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Financing Sources, R&D Investment and Enterprise Risk

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Abstract

Research and development (R&D) investment of high-tech enterprises has an impact on enterprise risk, but the effect is different when funding sources are different. This paper aims to study the relationships among financing sources, R&D investment and enterprise risk. The empirical results suggest that the relationship between endogenous financing rate and R&D investment is significantly positive, and asset-liability ratio has a significantly negative impact on R&D investment. Furthermore, the study shows that relationship between enterprise risk and R&D investment can be described with a quadratic parabola.

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Keywords: Financingsources, Investment, Enterprise risk;

1. Introduction

With the increasingly fierce market competition, innovative enterprises need to design and improve their capital structure and cultivate the dynamic technological innovation capability, so as to adapt to environmental changes and form a continuous innovation advantage. R&D (Research and Development) innovation is the key to the management of innovative enterprises. However, many kinds of uncertainty factors in R&D activities will form a complex R&D innovation risk [1]. As important innovation activities, R&D had increasingly been paid more attention by enterprises, especially high-tech enterprises. And it is an important condition for high-tech enterprises to promote the innovation performance. However, research and development activities usually need a lot of funds, and long cycle, which lead to the enterprise risk existing in the process of R&D investment. It means that the innovation performance of R&D activities is uncertain in the future. So companies will be accompanied by varying degrees of financial risk issues when they invest in research and development. R&D investment has the characteristics of periodicity and high risk, and these characteristics indicate that R&D

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investment needs a lot of long-term funds. These funds are mainly from the company's endogenous financing and exogenous financing. With the increase of R&D investment, the priority order of financing ways is from endogenous financing to debt financing, and enterprise risk firstly decreases and then increases. So it is very meaningful to study the relationship among financing sources, R&D investment and enterprise risk. The essential characteristic of Growth Enterprise Market (GEM) companies is the sustainable innovation, so this relationship may become more prominent in these companies. In the process of research and development of the GEM companies, inappropriate collocation and unreasonable application of capital will lead to financial risks, resulting in damage of the enterprise credit and loss of market share, and even survival crisis. In this paper, the research on financing and enterprise risk in R&D activities will help enterprises to avoid financial risk issues caused by the mismatch of R&D funding sources and expenditure intensity over capacity, so that the enterprises can obtain the sustainable innovation advantage.

The existing papers mainly focus on the influence of different financing sources on the R&D investment of enterprises [2-11]. Papers written on an empirical analysis of financing sources, R&D expenditure and enterprise risk suffer severe shortages. Research in this field is of great significance. Based on this, we take the GEM Listed Corporations as research sample to analyze the impact of financing sources (internal financing and debt financing) on R&D investment and the impact of R&D investment intensity on enterprise risk.

2. The Theory Analysis And Hypotheses

R&D activity is a process of transforming knowledge into economic and social benefits. This whole process takes time and big chunks of capital to invest. Companies generally choose endogenous financing as the preferred source of capital when they invest in R&D activities. Endogenous financing is the internal accumulation of enterprises, which is the preferred choice of firms in R&D activities. It also has the advantages of lower cost, less constraint and less risk, so it can reduce the debt pressure of corporations. Based on Pecking Order Theory, Myers [2] discovered that the financing sources of R&D investment in companies were sorted by the way of internal financing to external financing. The R&D investment of enterprises mainly depended on internal financing sources, and the second was external financing. The research results from Himmelberg and Petersen [3] showed that R&D expenditure had a significant positive correlation with internal financing. Kamien and Schwartz's research [4] also emphasized that the effect of technological innovation mainly depended on the degree of endogenous financing. Liu [5] analyzed the impact of financing sources on the company's R&D investment with the empirical data of listed high-tech enterprise in China. The research found that the enterprise's R&D investment mainly relied on internal financing and equity financing. R&D investment activities have the characteristics of higher risk, more investment and longer investment cycle, so compared with external financing, endogenous financing has no fixed debt repayment period, which can reduce the operational and administrative pressure of enterprises. Therefore, endogenous financing is more suitable for enterprise's R&D investment. On the basis of the above analysis, hypothesis 1 is proposed as follows:

H1: R&D intensity is significantly positively correlated with the ratio of endogenous financing.

