Research on the Impact of High-tech Enterprises' Investment in R&D Staff on their Financial Competitiveness

– Panel Data Analysis with Stata

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Abstract. Taking 2014-2019 A-share listed high-tech enterprises as the research objects, the paper carries out research on the impact of high-tech enterprises' investment in R&D staff on their financial competitiveness through Stata, the data analysis software. It first uses factor analysis to assign values to financial competitiveness and then examines the impact of investment in R&D staff on enterprises' financial competitiveness. It can be seen from the research results that the investment in R&D staff will bring a positive incentive effect in the long run despite its adverse impact on enterprises' financial competitiveness in the short term.

Keywords: enterprises' investment in innovation; the investment in R&D staff; financial competitiveness; factor analysis

1 Introduction

In 2006, China proposed to develop itself into an innovative country by 2020. Now, its investment in innovation has been greatly improved, in a trend of steady and continuous growth. According to the data released by the National Bureau of Statistics, China's total investment in R&D expenditure was 2,214.36 billion yuan in 2019, with an investment intensity (the ratio of R&D expenditure to GDP) of 2.23%, exceeding the basic condition of 2%, equipped with 4,800,800 R&D personnel, ranking first in the world, which indicates that China has possessed the characteristics of an innovative country. As human resources represent the first element of innovation, it is necessary to research the investment in R&D personnel when a new round of technological revolution and industrial transformation is rapidly advanced against a background of today's complicated international situation.

The concept of financial competitiveness is put forward as a result of the orderly integration of traditional financial management theories and modern competitiveness-

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related theories. Based on the input of such resources as knowledge, technology and talents, financial competitiveness, with knowledge and innovation serving as its basic core, reflects the core competitiveness of enterprises in the financial field. By raising their financial competitiveness, enterprises can achieve resource optimization and enterprise value maximization. As an important part of the socialist market economy in China, high-tech enterprises represent the core driving force for the advance of the innovation-driven development strategy. Compared with their counterparts in other industries, high-tech enterprises face more rapid technology updating, more drastic changes in the dynamic market environment and thus more fierce competition. Therefore, it is more representative and realistic to carry out research on the relationship between the investment in scientific research personnel and the financial competitiveness of high-tech enterprises.

2 Literature Review

Regarding the research on the impact of R&D investment on enterprises' development, no unified opinion has been formed yet. Generally, there are three main points of view on this topic. First, R&D investment facilitates enterprise development. B. Burcin Yurtoglu (2016) [1], Mahmut Erdogan & Adilya Yamaltdnova (2019) [2], Ola Lome, Alf Gunnar Heggeseth & Øystein Moen (2016) [3], Zhang X. D. & Song J. (2018) [4] and other scholars have respectively studied the relationship between R&D investment and corporate performance, financial performance, corporate earnings and stock value and all drawn the conclusion that there was a positive correlation between these research objects. Second, technological innovation brings a negative incentive effect on enterprise development. Zhang Z. C. (2018) [5] concluded that there was a negative correlation between enterprise value and innovation investment by studying enterprises listed as high-tech ones from 2013 to 2017. Third, there is no linear relationship between R&D investment and enterprise development. Minsung Kim (2020) [6] concluded that there was an inverted U-shaped relationship between R&D investment and economic growth after studying panel data of 14 countries in 17 years. And Liu X. Z. et al. (2017) [7] also proved that there was an inverted U-shaped relationship between corporate performance and R&D investment.

The topic of financial competitiveness is a relatively new research field in the modern financial management discipline system. Its research is still under exploration in the world, and its research topics are mainly focused on the evaluation system of financial competitiveness. The construction of financial competitiveness evaluation system can be roughly divided into single index evaluation and multi-dimensional evaluation. According to the latter evaluation model which is mainly based on the idea of weight in statistical analysis, the evaluation system is weighted to calculate the comprehensive score of the financial competitiveness of an enterprise. Because its results are more objective and comprehensive, this model is widely used.

