An Empirical Study on the Impact of R&D on Enterprises Earnings Quality
-- Panel Data of Listed Companies in Computer Application Service Industry on Growth Enterprises Market (GEM)

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ABSTRACT
This paper builds a multiple linear regression model and Cobb-Douglas(C-D) production function model from the perspective of absolute value index and relative value index, and comprehensively discusses the relationship between R&D investment and enterprise profit quality by taking listed companies in computer application industry of GEM in China from 2018 to 2020 as the research example. Findings of Research:
(1) The number of R&D funds invested by listed companies in the computer application service industry has increased continuously in the past three years but its proportion has not increased;
(2) The investment intensity of R&D funds and personnel both can improve the earnings quality of enterprises.
(3) R&D funds investment and enterprises earnings quality have no significant lag effect but there is a significant lag effect between investment in personnel and corporate earnings quality.

Keywords: *computer application industry; investment in research and development (R&D); earnings quality*

1. INTRODUCTION

The State Council issued the *State Council's Opinions on Further Improving the Quality of Listed Companies* in 2020, which respectively reflected the requirements for listed companies in the new era from seven aspects, showing the central government's higher quality requirements for enterprise development.

During the "14th Five-Year Plan", enterprises in China have gradually approached the scientific and technological frontier in some fields in the world. Their external environment for innovation and development is also changing profoundly. Problems including insufficient innovative talents, lagging development of a protective system of intellectual property rights, deviation of orientation of innovation elements allocation, and obstruction of continuous in-depth embedding into the global innovation system will have adverse effects on enterprises in China to further climb the international innovative chain. According to the results of the 2020 National Bureau of Statistics, the internal R&D expense of enterprises in China in 2019 increased by 39.34% in terms of R&D funds investment; the proportion of internal R&D expense of enterprises above designated size in main business increased by 0.41% in 2019 compared to that in 2016. While the number of R&D personnel increased by 21.79% compared with 2016[1] .

The steady increase in R&D investment has played a good role but why is the increase out of proportion to the development of the enterprise? Why do enterprises still lack core competitiveness in the world? What is the relationship between the current R&D investment and the earnings quality of enterprises in China?

The existing literature cannot get a consistent conclusion, therefore this paper conducts an empirical study on the performance generated by R&D investment elements (profitability in specific in this paper) taking the listed companies of the computer application service industry in GEM of Shenzhen Stock Exchange as the research object, summarizes the development trend of R&D investment in sample companies from 2018 to 2020, and tests the correlation between the two.

2. LITERATURE REVIEW AND THEORETICAL HYPOTHESIS

2.1 Literature review

There are a lot of scholars who have studied the relationship between R&D investment and enterprise earnings quality after reading much existing literature. However, their conclusions are not uniform after studying. This paper will divide the previous research views into the following four categories after sorting out.

First opinion is that there is a linear positive correlation between R&D investment and business performance, and most studies show that there is a lag effect between the two. Griliches(1981)took 1000 manufacturing enterprises in the US as samples to study the relationship between innovation investment and enterprise performance and found that the R&D expenditure had a significant positive correlation with enterprise performance through the C-D production function model. The study of David Aboody and Barueh Lev (2006) found that American chemical industry companies had a more remarkable improvement in the quality of their earnings after increasing R&D expenditure[2-3]. Wang Wei(2019) explored the relevant data information of 468 listed companies on GEM in 2017 and found that R&D investment had a significant positive impact on the operating revenue and growth rate of gem enterprises in the current period[4].

The second opinion is that the R&D investment is positively correlated with enterprise performance but there is no lag effect. Zhang Jijian and Li Xiangchun (2009) selected 71 listed companies in China's high-tech industry and took their annual report data from 2003 to 2007 as samples to draw a conclusion through empirical analysis: although the R&D investment had a positive correlation with current enterprises' performance, there was no lag effect[5]. The research of Ren Haiyun and Shi Ping (2010) also reached the same conclusion[6].