Debt capital must pay principal and interests on time, and the repayment of debt interest requires a stable cash inflow as a support. R&D activities have long payback period, if companies use debt capital in R&D activities, funding return can be difficult to ensure. Once the R&D activities fail, the company will face financial difficulties. In addition, as R&D is a high-risk investment activity, the creditors will require risk returns in R&D investment. It leads to the high burden of interest rates. Thus, returns on investment will fall because of the excessive investment cost. In the aspect of the impact of external financing on corporate R&D expenditure, Aivazian [6] studied the impact of financial leverage on corporate investment decisions through empirical research with data of Canadian listed Corporation, and the study found that the debt ratio and the enterprise' s investment expenditure had a significant negative correlation. According to the empirical analysis of Wen [7], the debt constraints and debt sources had an impact on the company's R&D investments, and debt

financing and corporate R&D investment intensity was significantly negatively correlated. But because it is difficult for the new high-tech industry to meet their fund demands through the endogenous financing means, must excavate debt financing way satisfied with his need. On the basis of the above analysis, hypothesis 2 is proposed as follows:

H2: The higher level of debt financing, the less R&D investment of enterprises will be.

R&D activities are characterized by long duration and need large capital investment. Generally speaking, internal financing is difficult to meet the financial needs of R&D activities and enterprises often need to utilize external financing to supplement funds for R&D activities. Different financing sources of R&D activities lead to different degree of enterprise risk. Cui [8] found that corporate R&D expenditure and capital sources interact through his study. When the capital source was reasonable, enterprise risk was low and enterprise could get the benefit from it; but if the arrangement of the capital source was not reasonable, it would increase enterprise risk. O'Bien [9] found that enterprises which invest in R&D through debt, but failed to meet the requirements of the contract in debt maturity, then creditors with the priority to claim could request the enterprise bankruptcy, which would increase the risk of enterprise bankruptcy. Jensen and Meckling [10] proposed that there would be an asset substitution problem between shareholders and creditors, and the enterprise shareholders had an incentive to invest in risky assets with the debt and take the opportunity to transfer some risk to creditors. Huang et al. [11] adopted individual random effect model to verify the relationship between R&D investment and risk, and the research results showed that R&D investment and bankruptcy risk was significantly positive correlation. Analysis of the impact of financing sources on R&D investment shows that endogenous financing is the first choice and debt financing is the next in R&D activities. When the required funds of R&D investment exceed the amount of endogenous financing, enterprises need to meet the demand for funds through debt financing, which will make debt capital increase with the rise of R&D investment. R&D investment has the characteristic of high risk. If enterprises invest a large amount of debt capital in the process of R&D investment, once the R&D activities fail, the resources consumed by R&D may trigger the financial crisis of the company and increase the enterprise risk. Therefore, R&D expenditure should have a "degree". At the apex of the parabola (the risk is minimum), the level of R&D investment is the best. On the basis of the above analysis, hypothesis 3 is proposed as follows:

H3: The relationship between R&D intensity and Z-score is a parabola going upwards.

3. Research method

3.1. Sample and Data Collection

The GEM Listed Corporations are mainly the high-tech and independent innovation oriented enterprises, and these companies have obvious characteristics of technological innovation. Since these listed companies have the features of high proportion of intangible assets, high growth potential, unstable operations and small scales, the main founding purpose of GEM is to support the development of high-tech enterprises and growing enterprises. It is the best choice to take the GEM Listed Corporations as the research sample to reveal the relationship among financing sources, R&D investment and enterprise risk. Therefore, we select GEM Listed companies (2010-2014) as the research sample and screen the sample with following principles: the samples of ST or data with missing key values were removed from the study; We take into account the special nature of some industries in the first and third categories (such as agriculture, forestry, animal husbandry, fisheries, services, real estate and financial), enterprises belonging to these categories were removed from the study. After the above methods of screening and sorting, we got a total of 553 observations. Data were extracted from CSMAR Database except for R&D expenses, which were manually collected from company annual reports.