After reviewing the existing related research at home and abroad, the following shortcomings are found: first, there is no unified opinion on the correlation between enterprises' investment in innovation and their development; second, a unified standard

on the evaluation system of financial competitiveness has not yet been formed in the academic circle, so the conclusions drawn through different weight assignment calculation methods are quite different. Third, there have been many academic research achievements on either R&D investment or financial competitiveness, yet few simultaneously cover the two. In view of the insufficiency of current research, the paper aims to study the impact of high-tech enterprises' investment in R&D staff on their financial competitiveness. The research will, to a certain extent, help clarify the relationship between the investment in R&D personnel and financial competitiveness, thereby providing a certain reference for managers to make correct decisions.

3 Theoretical Analysis and Research Hypothesis

The theory of endogenous growth which makes up for the deficiency of the Solow model explains the path of endogenous economic growth and deeply expounds on the impact of knowledge and technological innovation on economic growth: human capital which plays an extremely important role in economic growth is indispensable in the development of enterprises. It recognizes the role of human capital in enterprise development.

The impact of enterprises' investment in R&D staff on their financial competitiveness is mainly reflected in the following aspects: First, enterprises' investment in technological innovation is a prerequisite for improving their financial competitiveness. As talents serve as a key factor in innovation, only when sufficient investment is put in talents can an enterprise continuously acquire new technologies and products which enable it to quickly hold more market shares to obtain excess profits, thus forming its own financial competitiveness and facilitating it to be in a positive circle of development. Second, from a long-term perspective, the investment in R&D personnel will further improve an enterprise's core competitiveness while improving its performance, enabling it to perch in a favorable position in the industry. The purpose of the investment in technological innovation by an enterprise is to maximize its own value, which coincides with the function of financial competitiveness, that is, to optimize resources and maximize enterprise value. Finally, the results of technological innovation often become the unique competitive advantage of enterprises, assisting them to form a positive circle. Under the action of signal transmission, the improvement of enterprise competitiveness will send positive signals to investors, which will stimulate further investment. The increase in investment, in turn, will make the enterprise increase its investment in R&D again to form a new competitive advantage, enabling it to enter a positive circle of actively carrying out R&D and innovation and show better development capabilities, profitability, operational capabilities and solvency, thereby improving the financial competitiveness of the enterprise. Based on the above analysis, hypothesis **H1** is proposed: **high-tech enterprises' investment in R&D staff is positively correlated with their financial competitiveness.**

On the one hand, enterprises' investment in R&D staff serves as an effective weapon to consolidate and expand the market and enhance the enterprise value. On the other hand, the investment in R&D personnel is also accompanied by extremely high risks

due to its disadvantages of a long cycle, high input and immediate effect unavailability. Laura Putre (2016) [8], Carolin Bock & Mazimilian Schmidt (2015) [9] and others have confirmed through empirical research that technological innovation has a significant promoting effect on corporate performance and it is accompanied by a significant time lag. By constructing a binary logistic model, Ola Lome, Alf Gunnar Heggeseth & Øystein Moen (2016) [3] found that the impact of enterprises' investment in R&D on their earnings has a deferred effect, and its impact lagging for three phases is the most significant one. Dejan Ravselj & Aleksander Aristovnik (2020) [10] came to a similar conclusion that R&D expenditure is ineffective in the short term, but it will bring positive benefits to enterprises' competitiveness in the long run. Based on the characteristics of the investment in R&D personnel, a hypothesis **H2** is further proposed: **the impact of high-tech enterprises' investment in R&D staff on their financial competitiveness has a time lag effect.**

4 Research Design

4. 1 Sample Selection and Data Sources

The paper selects 2014-2019 A-share listed high-tech enterprises as the original samples and excludes financial ones, those in an abnormal state such as ST and *ST and those with missing data. Finally, a total of 7,566 valid company annual samples were obtained. At the same time, the main continuous variables are winsorized at the levels of 1% and 99%. The data needed in the paper are all taken from the CSMAR database, and the data analysis software Stata is used for data processing and analysis.

