

Managerial Ability and R&D Investment: An Empirical Analysis Based on DEA-Tobit Model

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Abstract—DEA is a statistical procedure used to evaluate the relative efficiency of separable entities, termed “decision-making units” (DMUs), where each DMU converts certain inputs into outputs. The DEA efficiency methodology can provides an ordinal ranking of relative efficiency compared to the Pareto-efficient frontier, and the widely used efficiency measure require that weights be explicitly set, which is more advantageous than the conventional measures of efficiency. The Tobit model is a dependent variable limited model. Since the efficiency value measured by the DEA model is a truncated discrete distribution value between 0 and 1, the Tobit model can effectively avoid the problems of bias and inconsistency in parameter estimation. Based on this, this paper takes Chinese A-share listed companies from 2008 to 2018 as samples, adopts DEA-Tobit model to measure managerial ability, and studies the impact of managerial ability on firm innovation investment. It is found that managerial ability is negatively correlated with R&D investment. Further research shows that the negative relationship between managerial ability and firm innovation investment is more significant in non-state-owned companies. Transparency of accounting information can alleviate the restraining effect of managers ability on innovation input. This study not only enriches the research literature in the field of managerial ability and firm innovation input, but also has important enlightenment significance on how to improve managerial innovation willingness in reality and further promote firm innovation behavior.

1 Introduction

As the final maker and implementer of innovation decision, managers plays a decisive role in the investment of firm innovation. Therefore, it is of great theoretical value and practical significance to study the factors that influence or restrict the managers in making innovation decisions, to promote the innovation behavior of companies and to improve the overall innovation investment level of China.

Since the measurement model of managerial ability was proposed [1], firm innovation has gradually become an important topic in the research field of managerial ability[2]. China scholars used listed companies in China as samples to demonstrate the relationship between managerial ability and firm innovation investment, but the results were very different. However, some scholars held different views and found that managerial ability had an inhibitory effect on firm innovation investment[3,4]. By combing the above literatures, there are still two problems that need to be further studied. First, domestic researches on managerial ability and firm innovation investment have not yet reached a consistent conclusion. Moreover, the reliability and universality of research conclusions are affected by the number of samples and the time span because of the small number of domestic research samples and short time span. Second, when using the managerial

ability model, the above research did not strictly follow the model steps, resulting in a large deviation. Specifically, the measurement of managers ability is divided into two steps. First, data envelopment analysis (DEA) is used to measure the operating efficiency of the company. But this process needs to adopt the variable scale return model, while domestic scholars adopt the constant scale return model. Secondly, the company's operating efficiency includes both the efficiency generated at the company level and the efficiency generated by the managers level. Therefore, Tobit model is used to return to the influence factors at the company level, such as total assets and firm years, to find out the efficiency generated by the managers level, namely the managers ability. We estimate the following Tobit regression by industry and include year fixed effects and cluster standard errors by firm and year to control for cross-sectional and intertemporal correlation. However, domestic studies only cluster standard errors by firm and even did not include year fixed effects, resulting in large errors in the model.

Based on this, this paper takes Chinese A-share listed companies from 2008 to 2018 as research samples, and after complying with managerial ability model requirements, it uses DEA-Tobit model to measure managerial ability and studies the impact of managerial ability on firm innovation investment. It is found that managerial ability is negatively correlated with innovation investment. Further research shows that the

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negative relationship between managers ability and firm innovation investment is more significant in non-state-owned companies. Transparency of accounting information can alleviate the restraining effect of managers ability on innovation input.

The contributions of this paper are as follows: first, compared with previous studies, this paper has a larger sample size and a longer time span. Moreover, it makes up for the problems existing in previous studies in measuring managerial ability, and the empirical results are more accurate. Second, this paper brings managerial ability, innovation input and related factors that influence the relationship between them into the unified research framework, so as to help people to have a deeper understanding of the mechanism by which managerial ability affects innovation input of listed companies in China.