3.2. Regression model

In order to verify the hypotheses 1 and 2, we draw lessons from the research of Jie and Fang [12], Chen and Yang [13] and design the following models to explore the impact of financing sources on R&D intensity. Our regression models are shown in Eq. (1) and Eq. (2).

$$RD = \alpha_0 + \alpha_1 END + \alpha_2 EQU + \alpha_3 ROA + \alpha_4 SIZE + \alpha_5 \sum INDUST + \alpha_6 \sum YEAR + \varepsilon \quad (1)$$

$$RD = \beta_0 + \beta_1 LEV + \beta_2 ROA + \beta_3 SIZE + \beta_4 \sum INDUST + \beta_5 \sum YEAR + \mu \quad (2)$$

Where α_i and β_i respectively denotes the regression parameters of the model, ε and μ respectively denotes the error term of the model.

Following the enterprise risk measurement method of Altman [16] as well as the research of Huang et al. [11] on the impact of R&D investment on enterprise risk, in order to verify the hypothesis 3, we design the following model to explore the impact of R&D intensity on enterprise risk. Our regression model is shown in Eq. (3)

$$Z = \gamma_0 + \gamma_1 RD^2 + \gamma_2 RD + \gamma_3 OPE + \gamma_4 FAT + \gamma_5 LEV + \gamma_6 SIZE + \gamma_7 \sum INDUST + \gamma_8 \sum YEAR + \upsilon \quad (3)$$

Where γ_i denotes the regression parameters of the model and υ denotes the error term of the model.

3.2.1. Dependent variables

R&D intensity is an important index that measures the R&D activities.So the dependent variable of model 1 and 2 is R&D Intensity. In this paper, we measure R&D investment by R&D intensity (R&D investment / Operating income), which is commonly used to reflect the level of R&D expenditure.

The dependent variable of model 3 is enterprise risk. Enterprise risk also known as operational risk, which means that the uncertainty and unpredictable factors will affect enterprise to achieve its goals in future. The operational risk is inherent in the business activities and is difficult to measure accurately since it mainly comes from the uncertainty of objective economic environment. Therefore, we choose financial risk that can be easily controlled and measured to replace enterprise risk. Following Dai [14] and Yu [15], we measure the financial risk of enterprises by Z-score model which is invented by Altman [16], a famous American scholar. Altman's Z-Score model is mainly used to predict the possibility of financial failure or bankruptcy of enterprises and the situation of financial crisis. The function is as follows:

$$Z = 1.2 * X_1 + 1.4 * X_2 + 3.3 * X_3 + 0.6 * X_4 + 0.999 * X_5$$

Where X1 = Working capital / Total assets
X2 = Retained Earnings / Total assets
X3 = Earnings before interest and taxes / Total assets
X4 = Market value equity / Book value of total debt
X5 = Sales / Total assets
Z = Overall Index
Prediction from Z-score model: Z>3, the financial situation of the enterprise is safe; 1.8<Z⩽3, the financial

situation of enterprise is in the grey area, enterprise must pay attention to it; Z≤1.8, judging from the financial data that the enterprise is going bankrupt.

3.2.2. Explanatory variables

Financing sources are chosen as explanatory variables in model 1 and 2.Asset-liability ratio (LEV) is the substitute variable of debt financing, and the substitute variable of internal retained financing is endogenous financing rate (ENT). Endogenous financing is the capital, which comes from the business activities. It is the internal financing of company. Following Jing etc. [17], we take the sum of surplus reserves and undivided profits as the amount of endogenous financing. Endogenous financing rate is the ratio of endogenous financing amount to total assets. R&D Intensity is chosen as explanatory variable in model 3 to measure the level of R&D investment activities.

