Table 5, we test the relationship for firms that are financially constrained and financially unconstrained. We adopt the Kaplan-Zingales Index, a measurement of

Table 2
Correlation matrix.
This table reports the Pearson product-moment correlation coefficients (PPMCCs). All variables are defined in Appendix B and winsorized at the 5th and 95th percentiles. Coefficients in **bold** are significant at the 5% level.

	Total q	MA-score	CASH	SIZE	MBE	LEV	ROE	ACQ	REP	STD	LTD
Total q	1	**0.15005**	**0.38216**	**0.25195**	**0.01466**	**−0.1743**	**0.06002**	**0.09367**	**0.09499**	**0.01592**	**0.05598**
MA-score		1	**0.1381**	**0.12059**	0.00495	**−0.1406**	**0.15805**	**0.06504**	**0.14099**	**0.0229**	**0.02053**
CASH			1	**0.00581**	**0.01207**	**−0.3474**	**−0.0833**	**0.05035**	**0.08535**	**−0.0231**	**0.03672**
SIZE				1	**0.01224**	**−0.0233**	**0.27118**	**0.12944**	**0.20427**	**−0.0506**	**0.03977**
MBE					1	**−0.0118**	**0.00747**	0.00367	−0.00066	−0.00426	0.00425
LEV						1	0.0045	**0.00968**	**−0.1212**	**0.13277**	**0.16837**
ROE							1	**0.06067**	**0.0962**	**−0.0394**	**0.00924**
ACQ								1	**0.12938**	**0.13773**	**0.33537**
REP									1	0.00045	**0.05189**
STD										1	**−0.0138**
LTD											1

Table 3
(a) Baseline regression (1).

This table reports regression coefficient estimates of the relation between Total q and MA-score. Our sample spans from 1987 to 2015. The dependent variable is Total q, as proposed by Peters and Taylor (2017), which is our proxy for investment opportunity. All the variables are defined in Appendix B. We report the results estimated by the fixed-effects model and random-effects model by considering different control variables, respectively. Year dummy variables are included in both regressions. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

	Fixed effects			Random effects		
	(1)	(2)	(3)	(1)	(2)	(3)
MA-score	0.5860***	0.5792***	0.5889***	0.6928***	0.6909***	0.6871***
	(9.96)	(9.88)	(9.99)	(12.5)	(12.52)	(12.40)
CASH	1.8050***	1.7846***	1.8136***	2.1521***	2.1698***	2.1598***
	(46.01)	(45.64)	(46.04)	(57.89)	(59.11)	(57.83)
SIZE	0.5640***	0.5606***	0.5649***	0.4196***	0.4186***	0.4178***
	(71.85)	(72.13)	(71.81)	(76.94)	(77.3)	(76.93)
MBE	0.0002	0.0001	0.0002	0.0001	0.0001	0.0001
	(1.07)	(1.05)	(1.09)	(0.71)	(0.71)	(0.71)
LEV	0.1028***		0.1211***	−0.0239		−0.0321
	(4.47)		(5.00)	(−1.2)		(−1.55)
ROE	0.1182***	0.1142***	0.1179***	0.0911***	0.0924***	0.0916***
	(10.12)	(9.78)	(10.09)	(8.07)	(8.17)	(8.10)
ACQ	−0.0694***	−0.0516***	−0.0497***	−0.0206**	−0.0192*	−0.0198*
	(−7.22)	(−4.87)	(−4.68)	(−2.22)	(−1.85)	(−1.91)
REP	−0.3197***	−0.3223***	−0.3140***	−0.3040***	−0.3022***	−0.3048***
	(−10.17)	(−10.24)	(−9.96)	(−9.81)	(−9.75)	(−9.81)
STD		0.0116	0.0015		0.0349***	0.0376***
		(1.61)	(0.20)		(4.78)	(5.00)
LTD		−0.026***	−0.0348***		−0.0127**	−0.0103**
		(−4.76)	(−6.09)		(−2.32)	(−1.81)
Sample Size	129,905	129,767	129,767	129,905	129,767	129,767
Constants	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.3691	0.3687	0.3692	0.3589	0.3586	0.3584

Table 3(b)
Baseline regression (1).

This table reports regression coefficient estimates of the relation among Total q, lag one period of MA-score and log one period of control variables. Our sample spans from 1987 to 2015. The dependent variable is Total q, as proposed by Peters and Taylor (2017), which is our proxy for investment opportunity. All the variables are defined in Appendix B. We report the results estimated by the fixed-effects model and random-effects model by considering different control variables, respectively. Year dummy variables are included in both regression. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