4.2 Model Setting and Variable Description

Referring to the existing literature and the above analysis, the paper construct Model 1 to examine the impact of the investment in R&D staff on financial competitiveness.

$$FC_{i,t}=\beta_0+\beta_1 RS_{i,t}+\beta_2 Lnsize_{i,t}+\beta_3 Top_{i,t}+\beta_4 Lev_{i,t}+\beta_5 Current_{i,t}+\varepsilon_{i,t} \quad \text{(Model 1)}$$

Table 1. Selection and Definition of Variables [self-drawing]

Variable nature	Variable names		Calculation formulas
Dependent variables	Financial Competitiveness (FC)	Cash Ratio (X1)	Monetary funds+Marketable securities/Current liabilities
		Current asset turnover ratio (X2)	Net income from main business/Total average current assets
		Net profit ratio of total assets (X3)	Net profit/Average total assets
		Tobin's q value (X4)	Enterprise market price (share price) / Enterprise replacement cost
		Operating income growth rate (X5)	(Current operating income - Last period operating income) /Last period operating income

Independent variables	R&D staff ratio (RS)	Number of R&D staff/Total number of staff
Control variables	Enterprise size (Lnsize)	Natural logarithm of total assets
	Stock share distribution (Top)	Number of shares held by the largest shareholder/Total number of shares
	Asset-liability ratio (Lev)	Total assets/Total liabilities
	Cash capability (Current)	Net cash flow from operating activities/Total assets

1) Evaluation of Financial Competitiveness (FC).

In the formula, the evaluation of financial competitiveness (FC) mainly refers to the research results of Xi S. [11], and the method of factor analysis is used to build a multi-dimensional evaluation system to assign values. According to the research content, the paper selects solvency, profitability, development capability and operating capability as the evaluation indicators of financial competitiveness. The larger the calculated value, the stronger the financial competitiveness of the enterprise, and vice versa. The specific idea is as follows: first, the common factors are proposed by year and the factor loadings are recorded; second, the weights of the common factors in each year are determined according to the annual factor loadings; finally, the annual comprehensive score of the financial competitiveness of each high-tech enterprise is calculated respectively. The 2014 financial competitiveness assignment process is shown below.

KMO (Kaiser-Meyer-Olkin) and the Bartlett test are performed on the data that have been subjected to standardization (z-score) to obtain the value of the KMO statistic, which is 0.563>0.5, indicating that the information between the variables is correlated. The obtained significance P is approximately 0.00<0.05, and it is reasonable to reject the null hypothesis and consider that there is a correlation between the variables, which meets the preconditions for factor analysis.

It can be seen from Table 2 of the total variance explanation that when the first four factors are extracted, the cumulative contribution rate can reach 84.850%, namely, the first four factors can explain 84.850% of the variables. The percentage of the variance of each factor after rotation is 27.961%, 20.700%, 19.864% and 16.325% respectively. Generally speaking, the cumulative contribution rate of the extracted factors should reach 85% or more. But here the weight of each extracted factor only needs to be determined on the basis of the factor load, and the cumulative contribution rate is close to 85%, so it is still appropriate to use factor analysis for objective assignment.

Table 2. Total Variance Explanation[1] [self-drawing]

Components	Initial eigenvalues			Extraction Sums of Squared Loadings		
	Total	Variance percentage	Cumulative %	Total	Variance percentage	Cumulative %
1	1.398	27.961	27.961	1.398	27.961	27.961
2	1.035	20.700	48.662	1.035	20.700	48.662
3	0.993	19.864	68.526	0.993	19.864	68.526
4	0.816	16.325	84.850	0.816	16.325	84.850
5	0.757	15.150	100.000	—	—	—

[1]The extraction method: principal component analysis

In order to make the explanation and calculation easy, the method of maximum variance is used for factor rotation to output clearer and easier results for analysis. It can be seen from Table 3 of the rotated component matrix that the common factor 1 has a considerable loading on the net profit ratio of total assets and Tobin's q value, which are 0.831 and 0.728 respectively, so it can be named as the profitability factor (F1). Similarly, the loadings of common factor 2, common factor 3 and common factor 4 on the cash ratio, the current asset turnover rate and the operating income growth rate are 0.978, 0.996 and 0.999 respectively, which are all much larger than the loadings on other variables, so they can be named as solvency factor (F2), operating capability factor (F3) and development capability factor (F4) respectively.