Table1. Definitions of variables

Variables	Symbols	Definition
R&D Intensity	RD	R&D investment / Operating income
Z-score	Z	As shown in the formula (1)
Asset-liability ratio	LEV	Total liabilities / Total assets
Endogenous financing rate	END	(Surplus reserves + Undivided profits) / Total assets
Operating-profit margins	OPE	Operating profit / Operating income
Equity financing rate	EQU	(Equity + Capital reserves) / Total assets
Fixed asset turnover	FAT	Operating income / Average net fixed assets
Return on assets	ROA	(Net profits + Interest charges + Income tax) / Average total assets
Company size	SIZE	Natural logarithm of total assets
Year dummy variable	YEAR	From 2010 to 2014, a total of 4 year virtual variables were generated.
Industry dummy variable	INDUST	According to the Commission by industry, the paper sample after a screening involving a total of 5 industry virtual variables.

3.2.3. Control variables

According to the empirical research results of Wen [7] , Liu [5] and Wang etc. [18], model 1 selects year dummy variable (YEAR), Industry dummy variable (INDUST), company size (SIZE) and return on assets (ROA) as control variables, model 2 introduces equity financing (EQU) on the base of model 1. Following Dai [14] and Huang etc. [11], model 3 selects operating-profit margins (OPE), fixed asset turnover (FAT), LEV and SIZE as control variables.

The specific definitions of variables are shown in table 1.

4. Empirical analysis result

4.1. Descriptive statistical analysis

The descriptive statistics of the main variables are shown in Table 2. The maximum of R&D intensity (R&D) is 1.032, the minimum is 0, and the standard deviation is 0.092, which indicates that there are small

differences in the R&D investment of the observation samples. The mean value of Z is 1.511, which is in the "bankruptcy" region, and its standard deviation is large. It indicates that the risk of listing Corporations in the study sample is generally large, but there are remarkable differences among individuals. The mean value of endogenous financing rate (END) is 0.182, the mean value of equity financing rate (EQU) is 0.591, and the mean value of asset-liability ratio (LEV) is 0.211. The smallest one of the three mean values is endogenous financing rate (END), which indicates that the endogenous financing ability of GEM listed companies is limited. The maximum of asset-liability ratio (LEV) is 0.687, the minimum is 0.011, and the standard deviation is 0.147, which indicates that there are big differences in the proportion of debt financing of the observation samples. The average asset-liability ratio (LEV) is 0.211, which indicates that the average level of companies' debt is generally higher than the endogenous financing. The reason is that debt is bound by bank credit and must pay principal and interests on time, which will lead to higher overall risk of enterprises. The standard deviation of fixed asset turnover (FAT) is big, which means that there are big differences in the operational capability of the enterprises.

Table2. A descriptive statistics (2010-2014)

Variables	Min	Max	Mean	Std. dev.
Z	0.0993	3.977	1.511	0.459
R&D	0	1.032	0.06	0.092
END	-0.269	0.632	0.182	0.09
LEV	0.011	0.687	0.211	0.147
ROA	-0.082	0.396	0.062	0.05
SIZE	18.679	22.904	20.901	0.609
FAT	0.393	67.656	6.885	9.188
OPR	-0.428	0.713	0.153	0.143
EQU	0.111	0.9	0.591	0.152

4.2. Regression analysis

Model 1 examines the relationship between R&D investment and endogenous financing. The empirical result is shown in table 3. The regression result shows that the endogenous financing rate (END) and R&D intensity (R&D) has a significant positive correlation, which means that the R&D investment of enterprises will increase when the strength of endogenous financing increases. R&D investment depends on the endogenous financing. Hypothesis 1 is supported. Therefore, managers of enterprises prefer using endogenous capital for the high-risk R&D investment projects, because of the lower cost and the less risk of endogenous capital.