	Fixed effects			Random effects		
	(1)	(2)	(3)	(1)	(2)	(3)
Lag_MA-score	0.5034***	0.5079***	0.5067***	0.5774***	0.5890***	0.5768***
	(8.24)	(8.2)	(8.26)	(10.32)	(10.52)	(10.26)
Lag_CASH	0.9826***	0.9925***	0.9888***	1.2732***	1.3089***	1.2777***
	(23.9)	(24.19)	(23.93)	(34.03)	(35.47)	(33.95)
Lag_SIZE	0.2066***	0.2077***	0.2071***	0.1649***	0.1666***	0.1678***
	(30.44)	(31.04)	(30.44)	(36.41)	(36.98)	(36.41)
Lag_MBE	0.0002	0.0002	0.0002	0.0000	0.0000	−0.00001
	(0.77)	(0.78)	(0.78)	(−0.13)	(−0.1)	(−0.13)
Lag_LEV	−0.0308		−0.1572	−0.0977***		−0.0973***
	(−1.29)		(−0.63)	(−4.69)		(−4.46)
Lag_ROE	0.1596***	0.1592***	0.1588***	0.1264***	0.1279***	0.1261***
	(11.65)	(11.6)	(11.58)	(9.85)	(9.96)	(9.82)
Lag_ACQ	−0.0687***	−0.0554***	−0.0556***	−0.0468***	−0.0421***	−0.0442***
	(−6.61)	(−4.79)	(−4.80)	(−4.75)	(−3.82)	(−4.00)
Lag_REP	−0.1309***	−0.1262***	−0.1273***	−0.1072***	−0.0984***	−0.1065***
	(−3.79)	(−3.64)	(−3.67)	(−3.23)	(−2.96)	(−3.20)
Lag_STD		−0.0104	−0.0091		0.0035	0.0115
		(−1.28)	(−1.10)		(0.44)	(1.41)
Lag_LTD		−0.0212***	−0.0201***		−0.0152**	−0.0076
		(−3.46)	(−3.12)		(−2.52)	(−1.21)
Sample size	115,205	115,079	115,079	115,205	115,079	115,079
Constants	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2 (within)	0.1282	0.1282	0.1282	0.1247	0.1246	0.1245

Table 4
Baseline regression (2).

This table reports regression coefficient estimates of the relation between Total q and MA-score by excluding some control variables that might cause multicollinearity. Our sample period is from 1987 to 2015. The dependent variable is Total q, as proposed by Peters & Taylor, 2017 which is our proxy for investment opportunity. All the variables are defined in Appendix B. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

	(1)	(2)	(3)
MA-score	1.0996***	0.9636***	0.6695***
	(16.84)	(15.31)	(10.91)
Control variables	Exclude size and cash	Exclude size	Exclude cash
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Sample size	132,634	129,788	132,606
R^2 (within)	0.1077	0.183	0.3238

Table 5
Relation between investment opportunity and managerial ability in different industries.

This table presents how managerial ability (MA-score) affects investment opportunity (Total q) in different industries. Industries are defined by their two-digit SIC code, where 01–09 stand for Agriculture, Forestry & Fishing, 10–14 stand for Mining, 15–17 stand for Construction, 20–39 stand for Manufacturing, 40–48 stand for Transportation & Communications, 50–51 stand for Wholesale Trade, 52–59 stand for Retail Trade, and 70–89 stand for Services. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

Industry	Agriculture, forestry & fishing	Mining	Construction	Manufacturing
MA-score	1.4079***	0.2273*	1.0690***	0.6034***
	(2.95)	(1.85)	(3.97)	(6.17)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Sample size	664	11,216	1628	63,789
P-value	0.0000	0.000	0.0000	0.0000
R^2 (within)	0.4824	0.4495	0.4110	0.3836

	Transportation & communications	Wholesale trade	Retail trade	Services
MA-score	0.2591*	−0.5341**	−0.0925	1.1557***
	(1.87)	(−2.48)	(−0.49)	(9.21)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Sample size	9667	5861	9922	27,020
P-value	0.0000	0.0000	0.0000	0.0000
R^2 (within)	0.3686	0.3898	0.4532	0.5123

reliance on external funds developed by Kaplan and Zingales (1997),[9] to divide the sample firms in order to test our Hypothesis 2. Firms with a high KZ index value rely more on external financing and are considered financially constrained. We estimate Eq. (3) separately for the subsamples that are above Q3 for the KZ index and below Q1 for the KZ index. The result shows that a positive relation between managerial ability and investment opportunity is significant only in financially unconstrained firms, in which the KZ index is below Q1. Jagannathan, Masta, Meier, and Tarhan (2016) show that financially unconstrained firms will inflate their discount rate and thus be able to wait for better investment projects. It appears that just like the old saying goes, *you can't make a silk purse out of a sow's ear*, meaning managers will not be able to seize investment opportunities and realize future growth without sufficient funds and resources. Since financing constraints can force firms to abandon investment projects. Thus, mere availability of greater investment opportunities do not translate into higher investment for financially constrained firms. Given financial constraints, a conjecture is that a firm with higher managerial ability will underinvest less than a firm with lower managerial ability.

[9] The definition of the KZ index is found in Appendix A.

Table 6
Subsample analysis.

This table reports regression coefficient estimates of the relation between investment opportunity (Total q) and managerial ability (MA-SCORE) for subsamples of our data. Panel A reports regression results for firms above Q3 and below Q1 of Kaplan-Zingales, a relative measurement of financial constraint detailed in Appendix A. Firms with a high KZ index value rely more on external financing and are considered as financially constrained. Panel B reports regression results for firms above Q3 and below Q1 of the Altman *Z*-score introduced by Edward Altman (1968). T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

Panel A: Above Q3 and below Q1 of the Kaplan-Zingales index

	Financially constrained		Financially unconstrained	
	(Above Q3)		(Below Q1)	
MA-score	−0.1098	0.0729	0.7369***	0.3482***
	(−1.01)	(0.71)	(6.13)	(3.41)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	Yes
Sample size	31,672	31,672	30,684	30,684
P-value	0.0000	0.0000	0.000	0.000
R^2 (within)	0.2510	0.3070	0.4755	0.5604

