Research on the Influence Factors of the R&D Intensity of China's Manufacturing Industry

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ABSTRACT: Enterprise R&D intensity is affected by internal and external factors. According to the listed companies of China's manufacturing enterprises and the analysis of the data of industry breakdown in 2013, the study finds: The lower asset-liability ratio is, the greater its R&D intensity will be. Corporate profitability and market competition situation have a weak influence on R&D intensity. High-tech enterprise identity is a critical factor influencing enterprise R&D intensity.
KEYWORD: Manufacturing Enterprises; R&D Intensity; Influence Factors; Logistic Regression Analysis

1 INTRODUCTION

The implementation of innovation driven development strategy and the realization of sustainable economic development in China is up to the innovation ability of enterprises to a large extend. Enterprise innovation is out of the question without R&D investment. According to the statistical data of State Statistics Bureau, all kinds of enterprises in China invested RMB 907,580,000,000 Yuan in R&D in 2013, which accounted for 76.6% of the total investment in R&D in China. It can be seen that enterprise R&D investment plays a dominant role in China. The State Council proposes that the proportion of the average R&D investment of national large and medium-sized industrial enterprises in main business income should be raised to 1.5% by 2015. The realization of the goal needs to mobilize all the internal and external positive factors of enterprises and make earnest efforts. Based on the data of the listed companies of China's manufacturing industry in 2013, the paper studies the internal and external factors influencing enterprise R&D intensity from micro-enterprise perspective, specifically estimates the degree of influence of various factors and finally brings up suggestions and countermeasures according to the research result.

2 INFLUENCE FACTORS AND RESEARCH HYPOTHESIS

Domestic and foreign scholars have conducted many researches on the influence factors of enterprise R&D intensity. Through collation and analysis, the influence factors can be divided into two types, namely the internal and external factors of enterprises.

2.1 *The Internal Factors of Enterprise*

Financial situation and profitability are the internal crucial factors which reflect the operating conditions of enterprises and exert a direct and profound influence on R&D investment. Capital structure intensively embodies the financial situations of enterprises. The lower the lever ratio of enterprise capital structure is, the more beneficial the investment in technological innovation will be. Firstly, low lever enterprises are better in keeping the sustainability of R&D intensity and guaranteeing the adequate money of promoting new products. Secondly, the first hypothesis is raised by taking capital structure as the first independent variable influencing enterprise R&D intensity. In this case, the lower the asset-liability ratio of enterprises is, the greater R&D intensity will be. The stronger enterprise profitability is, the more profits enterprises will make and the capital used for R&D investment will be. A significant positive correlation relationship is thus shown between profitability and R&D intensity. The higher the profit level of enterprises is, the greater its R&D intensity will be. Thirdly, the second hypothesis is put forward by taking profitability as the second independent variable influencing enterprise R&D intensity. As a result, the stronger enterprise profitability is, the greater R&D intensity will be.

The nature of enterprise controlling shareholders and whether the governance and management layers hold shares are the important issues of corporate

governance which influence the governance structure of enterprises and enterprise R&D intensity in the end. If enterprise controlling shareholders are state-owned legal persons, the manager is usually negative in R&D activities due to under excitation and the limitation of his tenure. The higher the proportion of state-owned property rights of China's enterprises is, the lower their output efficiency of R&D will be. Fifthly, the third hypothesis is presented by taking the nature of controlling shareholders as the third independent variable influencing enterprise R&D intensity. Under the circumstances, the R&D investment of state-controlled enterprises is lower than that of non-state-holding enterprises. As an effective incentive measure, the shareholding of the governance and management layers can avoid the short-termism of enterprises and exert a positive influence on enterprise R&D investment. The shareholding the governance and management layers plays a role in boosting enterprise R&D investment and increasing the investment in innovation and R&D of enterprises. Sixthly, the fourth hypothesis is proposed by taking the shareholding of the governance and management layers as the fourth independent variable influencing enterprise R&D intensity. In this case, the shareholding of the governance and management layers is beneficial for enterprises to improve R&D intensity.

2.2 *The External Factors of Enterprises*

The government formulates fiscal and tax policies. The tax policy and fiscal subsidy policy of the government are the important means of facilitating enterprise R&D investment. The preferential tax policy plays a role in promoting R&D intensity obviously. Seventhly, tax preference can stimulate the R&D activities of enterprises to a great degree compared with fiscal subsidy. Eighthly, the fifth hypothesis is raised. Namely, tax preference facilitates enterprise R&D intensity. The government funding accelerates enterprise R&D investment and the incentive is continuous. Ninthly and tenthly, the sixth hypothesis is brought up by taking government subsidy as the sixth independent variable influencing enterprise R&D intensity. Namely, the government subsidy improves enterprise R&D intensity.