According to the regression result of model 2 in table 3, R&D intensity and the Asset-liability ratio is negatively related on the 1% significance level. It is namely that the R&D investment will decrease with the increase of debt level, which supports hypothesis 2. R&D investment has the characteristics of high risk, non-reversibility and long payback period, so that creditors usually require some risk compensation when they loan to the R&D project. This causes the high cost of debt financing to the company's R&D investment and enterprises must bear the pressure of debt-servicing. The source of debt financing has a significant constraint to enterprise's R&D project. Only when the internal capital is not sufficient, enterprises will choose debt financing to supplement their capital needs.

The model 3 verifies the relationship between R&D intensity and enterprise risk. The result shows that the relationship between enterprise risk and R&D investment can be described by a parabola. Hypothesis 3 is fully validated. In the early stage of R&D investment, enterprises need to put a large amount of capital into the opening of R&D projects and the purchase of R&D resources which lead to the relative shortage of funds accompanied by the increase in corporate financial risk; However, with the continuous development of R&D projects, R&D investment is relatively stable and corporate risk will be reduced accordingly.

Table3. Regression results of Financing Sources, R&D investment and Enterprise Risk

Variables	RD		Z
	Model 1	Model 2	Model 3
Constant	-0.121	-0.022	4.2300***
	（-0.784）	（-0.156）	（6.934）
RD^2			0.860**
			（-2.032）
RD			-1.379***
			（-3.868）
LEV		-0.117***	-0.862***
		（-4.074）	（-6.814）
END	0.101*		
	（1.722）		
EQU	0.108***		
	（3.517）		
ROA	-0.191*	-0.196*	
	（-1.795）	（-2.513）	
SIZE	0.007	0.008	-0.128***
	（1.048）	（1.128）	（-4.660）
OPE			1.273***
			（10.513）
FAT			0.013***
			（7.119）
YEAR	control	control	control
INDUST	control	control	control
adj.R^2	8.6%	9.2%	43.2%
F	5.009***	5.645***	31.020***

Notes: T-Values within parentheses (.). ***, **, * indicate significance at the 10%, 5%, and 1% levels, respectively.

5. Conclusions

In this paper, we choose GEM listed companies from 2010 to 2014 as the research sample to study the relationship among financing source, R&D investment and enterprise risk of the high-tech enterprises and

independent innovation enterprises. Based on the empirical analysis, most of the hypotheses are supported. And obtained results show that R&D intensity is positively correlated with endogenous financing, while R&D intensity is negatively correlated with asset-liability ratio. Furthermore, the empirical analyses reveal a parabolic relationship between Z-score (the index of measuring the enterprise risk) and R&D intensity, which means that the enterprise risk firstly decreases and then increases with the rise of R&D investment. The study shows that the first choice for high-tech and innovative enterprises is endogenous financing when they invest in R&D, which is considered as the low-risk and low-cost source of funds. If the source cannot meet the need of the enterprises, they would consider the external debt financing. The financing method is consistent with the pecking order theory. The above analysis further shows that in the early stage of R&D activities, enterprises will put a lot of capital into R&D investment, which makes Z-score decrease and corporate financial risk rise; But with the development of enterprise R&D activities, the R&D investment will be maintained at a stable level, making Z-score increase and corporate risk controlled.

Based on the above analysis we can know that the sources of financing will have an impact on R&D investment intensity of GEM companies, while R&D investment intensity will affect the risk of enterprises. Thus, the GEM companies need to avoid risks when promoting R&D activities. So the enterprises should make efforts in the following 2 areas: on the one hand, in order to enhance the level of R&D activities, enterprises should develop a scientific R&D financing strategy and make a reasonable financing arrangement. Debt financing with reasonable size and structure do improve the corporate performance and optimize the capital structure; On the other hand, enterprises should attach importance to the risk of R&D investment and take effective measures to reduce the risk of enterprises. On the basis of fully understanding and analyzing the sources of financing and the ability of risk tolerance, the technological innovation-oriented enterprises can achieve the goal of successfully avoiding risk and sustainable development.

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