Panel B: Above Q3 and below Q1 of the Altman Z-score

	Strong balance sheet		Weak balance sheet	
	(Above Q3)		(Below Q1)	
MA-score	0.8337***	0.2583**	−0.0649	0.1030
	(5.20)	(2.01)	(−0.86)	(1.35)
Control variables	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	NO	Yes	No	Yes
Sample size	31,236	31,236	30,844	30,844
P-value	0.0000	0.0000	0.0000	0.0000
R^2 (within)	0.2470	0.4564	0.1997	0.2241

In Panel B of Table 6, we revisit our Hypothesis 2 with subsamples divided by the Altman *Z*-score. The Z-score is a linear-combined measure of five financial ratios for predicting bankruptcy, as introduced by Edward Altman. A lower (higher) Z-score indicates that the possibility of default is higher (lower). We observe a statistically significant coefficient on the MA-score only for the above Q3 subsamples - namely, the group of sample firms with stronger balance sheets and lower probability of filing for bankruptcy. Marchica and Mura (2010) document that firms with conservative leverage policy and superior financial flexibility are associated with better investment ability. Overall, our results in Table 6 suggest that managerial ability only affects investment opportunity for firms with a healthy financial condition.

4.4. The relationship in different economic environments

Andreou et al., 2016 document a positive and robust relation between managerial ability and investment. We go further to examine the possibility that managers matter more for firms in particular economic environments. In Panel A of Table 7, we test whether the degree of competition in an industry can influence the relationship we are interested in. The model is estimated by including a dummy variable that takes the value of one (zero) when the firm's HHI index is below (above) 2500, since the Department of Justice of the United States considers a market with a HHI index in excess of 2500 to be highly concentrated. The

Table 7
Relation between investment opportunity and managerial ability in competitive industries and during recessions.

Panel A of Table 7 reports the relation between investment opportunity and managerial ability in competitive industries. The HHI dummy variable in Panel A is defined as 1 when HHI is below 2500 and 0 when HHI is above 2500, as the Department of Justice of the United States consider a market with HHI in excess of 2500 to be highly concentrated. Panel B of Table 7 reports the relation between investment opportunity and managerial ability during a recession period. The value of one is assigned to the recession dummy variable in Panel B when data fiscal years equal 1990, 1991, 2001, 2007, 2008, and 2009; and zero otherwise.

Panel A: Interaction regression of MA-score and HHI dummy

	Specification 1	Specification 2	Specification 3
MA-score	0.5889***	0.3184***	0.2975***
	(19.01)	(3.92)	(3.68)
Dummy	−0.3560***	−0.0308***	
	(−2.96)	(−2.55)	
MA-score*dummy		0.3058***	0.3295***
		(3.60)	(3.90)
Control variables	YES	YES	YES
Firm fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
Sample size	129,767	129,767	129,767
P-value	0.0000	0.0000	0.0000
R^2 (within)	0.3693	0.3693	0.3693

Panel B: Interaction regression of MA-score and recession dummy

	Specification 1	Specification 2	Specification 3
MA-score	0.7567***	0.8446***	0.8360***
	(22.63)	(23.44)	(23.19)
Dummy	−0.0734***	−0.0743***	
	(−11.43)	(−11.58)	
MA-score*dummy		−0.3542***	−0.3399***
		(−6.53)	(−6.27)
Control variables	YES	YES	YES
Firm fixed effects	YES	YES	YES
Year fixed effects	NO	NO	NO
Sample size	129,767	129,767	129,767
P-value	0.0000	0.0000	0.0000
R^2 (within)	0.2628	0.2631	0.2622

result shows a negative coefficient on the competition dummy, meaning that firms in a more competitive industry are associated with lower investment opportunity. However, we observe a coefficient with an opposite sign on the MA-score*dummy term compared to the direct effect of the competition dummy, indicating that the manager's effect is more pronounced for firms in a competitive industry, and that higher ability managers are able to mitigate the adverse impact of competition. We conjecture that investments by firms in highly concentrated industries are more stable and harder to be influenced by other factors such as price uncertainty (Ghosal and Loungani (1996)) and managerial ability.

In Panel B of Table 7, we include an indicator variable for a recession to examine the relation between managerial ability and investment opportunity during economic expansion and recession. We define the recession indicator as one when the data fiscal year equals 1990, 1991, 2001, 2007, 2008, and 2009 and zero otherwise based on the business cycle reference date documented by the National Bureau of Economic Research. The estimated coefficient of the recession indicator is significantly negative, meeting our expectation that firms should invest less during a recession or depression. The coefficient on the interaction term is also significantly negative, meaning that although managerial ability is positively related to investment ability during a recession, it is smaller in magnitude compared to an expansion period. Since our proxy for managerial ability is a measurement that captures the efficiency in using revenue-generating resources, the result in Panel B is consistent with our expectation that a manager's effect could be more pronounced during an expansion period, because of sufficient inputs and available resources.

Table 8
Different proxy for investment opportunity and MA-score.