Market competition is also an important external factor influencing enterprise R&D investment. The impact of market competition on the investment in China's industrial innovation is non-linear. The motivation of innovation is not strong at the strongest and weakest ends of market competition. Only the market competition at a moderate degree can have a significant positive incentive effect on the investment in enterprise innovation. Eleventhly, enterprises can make profits and provide cash for R&D investment only through taking a place in market competition. Therefore, the market competition situation is considered as the sixth independent variable influencing R&D investment.

A major disagreement exists in the aspect of the influence of foreign direct investment (FDI) on R&D investment. According to research findings, the influence of FDI to the industrial technological development of China is not evident. Twelfthly, some researches also think that FDI can improve the independent R&D ability of domestic-funded enterprises. Thirteenthly, FDI is taken as the seventh variable influencing enterprise R&D intensity.

3 SAMPLE SELECTION, VARIABLE DEFINITION AND MODEL SPECIFICATION

3.1 *Sample Selection*

The research samples of the paper are from the main manufacturing-listed companies of Shanghai and Shenzhen Stock Exchange. The relevant data of the listed companies of manufacturing industry in 2013 is selected. There are 494 samples in total.

3.2 *Variable Definition*

3.2.1 *Dependent Variable*

The paper takes enterprise R&D intensity as the dependent variable which is represented by annual R&D expenditure divided by annual main business income.

3.2.2 *Independent Variable*

1) Financial situation is represented by asset-liability ratio, namely year-end total liabilities divided by year-end total assets.
2) Profitability is represented by basic earnings per share, namely the net profits of common shareholders in the company divided by the weighted average of issued common shares.
3) Controlling shareholders are divided into three types, namely state-owned shareholders, institutional shareholders and social public shareholders. The paper divides the nature of controlling shareholders into state-owned and institutional shareholders.
4) The proportion of shareholding of the governance and management layers is represented by the total number of shareholding of year-end broad members and senior executives divided by the total number of issued shares.
5) Tax preference is represented by the return amount of taxes which is actually received annually.
6) The government subsidy is represented by the amount of government subsidy which is actually received annually.

7) Market competition situation is represented by the net cash flow of annual operating activities. The increase of the net cash flow of operating activities shows that the market share of enterprises' products or service is high and sales status is good.
8) FDI is represented by the proportion of enterprise shares held by foreign investors at the end of the year.

3.2.3 *Control Variable*

1) Enterprise scale is represented by the natural logarithm of year-end total assets.
2) ST companies are the listed companies which specially process stock exchange according to Shanghai and Shenzhen Stock Exchange.
3) High-tech enterprises are up to the identification of national high-tech enterprises.

See Table 1 for specific variable definition

Table 1: The Table of the Definitions of Dependent, Independent and Control Variables

	Name of Variable	Acronym of Variable	Demarcation of Variable
Dependent Variable	Y R&D Intensity	RDI	If the proportion of R&D investment in main business income exceeds 1%, it is 1; otherwise 0.
Independent Variable	X1 Asset-Liability Ratio	ALR	If asset-liability ratio is less than or equal to 60%, it is 1; otherwise 0.
	X2 Earnings per Share	EPS	If earnings per share are more than 0, it is 1; otherwise 0.
	X3 Nature of Controlled Shareholders	CSN	If controlled shareholders are in state-owned enterprises, it is 1; otherwise 0.
	X4 Shareholding of the Governance and Management Layers	GAMS	If the proportion of shareholding of the governance and management layers is more than 0, it is 1; otherwise 0.
	X5 Tax Preference	TP	If tax preference exists, it is 1; otherwise 0.
	X6 Government Subsidy	GS	If government subsidy exists, it is 1; otherwise 0.
	X7 Net Cash Flow of Operating Activities	ONCF	If the net cash flow of operating activities is more than 0, it is 1; otherwise 0.
	X8 FDI	FDI	If the proportion of FID is more than 0, it is 1; otherwise 0.
Control Variable	Enterprise Scale	ES	The logarithm of year-end total assets in 2013
	ST Companies	ST	If they are ST companies, it is 1; otherwise 0.
	High-tech enterprises	HTE	If they are high-tech enterprises, it is 1; otherwise 0.