Table 3. The Rotated Composition Matrix[2] [self-drawing]

	Components			
	1	2	3	4
Cash ratio (X1)	0.092	0.978	-0.071	-0.012
Current asset turnover ratio (X2)	-0.038	-0.071	0.996	-0.019
Net profit ratio of total assets (X3)	0.831	-0.072	0.015	0.042
Tobin's Q value (X4)	0.728	0.206	-0.066	-0.002
Operating income growth rate (X5)	0.033	-0.012	-0.019	0.999

According to the rotated component matrix, the calculation expression of each factor value can be obtained as follows:

$$F1=X1\times0.092+X2\times(-0.038)+X3\times0.831+X4\times0.728+X5\times0.033 \quad (1)$$

$$F2=X1\times0.978+X2\times(-0.071)+X3\times(-0.072)+X4\times(0.206)+X5\times(-0.012) \quad (2)$$

$$F3=X1\times(-0.071)+X2\times0.996+X3\times0.015+X4\times(-0.066)+X5\times(-0.019) \quad (3)$$

$$F4=X1\times(-0.012)+X2\times(-0.019)+X3\times0.042+X4\times(-0.002)+X5\times0.999 \quad (4)$$

The scores and rankings of each sample on the corresponding factors can be obtained by substituting the original data into the above formulas. According to the percentage of the variances of the extracted common factors, the comprehensive score of each enterprise's financial competitiveness in 2014 can be finally obtained through the following formula.

$$FC2014=F1\times(27.961\%/84.850\%)+F2\times(20.700\%/84.850\%)+F3\times(19.864\%/84.850\%)+F4\times(16.325\%/84.850\%)$$
$$=(F1\times27.961\%+F2\times20.700\%+F3\times19.864\%+F4\times16.325\%)/84.850\% \quad (5)$$

Similarly, the expression of the comprehensive score of financial competitiveness from 2015 to 2019 is:

[2]The extraction method: principal component analysis; the rotation method; varimax with Kaiser normalization; a. The rotation has converged after 5 iterations.

FC2015=(F1×29.222%+F2×20.977%+F3×19.210%+F3×16.254%)/85.662% (6)

FC2016=(F1×26.812%+F2×21.811%+F3×19.590% +F4×16.266%)/84.479% (7)

FC2017=(F1×28.329%+F2×23.127%+F3×19.690%+F4×15.342%)/86.488% (8)

FC2018=(F1×28.66%+F2×20.699%+F3×18.587%+F4×17. 473%)/85.389% (9)

FC2019=(F1×26.316%+F2×22.722%+F3×20.032%+F4×15.870%)/84.941% (10)

Thus, the 2014-2019 financial competitiveness data of the 1,261 listed companies are obtained, that is, the explained variable FC.

2) Selection and Evaluation of other Variables.

The larger the investment in R&D staff (RS), namely, the ratio of the number of R&D staff to the number of staff in the enterprise, the more the investment in R&D staff.

The control variables include enterprise size (Lnsize), stock share distribution (Top), asset-liability ratio (Lev) and cash capability (Current). The specific evaluation method is shown in Table 1.