This table documents the primary result of the robust test. We conduct the robustness test by employing different proxies for both dependent variables and independent variables to assess the robustness of our findings. We adopt MA-rank to alleviate possible measurement errors and document the results in column 2. In columns 3 and 4, we test our results using Tobin's q and capital the expenditure rate as alternative proxies for investment opportunity. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

Dependent variables	(1)	(2)	(3)	(4)
	Total q		Tobin's q	CAPX rate
	(Baseline model)			
MA-score	0.5889***		1.0433***	0.3145***
	(9.99)		(17.74)	(20.54)
MA-rank		0.2635***		
		(14.39)		
CASH	1.8136***	1.8116***	0.9680***	0.3599***
	(46.04)	(46.06)	(25.55)	(34.54)
SIZE	0.5649***	0.5667***	0.3693***	0.0474***
	(71.81)	(72.11)	(46.47)	(32.53)
MBE	0.0002	0.0002	0.0002	0.0001**
	(1.09)	(1.08)	(1.24)	(2.13)
LEV	0.1211***	0.1295***	0.0121	−0.0987***
	(5.00)	(5.36)	(0.42)	(−17.37)
ROE	0.1179***	0.1134***	0.1017***	0.0239***
	(10.09)	(9.78)	(7.66)	(7.38)
ACQ	−0.0497***	−0.5104***	−0.1693***	0.0517***
	(−4.68)	(−4.81)	(−17.01)	(15.16)
REP	−0.3140***	−0.3134***	−0.2897***	0.0267***
	(−9.96)	(−9.93)	(−10.00)	(3.27)
STD	0.0015	−0.0014	−0.0206***	0.0698***
	(0.20)	(0.19)	(−2.60)	(25.08)
LTD	−0.0348***	−0.0370***	−0.0549***	0.0697***
	(−6.09)	(−6.49)	(−9.02)	(31.29)
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Sample size	129,767	129,767	126,508	126,508
P-value	0.0000	0.0000	0.0000	0.0000
R^2 (within)	0.3692	0.3700	0.2088	0.1676

4.5. Robustness test

4.5.1. Different proxy for investment opportunity and MA-score

We conduct the robustness test by adopting different proxies in order to reconfirm our findings. Our baseline regression result is tabulated in column 1 of Table 8, and results of the robustness test are documented in the other columns. First, we change our proxy for managerial ability to the MA-rank, which is a rank measure of managerial ability also provided by Peter Demerjian, to alleviate possible measurement errors embedded in the MA-score. The result in column 2 shows that the MA-rank is positively and significantly related to Total q after controlling for firm fixed effects and year fixed effects. In column 3 and column 4, we test our result using alternative measures for investment opportunity. Kallapur and Trombley (1999) show that the ratio of capital expenditure divided by net plant, property, and equipment is consistently correlated with subsequently realized growth and therefore is a good proxy for investment opportunity. After controlling for the same control variables and effects, we still observe positive and significant relations between MA-score and our new investment opportunity proxies, Tobin's q and CAPX rate.

4.5.2. Different methodology for investment opportunity and MA-score

In order to confirm our baseline regression, we transform investment opportunity (Total q, Tobin's q, and CAPX rate), MA-score (MA-rank), and all control variables into first differences. This specification should also remove time-invariant firm effects (see Eq. (4)). Table 9 shows that all proxies of the MA-score operating on investment opportunity are still positive and significant. Hence, the results of this

Table 9
Different methodology for investment opportunity and MA-score.
This table documents the primary result of the robust test. We conduct the robustness test by employing different methodologies for both dependent variables and independent variables to assess the robustness of our findings in Eq. (4). We adopt MA-rank to alleviate possible measurement errors and use Tobin's q and the capital expenditure rate as alternative proxies for investment opportunity. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

	Total_q	Total_q	Tobinq	Tobinq	CAPX rate	CAPX rate
D_MA-SCORE	0.4001***		0.4544***		0.3582***	
	(9.51)		(10.53)		(21.24)	
D_MA-rank		0.1479***		0.1572***		0.1413***
		(11.08)		(11.64)		(26.62)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	114,546	114,546	110,737	110,737	114,523	114,523
R^2 (within)	0.1532	0.1534	0.1218	0.1218	0.0643	0.0657

methodology do not violate our Hypothesis 1.

4.5.3. Robust test for interact effect

We next test our findings on the interaction effect of managerial ability and economic circumstance by adopting Tobin's q and CAPX rate as proxies for investment opportunity. The results are tabulated in Table 10. In Panel B, the coefficient on MA-score*dummy is significant and negative, which is consistent with the result in Table 6. The only different result is in Panel A, whereby the interaction effect on the capital expenditure rate is positive, but insignificant. We think the insignificant coefficient may result from fewer information content contained in the capital expenditure rate compared to the book to market measures (Adam and Goyal 2007). Basically, we find no difference between the primary findings and other specifications adopting alternative measures, indicating that managerial ability is a driving factor of firm investment opportunity.

4.5.4. Subsample of positive MA-score

In accordance with the basic summary statistics, we see that the MA-score values are spreading either positive or negative in the original dataset. Based on the above reason, we are unable to consider that the coefficient of the MA-score after doing the regression estimation is actually significant with firms' investment opportunities. Therefore, we select the subsample that only contains a positive MA-score value to again run the regression that contains all control variables and excludes some variables causing multicollinearity. Columns (1) to (4) of Table 11 show the MA-scores are still positive and significant with investment opportunity (Total q).