3.3 *Model Specification*

The following Logit model is established according to selected variables:

$$\text{Logit}\,[RDI/(1-RDI)] = \alpha_0+\alpha_1\,ALR+\alpha_2 EPS+\alpha_3 CSN+\alpha_4 GAMS+\alpha_5\,TP+\alpha_6\,GS+\alpha_7\,ONCF+\alpha_8\,FDI+\alpha_9\,ES+\alpha_{10}\,ST+\alpha_{11} HTE+\varepsilon l$$

4 EMPIRICAL ANALYSIS

4.1 *Significance Testing*

Significance testing is conducted through adopting Pearson coefficient, calculating the dependent R&D intensity (original data and processed data) and various independent variables and using the method of two-sided test. The result is as follows:

Table 2 The Table of Significant Coefficients

Independent Variable	Name	Dependent Variable Y (RDI)	
		R&D Intensity (Original)	R&D Intensity (After Processing)
X1	Asset-Liability Ratio (ALR)	0.161**	0.211**
X2	Earnings per Share (EPS)	0.028	0.081
X3	Nature of Controlled Shareholders (CSN)	-0.057	-0.012
X4	Shareholding of the governance and management layers (GAMS)	0.071	0.071
X5	Tax preference (TP)	0.201**	0.315**
X6	Government Subsidy (GS)	0.107*	0.150**
X7	Operating Net Cash Flow (ONCF)	0.011	0.126**
X8	FDI (FDI)	-0.03	0.042
	Logarithm of Total Assets (ES)	-0.017	0.087
	ST Companies (ST)	0.001	0.076
	High-tech enterprises (HTE)	0.399**	0.560**

Remarks: ** stands for significant correlation at the level of 0.01 (two-sided) while * stands for significant correlation at the level of 0.05 (two-sided)

Firstly, a very significant correlation relationship is shown between R&D intensity and asset-liability ratio. The lower asset-liability ratio is, the more enterprises will be willing to invest in R&D.

Secondly, a significant correlation relationship is manifested between R&D intensity and tax preference and government subsidy, which indicates that national policy on tax preference and subsidy plays a positive role in improving enterprise R&D investment.

Thirdly, R&D intensity is correlated to operating net cash flow to some extend. The enterprises whose net operating cash flow is positive are obviously greater than those whose net operating cash flow is negative in the aspect of R&D intensity.

Fourthly, R&D intensity of high-tech enterprises is apparently greater than other enterprises.

4.2 *Logistic Regression Analysis*

4.2.1 *Preliminary Analysis*

A preliminary Logistic regression analysis is conducted through taking asset-liability ratio (ALR, X1), earnings per share (EPS, X2), shareholding of the governance and management layers (GAMS, X4), tax preference (TP, X5), government subsidy (GS, X6) and operating net cash flow (ONCF, X7) as factors and enterprise scale (ES), ST companies (ST) and high-tech enterprises (HTE) as concomitant variables. The result is as follows:

Table 3: The Table of Parameter Estimation of Preliminary Regression Analysis

R&D Intensity a		B	Standard Error	Wald	df	Significant Level	Exp(B)	The Confidence Interval of Exp(B) 95%	
								Lower Limit	Upper Limit
0	Intercept	.934	2.255	.172	1	.679			
	Asset Size	-.009	.095	.009	1	.926	.991	.823	1.193
	ST Companies	.041	.599	.005	1	.946	1.042	.322	3.373
	High-tech enterprises	-2.658	.293	82.253	1	.000	.070	.039	.124
	[Asset-Liability Ratio=0]	.708	.303	5.454	1	.020	2.030	1.121	3.679
	[Asset-Liability Ratio=1]	0b	.	.	0	.	.	.	.
	[Eamings per Share=0]	.137	.270	.258	1	.612	1.147	.675	1.949
	[Eamings per Share=1]	0b	.	.	0	.	.	.	.
	[Shareholding of the Governance and Management Layers=0]	-.036	.391	.009	1	.926	.964	.448	2.077
	[Shareholding of the Governance and Management Layers=1]	0b	.	.	0	.	.	.	.
	[Operating Net Cash Flow=0]	.225	.278	.654	1	.419	1.252	.726	2.159
	[Operating Net Cash Flow=1]	0b	.	.	0	.	.	.	.
	[Tax preference=0]	-.336	.368	.838	1	.360	.714	.348	1.468
	[Tax preference=1]	0b	.	.	0	.	.	.	.
	[Government Subsidy=0]	1.358	.936	2.105	1	.147	3.887	.621	24.330
	[Government Subsidy=0]	0b	.	.	0	.	.	.	.

Based on the above table, the established Logistic regression analysis model is as follows:

$$Logit\left(\frac{P(RDI-0)}{P(RDI-1)}\right) = 0.934 - 0.009*ES + 0.041*ST - 2.658*the + \alpha_1 ALR + \alpha_2 EPS + \alpha_3 GAMS + \alpha_4 ONCF + \alpha_5 TP + \alpha_6 GS + \varepsilon$$

If ALR is equal to 0, $\alpha_1 ALR$ is 0.708; otherwise 0. If EPS is equal to 0, $\alpha_2 EPS$ is 0.137; otherwise 0. If GAMS is equal to 0, $\alpha_3 GAMS$ is -0.36; otherwise 0. If ONCF is equal to 0, $\alpha_4 ONCF$ is 0.225; otherwise 0. If TP is equal to 0, $\alpha_5 TP$ is -0.336; otherwise 0. If GS is equal to 0, $\alpha_6 GS$ is 1.358; otherwise 0.