2 Theoretical analysis and research hypothesis

Based on the principal-agent theory analysis, under the condition of information asymmetry, high-ability managers tend to choose conservative investment strategies and prefer low-risk investment projects out of consideration of their own interests[5]. Innovation activities are high-risk investment projects, with a long R&D cycle, high risk of failure, lag of innovation earnings and failure of innovation projects all leading to unsatisfactory short-term financial performance of companies, and impaired performance is likely to make managers questioned by shareholders[6]. In order to protect their position, reputation and income, high-ability managers show obvious characteristics of risk defense[7]. Therefore, self-serving considerations will lead to conservative investment strategies, and managers is more inclined to reduce innovation input and increase investment projects that can quickly improve short-term performance. To sum up, this paper proposes the following hypothesis:

H1: Managerial ability is negatively associated with the level of R&D investment.

In companies with different property rights, there may be some differences in the influence of managerial ability on innovation investment. Research shows that profit is not the only goal of state-owned companies, and the managers is controlled by the government to a greater extent in terms of position appointment and removal and salary level, so firm performance is not the decisive factor for managers' retention and salary level [8]. Compared with state-owned companies, managers of non-state-owned companies shoulder more responsibilities as professional managers. Their appointment, dismissal and compensation are more dependent on the determination of market principles, and they are usually faced with greater market pressure [6]. Therefore, in non-state-owned companies, short-term performance is more closely related to the appointment and removal of managers positions and the level of earnings. Competent managers will also face greater performance pressure when investing in innovation, which exacerbates their short-

sighted behavior of avoiding risks. Therefore, this paper proposes the following hypothesis:

H2: Compared with state-owned companies, the managerial ability of non-state-owned companies has a more significant impact on the investment in innovation.

The transparent information environment can provide shareholders with more detailed information about the innovation behaviors of the managers, reduce the degree of information asymmetry, help them to have a more comprehensive understanding of the efforts of the managers in the research and development process, better supervise the managers, and restrain their short-sighted behaviors [9]. Thus effectively alleviates the negative relationship between managers ability and firm innovation investment. Therefore, this paper proposes the following hypothesis:

H3: Information transparency alleviates the negative relationship between managerial ability and firm innovation investment.

3 Study design

3.1 Sample selection

This paper selects Chinese A-share listed companies from 2008 to 2018 as research samples. All the financial data in this study are from the CSMAR database, and the R&D expenditure data are from the WIND database. In this paper, financial companies, ST and ST*, as well as companies with incomplete financial data and research and development data were excluded. Finally, 11,341 observed values were obtained, and the continuous variables were treated with 1% and 99% Winsorize.

3.2 Variable selection

3.2.1 Explanatory variables

This paper uses DEA-Tobit model to calculate the managerial ability[1], which is widely recognized by scholars at home and abroad. The measurement of managerial ability indicators is divided into two step:

First, data envelopment analysis (DEA) is used to measure the company's operating efficiency. Firstly, according to the industry classification standard of CSRC 2012, samples are divided according to categories, among which the manufacturing industry is divided according to sub-categories. Secondly, the firm is taken as the decision unit (DMUs), and the variable scale reward model is adopted to calculate the operating efficiency of the company.

$$\text{Max Firm Efficiency} = \frac{\text{Sale}}{v_i \text{CoGS} + v_i \text{SG\&A} + v_i \text{PPE} + v_i \text{RD} + v_i \text{GW} + v_i \text{Intan}} \quad (1)$$

In model (1), Sales represents operating revenue and acts as the unique output variable. Input variables were operating costs (CoGS), corporate sales and managers expenses (SG&A), net fixed assets (PPE), R&D expenditures (RD), Goodwill(GW), and intangible assets (Intan).