4.5.5. Endogeneity problem: Simultaneous equation model (SEM)

The empirical results indicate a strong, consistent association between managerial ability and investment opportunity. However, it is possible that our findings are vulnerable to endogeneity concerns. For example, firms with high investment opportunity could hire more able managers, indicating a reverse causality problem. The investment and managerial ability also may be determined simultaneously, by unobserved risk factors. In the previous analysis, we included firm and time fixed effects in our regressions to control for the time-invariant and time-varying factors that may affect both the investment opportunity and managerial ability. However, the complete elimination of endogeneity biases in empirical studies is unlikely. Therefore, we use a system simultaneous equations model (SEM) approach to reduce potential concerns about reverse causality and the simultaneous determination of investment opportunity and managerial ability.[10]

We begin by applying the SEM. We expand the default probability equation model by adding the debt maturity equation, as follows:

Table 10
Robust test for interaction effect.
This table shows the result of the robust test for the interaction effect documented in Table 6. We test our results using Tobin's q and the capital expenditure rate as alternative proxies for investment opportunity. The HHI dummy variable in Panel A is defined as 1 when HHI is below 2500 and 0 when HHI is above 2500. The value of one is assigned to the recession dummy variable in Panel B when the data fiscal year equals 1990, 1991, 2001, 2007, 2008, and 2009, and zero otherwise. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

Panel A: Interaction regression of MA-score and HHI dummy

Dependent variable	Tobin's q	CAPX rate
MA-score	0.8379***	0.2972***
	(10.05)	(11.50)
MA-score*dummy	0.2368***	0.0196
	(2.73)	(0.73)
Control variables	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	YES	YES
Sample size	126,508	129,397
P-value	0.0000	0.0000
R^2 (within)	0.2088	0.1676

Panel B: Interaction regression of MA-score and recession dummy

Dependent variable	Tobin's q	CAPX rate
MA-score	1.1833***	0.3578***
	(33.90)	(32.68)
MA-score*dummy	−0.3316***	−0.0848***
	(−6.32)	(−5.14)
Control variables	YES	YES
Firm fixed effects	YES	YES
Year fixed effects	NO	NO
Sample size	126,508	129,397
P-value	0.0000	0.0000
R^2 (within)	0.1633	0.1235

$$Total\ \ q = \alpha_{10} + \alpha_{11}\, MAscore + \gamma\, \mathbf{Controls} + \text{Industry FE} + \text{Year FE} + \varepsilon, \tag{3}$$

and

$$\begin{aligned} MAscore = {} & \alpha_{20} + \alpha_{21} \times Total\,q \\ & + \alpha_{22} \times CF + \alpha_{23} \times SIZE + \alpha_{24} \times AGE \\ & + \alpha_{25} \times HHI + \alpha_{26} \times RD + \alpha_{27} \times TANG \\ & + \text{Industry FE} + \text{Year FE} + \varepsilon \end{aligned} \tag{4}$$

where Eq. (3) is the investment opportunity regression we use in the main analysis.[11] In the managerial ability equation (see Eq. (4)), we

[10] Other studies also apply the SEM approach to reduce endogeneity concerns (e.g., Billett, King, & Mauer, 2007; Brockman, Martin, & Unlu, 2010).

[11] In our SEM approach, following the literature, we include industry fixed effects rather than firm fixed effects.

Table 11
Subsample of positive MA-score.
This table reports the regression coefficient estimates of the relation between Total q and positive MA-score by excluding some control variables that might cause multicollinearity. Our sample period is from 1987 to 2015. The dependent variable is Total q, as proposed by Peters and Taylor (2017), which is our proxy for investment opportunity. All the variables are defined in Appendix B. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

MA-score	0.6571***	1.5545***	1.3139***	0.7982***
	(6.53)	(13.83)	(12.24)	(7.61)
Control variables	Yes	Exclude size and cash	Exclude size	Exclude cash
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Sample size	53,467	54,413	53,473	54,407
R^2 (within)	0.3946	0.1347	0.1987	0.3559

follow Palia (2001) to use the following control variables. CF is the measure of firms' cash flow, *SIZE* is the logarithm of total assets, *AGE* is the years since the firm was established. *HHI* is Herfindahl index which measures the market concentration. *RD* is the logarithm of R&D expenditure divided by the firm's assets, and we replace missing value of R&D expenditure with 0.[12] *TANG* is the tangible assets divided by property, plant, and equipment. To capture industry fixed effects, we use single-digit Standard Industrial Classification (SIC) dummies. To estimate the SEM, we use a generalized method of moments (GMM), with the exogenous variables as instruments in the moment conditions. The GMM ensures that the standard errors of the estimates are robust to heteroskedasticity and autocorrelation.[13]

We perform results of a two-equation SEM in Table 12. The investment opportunity and the managerial ability exhibit a positively significant, bi-directional relationship. Therefore, the amplifying effect of managerial ability on the investment opportunity remains robust after we account for endogeneity.

4.5.6. Endogeneity problem: Granger causality

We discuss the relationship among profitability (ROE),[14] managerial ability, and investment opportunity and employ the Granger-Causality framework. We thus examine the inter-temporal relationships among these three variables. For the Granger Causality test (see Tables 13 and 14), at the 1% significant level, we can come to the following conclusions. The managerial ability is the granger cause of investment opportunity, and the investment opportunity is also the granger reason of managerial ability (bi-directional relation). Besides profitability is the granger reason of the investment opportunity, and the investment opportunity is the granger cause of profitability (bi-directional relation).