Firstly, three variables including enterprise asset size, ST companies and shareholding of the governance and management layers are removed in the following analysis due to the low significant levels of their regression coefficients.

Secondly, the probability of enterprise R&D intensity being 0 drops on the contrary if tax preference is equal to 0. Through analyzing the correlation between the variable tax preference and other variables, it is found that tax preference is highly correlated to high-tech enterprises (Correlation coefficient is equal to 0.594). Therefore, tax preference is removed in the following analysis.

4.2.2 *Logistic Regression Model*

After the above four variable are removed, the result of logistic regression analysis is as follows:

Table 4: The Table of Parameter Estimation of Further Regression Analysis

R&D Intensity a		B	Standard Error	Wald	df	Significant Level	Exp(B)	The Confidence Interval of Exp(B) 95%	
								Lower Limit	Upper Limit
0	Intercept	.604	265	5.211	1	.022			
	High-tech enterprises	-2.5.7	.238	110.604	1	.000	.081	.051	.130
	[Asset-Liability Ratio=0]	.694	.295	5.524	1	.019	2.002	1.122	3.573
	[Asset-Liability Ratio=1]	0b	.	.	0	.	.	.	.
	[Eamings per Share=0]	.129	.260	.246	1	.620	1.138	.683	1894
	[Eamings per Share=1]	0b	.	.	0	.	.	.	.
	[Operating Net Cash Flow=0]	.212	.271	.616	1	.433	1.236	.728	2.101
	[Operating Net Cash Flow=1]	0b	.	.	0	.	.	.	.
	[Government Subsidy=0]	1.299	.931	1.949	1	.163	3.667	.592	22.723
	[Government Subsidy=0]	0b	.	.	0	.	.	.	.

a. Reference type is 1. b. The parameter is set to 0 for redundancy.

The established logistic regression model is as follows:

$$Logit\left(\frac{P(RDI=0)}{P(RDI=1)}\right) = 0.604 - 2.507 * HTE + \alpha_1 ALR + \alpha_2 EPS + \alpha_3 ONCF + \alpha_4 GS + \varepsilon$$

If ALR is equal to 0, $\alpha_1 ALR$ is 0.694; otherwise 0. If EPS is equal to 0, $\alpha_2 EPS$ is 0.129; otherwise 0. If ONCF is equal to 0, $\alpha_3 ONCF$ is 0.212; otherwise 0. If GS is equal to 0, $\alpha_4 GS$ is 1.299; otherwise 0.

4.2.3 *The Results of Regression Analysis*

Given other factors are unchanged, the probability of high-tech enterprises (HTE=1) with low R&D intensity (RDI=0) will be 0.081 times of the original value compared with that with high R&D intensity (RDI=1). Namely the probability will decrease by 91.9%. The quantized data indicates that R&D intensity of high-tech enterprises is greatly different from that of general enterprises.

Given other factors are unchanged, the probability of low R&D intensity (RDI=0) will become 3.67 times (increase by 267%) of the original value compared with that of high R&D intensity (RDI=1) for the enterprises without government subsidy (GS=0). Its significant level is 0.163, which is relatively significant (fail to reach a=0.05 or 0.1). It shows that the government subsidy has a positive influence on enterprise R&D intensity. Thus, the sixth hypothesis is verified.

Given other factors are unchanged, the probability of low R&D intensity (RDI=0) will be 2 times of the original value (increase by 100%) compared with that of high R&D intensity (RDI=1) for the enterprises with high asset-liability (ALR=0) and the significance a of regression coefficient is more than 0.05, which indicates that the pressure of enterprise debts has a big influence on R&D intensity. The first hypothesis is thus verified.

Earnings per share and operating net cash flow have a positive but weak influence on enterprise R&D intensity, with an increase of 13% and 23% respectively. Therefore, the second hypothesis is verified.

5 CONCLUSION

The following suggestions are presented about how manufacturing industry mobilizes internal and external factors and improves R&D intensity. Firstly, it is necessary to keep low asset-liability, reduce the pressure of debt repayment and promote enterprises to invest more in R&D activities. Secondly, it is better to enhance profitability, make more profits and provide the sources of fund for enterprise R&D investment. Thirdly, it is suggested to improve market share, realize the withdrawal of funds and ensure the supply of cash flow for R&D investment. Fourthly, it is advised to try to win over government subsidy and obtain the identification of high and new technology. Among the government subsidies enterprises obtain, many are used for R&D so as to directly improve their R&D intensity. In addition, the enterprises passing the identification of high and new technology can obtain more governmental subsidies than general enterprises. Hence, passing the identification of high and new technology is an effective way to strengthen enterprise R&D investment. The two are complementary.

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