4. 3 Descriptive Statistics and Correlation Analysis

Table 4. Descriptive Statistics [self-drawing]

Variables	Sample Size	Average values	Min values	Max values	Standard deviation
FC	7,566	0.000	-4.132	12.22	0.510
RS	7,566	15.89	0	80.89	11.89
Top	7,566	32.30	3.390	89.09	13.87
Lev	7,566	0.409	0.00906	1.352	0.191
Lnsize	7,566	22.36	19.14	28.34	1.223
Current	7,566	0.0483	-0.474	0.874	0.0646

It can be seen from the descriptive statistical results in Table 4 that the highest financial competitiveness (FC) score is 12.22, the lowest is -4.132, and the average value is close to 0. It indicates the unbalanced development of high-tech enterprises in China, the large difference in strength between them and the low financial competitiveness of some companies. The maximum value of the R&D staff input (RS) is 80.89%, the minimum value is 0, and the average value is 15.89%, indicating the great differences in the high-tech enterprises' investment in R&D staff and the low level of R&D staff investment as a whole in China. The standard deviation of the investment in R&D staff (RS) is 11.89, which further indicates that there are great differences in the attention to and implementation of the investment in R&D staff in the industry.

5 Research Results and Analysis

Table 5. The Investment in R&D Staff and the Financial Competitiveness of Enterprises [self-drawing]

VARIABLES	FC	VARIABLES	FC
RS	-0.007*** (-5.57)	L.RS	0.003* (1.77)
Top	0.007*** (4.94)	Top	0.005*** (3.02)
Lev	-0.895*** (-11.81)	Lev	-1.167*** (-12.38)
Insize	0.120*** (6.63)	Insize	0.218*** (8.08)
Current	0.565*** (5.18)	Current	0.437*** (3.50)
Constant	-2.457*** (-6.05)	Constant	-4.652*** (-7.78)
Observations	6,305	Observations	5,044
R-squared	0.042	R-squared	0.050
f test	0	f test	0
r1_a	-0.198	r1_a	-0.268
F	44.26	F	39.90

Note: ***, **, * are significant at the level of 1%, 5%, and 10% respectively, and the values in brackets are those of t.

According to the output results of the regular effect model, the regression coefficient of the investment in R&D staff (RS) is -0.007, which is significant at the level of 1%, indicating that there is a negative correlation between the investment in R&D staff and enterprises' competitiveness, that is, the increase of the proportion of the investment in R&D staff will reduce the financial competitiveness of enterprises, which is inconsistent with the hypothesis H1. It is possibly due to the fact that it takes a long time to see the results of high-tech enterprises' talent training and introduction, so its direct contribution ability is negative. After lagging the variable RS by one phase, it is found that the regression coefficient becomes 0.003 and it is significant at the level of 10%, indicating that the one-phase lagged investment in R&D staff (L.RS) has a significant positive correlation with financial competitiveness (FC), which is consistent with the hypothesis H2. It indicates that in the long-term development, R&D staff can bring reliable transformed achievement to enterprises, which are the effective strength for enterprises to gather core competitiveness.

6 Conclusion

Taking 2014-2019 A-share listed high-tech enterprises as the research objects, the paper carries out research on the impact of high-tech enterprises' investment in R&D staff on their financial competitiveness through Stata, the data analysis software. According to the data analysis results, the increase in R&D staff can significantly enhance enterprises' financial competitiveness in the long run though it will weaken it in the short term. It indicates that the investment in R&D staff cannot quickly form effective financial competitiveness, as it weakens the turnover capability of enterprises in the short term. However, under the long-term influence, the innovation initiative of R&D staff begins to appear, which can directly and reliably provide enterprises with competitive advantages, improve their financial competitiveness and further significantly enhance their enterprise value.

In the face of innovation competition from other countries in the world, the Chinese government shall boost its support to provide room for talent development when carrying out macro-control in line with the market. And enterprises shall enhance their awareness of technological innovation to focus on cultivating innovative talents and fully boost the morale of R&D personnel. All in all, multiple measures shall be taken to provide an enabling internal and external market environment to enhance the confidence in and motivation of R&D investment, thereby realizing the sound development of enterprises' innovation.

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