As to profitability and managerial ability, the evidence shows higher managerial ability will bring higher profit of firms and there is no evidence to show firms with high profitability will hire more able managers (our new findings). Hence, these findings could tell us there exists no direct relation from profitability to managerial ability. We replace profitability with ROE, the results are still consistent with above argument.

Based on the above evidence, we derive the following two conclusions. First, we cannot completely rule out the bi-directional relationship between managerial ability and investment opportunity. Second, we find only managerial ability is the granger cause of profitability (*firms having managers with superior ability could gain more economic profits* via *better investment opportunities*). On the contrary, the

Table 12
Simultaneous equation model.
This table reports results of a system SEM that includes the investment opportunity and managerial ability equations in our sample. We estimate the SEM with a GMM, using the exogenous variables as instruments in the moment conditions. The GMM estimation method ensures that the standard errors of the estimates are heteroskedastic and autocorrelation consistent. The t-statistics, reported in parentheses, are obtained after considering clustered standard errors at the firm level. ***, **, and * denote significance of *t*-tests at the 1%, 5%, and 10% levels, respectively.

	Two-equation system	
	Total q	MA_score
Total q		0.02***
		(15.37)
MA_score	2.20***	
	(9.34)	
CF		0.00007*
		(1.82)
CASH	2.07***	
	(39.75)	
SIZE	0.15***	0.006***
	(48.32)	(12.31)
AGE		−0.0004***
		(−3.87)
MBE	0.0003***	
	(2.86)	
LEV	−0.11***	
	(−6.64)	
ROE	0.06***	
	(4.23)	
HHI		−0.000003***
		(−10.54)
ACQ	−0.07***	
	(−5.63)	
REP	−0.29***	
	(−8.11)	
STD	0.10***	
	(8.93)	
LTD	0.06***	
	(7.86)	
RD		0.04***
		(5.40)
TANG		−0.09***
		(−31.83)
Constant	Yes	Yes
Industry effects	Yes	Yes
Year fixed effects	Yes	Yes
Obs.	129,767	129,767

Table 13
Granger causality (1).
This table reports the results of Granger causality among investment opportunity, managerial ability and profitability.

Null hypothesis:	Obs	F-statistic	Prob.
Managerial ability does not Granger Cause Investment opportunity	150,840	44.562	0.000
Investment opportunity does not Granger Cause Managerial ability		388.091	0.000
PROFITABILITY does not Granger Cause Investment opportunity	57,072	4.387	0.012
Investment opportunity does not Granger Cause PROFITABILITY		12.407	0.000
PROFITABILITY does not Granger Cause Managerial ability	57,072	1.247	0.287
Managerial ability does not Granger Cause PROFITABILITY		14.625	0.000

[12] R&D/Total assets is the ratio of research and development expenditure (Compustat item *xrd*) to book value of total assets (Compustat item *at*). We replace missing values of *xrd* as zero (Gopalan, Song, and Yerramilli (2014)).

[13] Other instrumental variable techniques, such as two-stage least squares (2SLS), are special cases of GMM. For example, Greene (2003) and Kennedy (2003) report that, compared with 2SLS estimates, GMM estimates are more efficient when regression errors are heteroskedastic and/or autocorrelated; otherwise, the GMM estimates coincide with 2SLS estimates.

[14] We define profitability as earning before depreciation and amortization (EBITDA) divide by total assets (AT).

Table 14
Granger causality (2).
This table reports the results of Granger causality among investment opportunity, managerial ability and ROE.

Null hypothesis:	Obs	F-statistic	Prob.
Managerial ability does not Granger Cause Investment opportunity	150,840	44.562	0.000
Investment opportunity does not Granger Cause Managerial ability		388.091	0.000
ROE does not Granger Cause Investment opportunity	150,361	3.532	0.029
Investment opportunity does not Granger Cause ROE		149.213	0.000
ROE does not Granger Cause Managerial ability	150,361	0.434	0.648
Managerial ability does not Granger Cause ROE		150.086	0.000

Table 15
Reverse causality (1).
This table reports regression coefficient estimates of the relation between Total q and MA-score. Our sample spans from 1987 to 2015. Here, we use *Tobinq* to divide our sample into four quantiles (> 75%, 50%–75%, 25%–50%, and < 25%). The dependent variable is Total q, as proposed by Peters and Taylor (2017), which is our proxy for investment opportunity. We report the results estimated by the fixed-effects model and year dummy variables in the regression. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

	> 75%	50%–75%	25%–50%	< 25%
MA-score	0.203*	0.116**	0.046	−0.00006
	(1.90)	(2.14)	(0.99)	(−0.01)
Constants	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Sample size	26,414	29,092	30,156	30,788
R^2 (within)	0.1623	0.1242	0.1376	0.1767

results are not supporting *better profitability enable firms to hire superior managers*.