Second, Tobit model is used to calculate managers capability. In model (1), the company's operating efficiency includes both the efficiency generated at the company level and the efficiency generated by the managers level. Therefore, in order to exclude the influence at the company level, the six variables at the company level that affect the operation efficiency of companies are returned, and the influence of managers on the operation efficiency of companies is separated. The calculation is as follows:

$$Firm\ Efficiency = \alpha_0 + \alpha_1 Size_i + \alpha_2 MS_i + \alpha_3 FCF_i + \alpha_4 AGE_i + \alpha_5 HHI_i + \alpha_6 Foreign_i + Year_i + e_i$$

(2)

In model (2), Size is the natural logarithm of the number of assets at the end of the year; MS is the market share, is the market share, expressed by the proportion of the company's sales in the total revenue of companies in the industry. FCF is a dummy variable, which is 1 when the company has positive cash flow, or 0 when the company has positive cash flow. HHI is the degree of business diversification, expressed by the number of business scope; AGE is the AGE of a company, expressed by the natural logarithm of the company's listing years; Foreign is the dummy variable, where the company has overseas business is 1; otherwise, it is 0. We add annual fixed effect according to industry regression model (2), and adopt bidirectional cluster to correct standard errors to make the model more robust[1].E stands for residual, that is, managerial ability.

3.2.2 Explained variable

In this paper, the proportion of research expenditure divided by revenue was used to measure innovation input[4].

3.2.3 Transparency

Transparency is modified earnings quality model [10].Firstly, the industry and annual regression model is as follows:

$$TCA_{i,t} = \beta_0 + \beta_1 CFO_{i,t-1} + \beta_2 CFO_{i,t} + \beta_3 CFO_{i,t+1} + \beta_4 \Delta REV_{i,t} + \beta_5 PPE_{i,t} + e_{i,t}$$

(3)

TCA is total flow accrual, equal to operating profit minus operating cash flow plus depreciation and amortization expenses. CFO for operating cash flow, ΔREV is revenues change value, the PPE refers to the value of fixed assets, and annual designation for the company, i and t represent the company and the year, e for the error term. All variables divided by the average total assets. After regression, the standard deviation is calculated by taking the residual difference between the current year and the previous 4 years as the earnings quality index (DD) of the company in year t. Since DD is a reverse indicator, we multiply this indicator by -1 for the convenience of comparison. The larger DD is, the higher the earnings quality will be.

3.2.4 Control variables

Based on existing studies[3], I include a number of firm level variables which have been shown to affect innovative activity. Specifically, I include return on equity(ROA), annual growth rate of operating income(GROWTH), natural log of one plus the number of years(AGE), natural log of assets(Size), liabilities divided by total assets(LEV), net fixed assets divided by total assets(PPE), capital expenditures divided by total assets(ZBZC), managers compensation(SL), managers shareholding(HOLD), net cash flow from operations divided by total assets(FCF)and Assets divided by market value(TQ) as control variables.

3.3 The empirical model

This paper uses model (4) to test the impact of managers ability on firm innovation investment.

$$R\&D_{i,t} = \beta_0 + \beta_1 MA_{i,t} + \beta_2 Control_{i,t} + \sum Year + \sum Industry + e_{i,t}$$

(4)

In order to test the moderating effect of property right nature, equity incentive and information transparency on managers ability and firm innovation input, the interaction terms of managers ability and three moderating variables were added respectively on the basis of model (4), building models (5) and (6).

$$R\&D_{i,t} = \beta_0 + \beta_1 MA_{i,t} + \beta_2 SOE_{i,t} + \beta_3 MA \times SOE_{i,t} + \beta_3 Control_{i,t} + \sum Year + \sum Industry + e_{i,t}$$

(5)

$$R\&D_{i,t} = \beta_0 + \beta_1 MA_{i,t} + \beta_2 DD_{i,t} + \beta_3 MA \times DD_{i,t} + \beta_3 Control_{i,t} + \sum Year + \sum Industry + e_{i,t}$$

(6)

4 The empirical results

4.1 Descriptive statistics

Table 1 shows the descriptive statistical results of the main variables involved in this paper. From the perspective of explained variables, the mean value of innovation input is 0.041, indicating that the overall innovation input is not high, with a maximum value of 0.244, a minimum value of 0 and a standard deviation of 0.042, indicating that there are differences in innovation input levels among companies. From the perspective of explanatory variables, the mean value, maximum value and minimum value of the managerial ability of an firm are -0.249, 0.256 and -0.695 respectively, indicating that the managerial ability of the firm is generally low and different.