4.5.7. Endogeneity problem: Reverse causality

We test the possible situation that *it could also be the case that successful firms that have favorable investment opportunities attract and are able to hire superior managers*. Here, we adopt Tobin q to separate our sample into four quantiles and investigate the empirical result in each scenario by following Eqs. (5) and (6). If the more able managers could bring higher investment opportunity for their companies, then we expect the coefficient of α_{11} should be positive and significant. On the contrary, if successful firms that have favorable investment opportunities are able to hire superior managers, we expect β_{11} should be positive and significant.[15]

$$Total\ \ q = \alpha_{10} + \alpha_{11}\, MAscore + \gamma\, \mathbf{Controls} + \text{Firm FE} + \text{Year FE} + \varepsilon \tag{5}$$

$$MAscore = \beta_{10} + \beta_{11}\, Total\ \ q + \delta\, \mathbf{Controls} + \text{Firm FE} + \text{Year FE} + \varepsilon \tag{6}$$

Tables 15 and 16 provide overall picture across two equations. We find that the eq. (5) are only significant at the categories of Tobinq > 75% and 50% < Tobinq < 75%, and Eq. (6) performs no any significant level. Therefore, our empirical results support the idea that when firms have favorable investment chance, more able managers could bring higher investment opportunity for their companies.

4.5.8. Endogeneity problem: 2SLS

This section corroborates our findings with a two-stage least-squares (2SLS) approach to reduce potential concerns about reverse causality of investment opportunity and MA-score.[16] As to instrumental variables, we adopt the lag one period of managerial ability. The estimated coefficients of the MA-score are highly significant at the 1% level in the regression models with all control variables (Column 1 of Table 17) or when excluding some variables that might cause the multicollinearity problem (Columns 2 to 4 of Table 17). These results provide robust evidence that verifies our preliminary finding that superior managerial ability helps firms obtain more economic profits via better investment opportunities.

[15] The control variables of managerial ability are the same as SEM model.

Table 16
Reverse causality (2).
This table reports regression coefficient estimates of the relation between MA-score and Total q. Our sample spans from 1987 to 2015. Here, we use *Tobinq* to divide our sample into four quantiles (> 75%, 50%–75%, 25%–50%, and < 25%). The dependent variable is MA_score which is our proxy for managerial ability. We report the results estimated by the fixed-effects model and year dummy variables in the regression. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by '***' at 1%, '**' at 5%, and '*' at 10%.

	> 75%	50%–75%	25%–50%	< 25%
Total q	0.0007	−0.0018	0.00076	0.00018
	(1.20)	(−1.68)	(0.34)	(0.06)
Constants	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Sample size	21,002	26,441	27,067	24,373
R^2 (Within)	0.079	0.0348	0.0443	0.0177

Table 17
Endogeneity (2SLS).
This table reports the regression coefficient estimates of 2SLS. We adopt the lag one period of our independent variables to be our instrumental variables. Our sample period is from 1987 to 2015. The dependent variable is Total q, as proposed by Peters and Taylor (2017), which is our proxy for investment opportunity. All the variables are defined in Appendix B. T-statistics are reported in parentheses, and standard errors are clustered by firms. Statistical significance is designated by "***" at 1%, "**" at 5%, and "*" at 10%.

	2SLS	2SLS	2SLS	2SLS
MA-score	0.5616***	1.0385***	0.9333***	0.6237***
	(17.57)	(28.10)	(25.76)	(19.28)
Control variables	Yes	Exclude size and cash	Exclude size	Exclude cash
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Sample size	117,690	121,345	117,711	121,317
R^2 (within)	0.3565	0.1026	0.1692	0.3162

5. Conclusion

In this study we examine whether firms operated by superior managers can enjoy more favorable investment opportunities. The regression analysis exhibits a significantly positive relationship between managerial ability and investment opportunity after controlling for several firm characteristics and fixed effects. Additionally, a further test indicates that the relation varies in firms under different financial conditions. The positive relation is significant only in the subsamples below Q1 of the KZ Index or above Q3 of the Altman *Z*-score, meaning that even an exceptional manager still cannot seize an investment opportunity and realize future growth without sufficient funds and resources.

[16] Because the variance components are unknown, consistent estimates are required to implement feasible GLS. STATA (xtivreg) offers two choices: the Swamy-Arora method and the simple consistent estimators from Baltagi and Chang (2000).

This study has the following economic implications. First, our findings suggest that the boards of directors of firms in good financial condition or competitive industries should hire and retain superior managers to realize higher future growth. Second, managerial ability should be considered by investors seeking targets with better investment opportunities. Third, our findings may be useful to policy makers and regulators in planning regulations such as expensing employee compensation. Overall, our study documents that managerial ability is a key determinant of investment opportunity.

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Appendix A. We use the Kaplan-Zingales Index to capture the different interpretations of financial constraints mentioned above (high need for funds as well as high costs of external funds)

$$Kaplan - Zingales - index = -1.001909 \bullet \frac{Cash\ flow_{it}}{Total\ capital_{it-1}} + 0.2826389 \bullet Tobin's\ Q_{it} + 3.139193 \bullet Leverage_{it} - 39.3678 \bullet \frac{Dividend_{it}}{Total\ capital_{it-1}} - 1.314759 \bullet \frac{Cash_{it}}{Total\ capital_{it-1}}$$

Here, $Cash\ flow_{it}/Total\ capital_{it-1}$ is computed as Compustat items (IB + DP) / PPENT, $Tobin's\ Q_{it}$ as (LSE + CSHO*PRCC_F-CEQ-TXDB) / LSE, $Leverage_{it}$ as (DLC + DLTT) / (DLC + DLTT + SEQ), $Dividend_{it}/Total\ capital_{it-1}$ as (DVC + DVP) / PPENT, and $Cash_{it}/Total\ capital_{it-1}$ as CHE/PPENT. All of the Compustat items PPENT in the denominator of the equation are lagged.