TABLE I. DESCRIPTIVE STATISTICS

Variabl e	Obs.	Mean	Std.	Min	Max
R&D	11341	0.041	0.042	0	0.244
MA	11341	-0.249	0.237	-0.695	0.256
DD	6386	0.350	0.024	0.006	1.132
PPEA	11341	0.215	0.143	0.007	0.644
SL	11341	14.247	0.678	12.676	16.131

GROW	11341	-0.030	0.490	-0.424	2.011
TH					
FCF	11341	0.044	0.065	-0.136	0.227
TQ	11341	2.113	1.256	0.911	7.997
LEV	11341	0.406	0.200	0.047	0.857
SIZE	11341	22.071	1.244	19.92	26.098
ZBZC	11341	0.055	0.047	0.002	0.227
ROA	11341	0.067	0.096	-0.439	0.296
AGE	11341	1.992	0.760	0	3.178
HOLD	11341	0.158	0.209	0	0.689

4.2 Regression results

TABLE II. MANAGERIAL ABILITY AND R&D INVESTMENT

Variable	R&D		
	(1)	(2)	(3)
MA	-0.032*** (-7.29)	-0.036*** (-7.24)	-0.036*** (-9.85)
SOE		0.0021 (0.51)	
MA×SOE		0.013*** (2.58)	
DD			0.011 (-0.65)
MA×DD			0.102*** (3.63)
SL	0.002*** (2.81)	0.002*** (2.79)	0.001** (1.88)
ROA	-0.047*** (-4.81)	-0.048*** (-4.86)	-0.022*** (-2.99)
PPEA	-0.003 (-0.66)	-0.003 (-0.74)	-0.004 (-0.99)
GROWTH	-0.004*** (-6.18)	-0.004*** (-6.18)	-0.003*** (-3.78)
FCF	-0.004 (-1.18)	-0.004 (-1.13)	-0.004 (-0.89)
TQ	0.001*** (3.55)	0.001*** (3.44)	0.002*** (6.48)
LEV	-0.027*** (-7.36)	-0.027*** (-7.35)	-0.018*** (-5.95)
SIZE	0.001 (1.48)	0.001 (1.62)	0.003 (0.35)
ZBZC	0.027*** (3.79)	0.027*** (3.80)	0.021*** (2.70)
AGE	-0.002 (-1.45)	-0.002 (-1.33)	-0.004 (-0.79)
HOLD	0.007 (1.35)	0.006 (1.23)	0.002 (0.33)
Constant	-0.041* (-1.66)	-0.045* (-1.81)	-0.059*** (-2.65)
Firm	Yes	Yes	Yes
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
R ²	0.148	0.149	0.213
N	11341	11341	6386

***, ** and * denote significance at 1% 5% and 10% levels(two-tailed)

The result in Table 2, Column (1), shows the empirical results of managerial ability's investment in firm innovation. From the regression results of column (1), it can be seen that the regression coefficient of the

explanatory variable information transparency comprehensive index Tran is significantly positive at the 1% level, indicating that information transparency has a promoting effect on firm innovation investment. Hypothesis H1 is verified. Profitability (ROA), operating income GROWTH rate (GROWTH) and the asset-liability ratio (Lev) is negatively related to the innovation input, from another Angle, strong ability of managers is more inclined to quickly improve the short-term performance of investment projects, improve the corporate performance, but also suppresses the firm innovation input, logically consistent with the above analysis. Compensation incentive (SL), Tobin Q (TQ) and capital expenditure (ZBZC) are all positively correlated with innovation input, which is basically consistent with existing research[4].