We adopt the Altman *Z*-score, a formula introduced by Altman in 1968, as our measure of the probability that a firm will file for bankruptcy within two years.

$$\text{Altman Z} - \text{score} = 1.2 \bullet \frac{Working\ capital}{Total\ Assets} + 1.4 \bullet \frac{Retained\ earning}{Total\ Assets} + 3.3 \bullet \frac{EBIT}{Total\ Assets} + 0.6 \bullet \frac{Market\ value\ of\ equity}{Book\ value\ of\ liabilities} + 1.0 \bullet \frac{Sales}{Total\ Assets}$$

Here, *Working capital/Total Assets* is computed as Compustat items (ACT-DLC)/AT, *Retained earning/Total Assets* as RE/AT, *EBIT/Total Assets* as EBIT/AT, *Market value of equity/ Book value of liabilities*is computed as PRCC_G*CSHO/LT, and *Sales/Total Assets* as REVT/AT.

Appendix B

Variable	Definition
Dependent variable	
Total q	Total q is measured by scaling firm value by the sum of physical and intangible capital
Tobin's q	Liquidating value of market equity plus total debt plus preferred stock (Compustat items: PSTKL) minus deferred taxes and investment tax credits (Compustat items: TXDITC) all divided by book assets (Compustat item: AT)
CAPX rate	Ratio of capital expenditures (Compustat items: CAPX) over the net book value of plant, property. and equipment - Total (Compustat item: PPENT)
Independent variable	
MA-score	Residual of firm efficiency score estimated by the Demerjian, Lev, Lewis, and McVay (2012) DEA model
MA-score-rank	MA-score introduced by Demerjian, Lev, and McVay (2012) ranked from 1 to 10, by industry and year, and then scaled by 10, resulting in a range from 0.10 to 1.0.
Control variable	
CASH	Ratio of a firm's cash holdings (Compustat items: CH) to book value of total assets (Compustat item: AT)
SIZE	Nature logarithm of a firm's market value of equity (Compustat items: PRCC_F*CSHO)
MBE	Ratio of a firm's market value (Compustat items: CSHO * PRCC_F) to its book value of equity (Compustat item: CEQ)
LEV	Ratio of total debt (Compustat items: DLC + DLTT) to book value of total assets (Compustat item: AT)
ROE	Ratio of earnings before interest and tax (Compustat item: EBIT) to lagged book value of equity (Compustat item: CEQ)
ACQ	Acquisitions (Compustat item: AQC) divided by LAG property, plant, and equipment – Total (Compustat item: PPENT)
REP	Purchase of common and referred stock (Compustat item: PRSTKC) / LAG property, plant, and equipment - Total (Compustat item: PPENT)
STD	ΔDebt in current liabilities (Compustat item: DLC)/ LAG property, plant, and equipment - Total (Compustat item: PPENT)
LTD	Δ Long-Term Debt – Total (Compustat item: DLTT) / LAG property, plant, and equipment – Total (Compustat item: PPENT)

Appendix C. In the first step, Demerjian, Lev, Lewis, and McVay (2012) adopt data envelopment analysis (DEA), which is also used by Charns (1978) and Banker, Charnes, and Cooper (1984), to quantify firms' efficiency within their industries. The key advantage of DEA is that it can take multiple inputs and outputs into consideration simultaneously. Three flow variables (costs of inventory, selling, general and administrative expenses) and five stock variables (net property, plant, and equipment; net operating leases; net research and development; purchased goodwill; and other intangible assets) are considered as input resources in their approach. The firm efficiency score is estimated by solving the following optimization problem

$$max_v\ \theta = \frac{Sales}{v_1 COGS + v_2 SG\&A + v_3 PPE + v_4 OL + v_5 R\&D + v_6 GDWL + v_7 OtherIntan}$$

The DEA procedure fits a piecewise linear envelope to generate a firm efficiency score, θ, from one to zero - that is, the efficiency scores of observations lying on the frontier are one and other firms with efficiency scores less than one can improve their firm efficiency by reducing costs or increasing sales revenues.

The efficiency score generated by DEA cannot measure managerial ability, because it can be attributable to both firm-specific characteristics and the manager ability factor. Next, we follow Demerjian, Lev, and McVay (2012)[17] to isolate managerial ability by regressing the efficiency score on firm-specific characteristics and get an error term to measure managerial ability. Firm-specific characteristics that might overstate managerial ability include firm size, firm market share, cash flow indicator, and the firm's life cycle (*AGE*). On the other hand, the complexity of business operations measured by the concentration of business segments (*BSC*) and the foreign currency indicator are expected to understate managerial ability. The following Tobit model is estimated by industry and year fixed effects:

$$Efficiency\ Score = \alpha + \beta_1 SIZE + \beta_2 MarkerShare + \beta_3 CashFlowIndicator + \beta_4 AGE + \beta_5 BSC + \beta_6 ForeignCurrencyIndicator + \sum Year\ Fixed\ Effect + \varepsilon$$

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[17] Demerjian et al. (2012) propose a new measure of managerial ability, MA-score, which outperforms existing ability measures such as CEO tenure, CEO compensation, and media mentions. The measure captures managers' efficiency in generating revenues for a large sample of firms and demonstrates an economically significant manager specific component. They confirm that the MA-score is more attributable to the manager than to the firm through a series of valid tests and show that a new appointment of a higher MA-score manager is associated with a positive change in firm performance.