The result in Table 2, Column (2), shows the moderating effect of property right nature on managerial ability and innovation input. Among them, the coefficient of MA is significantly negative at the 1% level, and the interaction term between managerial ability and property rights (MA×SOE) is significantly positive at the 1% level, indicating that the inhibiting effect of managerial competence on firm innovation investment is more significant in non-state-owned companies. Hypothesis H2 is verified.

The result in Table 3, Column (3), shows the moderating effect of information transparency on managerial ability and innovation input. Among them, the coefficient of MA is significantly negative at the 1% level, and the interaction term between managerial ability and information transparency (MA×DD) is significantly negative at the 1% level, indicating that information transparency alleviates the negative relationship between managerial ability and firm innovation investment. Hypothesis H2 is verified.

5 CONCLUSION

Taking Chinese A-share listed companies from 2008 to 2018 as samples, this paper adopts DEA--Tobit model to measure information transparency and studies the impact of managers ability on firm innovation investment. It is found that managers ability has an inhibitory effect on innovation investment. Further study found that the negative relationship between managers ability and firm innovation input was more significant in non-state-owned companies, and accounting information transparency alleviated the negative relationship between managerial ability and innovation.

The conclusion of this paper has important theoretical and practical significance. In theory, the property right nature and incentive mechanism are incorporated into the study of managers ability and firm innovation input, which makes the mechanism of managers ability influencing firm innovation input more clear. In practice, (1) The research conclusions of this paper provide a theoretical basis for market regulatory authorities to formulate relevant policies to enhance the transparency of firm information. Transparent information environment can reduce the degree of information asymmetry between

managers, shareholders and external investors. It can not only guide the market to pay attention to the long-term value of the firm, but also improve the level of corporate governance, which is of great significance to the establishment of a perfect manager market, which is of great significance to the improvement of the overall innovation investment level in China. (2) This paper finds that information transparency can restrain short-sighted behavior of managers in investment. Therefore, companies should be aware of the importance of this means of internal governance and continue to strengthen their internal supervision so as to prevent excessive operation of financial information from damaging the sustainable development of companies.

References

1. Demerjian, P., Lev, B., Mcvay, S. (2012) Quantifying Managerial Ability: A New Measure and Validity Tests. *J. Management Science.*, 58: 1229-1248.
2. Chen, Yangyang, Podolski, Edward J, Veeraraghavan, Madhu. (2015) Does managerial ability facilitate corporate innovative success?[J]. *Journal of Empirical Finance*, 34: 313-326.
3. Yao, L, J., Zhou Y. (2018) Managerial Ability, Innovation Ability and Innovation Efficiency. *J. Accounting Research.*, 06: 70-77.
4. Deng, F., Li, Y, H. (2019) Managerial Ability, Ownership and Innovation Investment—Empirical Evidence Based on High-tech Listed Companies. *J. Journal of Industrial Technological Economics.*, 38: 19-26.
5. Aghion, J., Van Reenen, L., Zingales. (2013) Innovation and Institutional Ownership. *J. American Economic Review.*, 103: 277–304
6. Zhang, Z.G., Liu, Y, W., Yang, Q, X. (2014) Research on Management Tenure, Promotion Incentive and R&D Investment. *J. Accounting Research.*, 09: 81-88+97.
7. He, W, F., Liu, W., Huang, K, L., (2016) Managerial Ability and Corporate Risk-taking. *J. China Soft Science.*, 05: 107-118.
8. Wen, J., Feng, G, F. (2012) Heterogeneous Institutional Investor, Nature of Firm and Independent Innovation. *J. Economic Research Journal.*, 47: 53-64.
9. Armstrong C S, Guay W R , Weber J P . (2010) The role of information and financial reporting in corporate governance and debt contracting. *J. Journal of Accounting and Economics.*, 50: 0-234.
10. Xin, Q, Q., Kong, D, M., Hao, Y. (2014) Transparency and Stock Return Volatility. *J. Journal of Financial Research.*, 10:193-206