The third opinion is contrary to the above two opinions. They believe that there is no linear relationship between R&D investment and enterprise performance, even some scholars think that there is a negative correlation between the two[7-9]. Ohlsson as a representative of the theories put forward the paradox of funding growth for research and experimental development in1987. Jian Zhang and Linghong Zhang (2014) studied the growth ability and profitability of enterprises and found that the R&D investment and profitability of enterprises showed a significant negative correlation that would even affect their benefits in the next two years, taking the panel data of listed companies in China for three consecutive years as the research sample[10]. Wang Ruiqi came to the same conclusion when she studied corporate value[11].

The fourth opinion proposes that the relationship between R&D investment and enterprise performance is not only a simple linear correlation but also an inverted U-shaped as the R&D investment increases[12]. Namely, there is a critical value for increasing R&D investment, once the investment exceeds a certain value, the performance will not increase anymore[13]. Ming Liang (2010) took data from different time and different markets respectively to find an optimal R&D investment level through empirical research[14]. When the investment exceeds the critical value, the increase in cost will lead to a decrease in enterprise performance[15].

The recent research results mainly focus on the first two opinions by referring to the previous literature. The current researches have some defects besides inconsistent conclusions, such as single absolute value analysis or relative value analysis is used in empirical research, and the reliability of the research conclusions is not repeatedly tested by combining the two numerical values. This paper innovatively adopts the relative value and absolute value of R&D investment of listed companies in the computer application service industry to carry out the repeated empirical test on the impact of current and lagging earnings quality.

2.2 The Theoretical Hypothesis

Compared with the traditional industry, the computer application industry focuses more on innovation and development. The investment will be increased to have a higher profit and better earnings quality. This paper analyzes the listed companies in the computer application industry on the GEM and proposes hypothesis a s follows to verify whether the investment will help improve the earnings quality based on the existing research.

H1a: the R&D funds' investment and the current earnings quality of the computer application industry have a positive correlation.

H1b: the R&D personnel investment in the computer application industry has a positive correlation with the current earnings quality of the enterprise.

The conditions required for research and development also add to the uncertainty of the outcome. There is a disagreement on whether there is a significant lag between R&D investment and profitability in time due to the differences between R&D technology teams, and the time and value of R&D investment into new technology and new products. This paper put forward the following hypothesis by reading and sorting out existing research in combination with the characteristics of the computer application industry:

H2a: the R&D funds' investment and earnings quality of the computer application industry on GEM have significant time lag;

H2b: the R&D personnel investment and earnings quality of the computer application industry on GEM have a significant time lag.

3. RESEARCH DESIGN

3.1 Variable selection and definition

This paper focuses on the relationships between R&D investment and earnings quality of listed companies in the computer application industry. The absolute value index of main business profit (P) and the relative value index of main business profit rate (MBRP) are selected to reflect the earnings quality of the company because the above indexes exclude the influence of other factors and can directly reflect the actual profitability. The index of R&D investment is mainly divided into two parts: K as the R&D capital investment, i.e. the R&D expenditure; L as the number of R&D personnel, here referring to the average of the number of R&D personnel at the beginning of the year and the number at the end of the year. This paper adopts two relative value indexes, RDI (variable R&D capital investment intensity) and TPI (R&D personnel investment intensity) to explain how much the R&D investment is from different angles, as the scale of the listed companies in the computer application industry of GEM is quite different, and the absolute value index may vary greatly and unconvincing for the enterprises of different sizes. In addition, SIZE (company scale), and LEV(financial lever effect) (asset-liability ratio) are selected as the control variables in this paper referring to the existing literature. The definitions and descriptions of the study variables are shown in Table 1 on the next page.

3.2 Sample Selection and Source Of Data

The samples are listed companies in the computer application service industry in GEM in China in this research. As of March 27, 2022, 162 of the 1147 listed companies in GEM are computer application service industry. The study period was from January 1, 2018, to December 31, 2020. To ensure the validity of the data, the above 162 companies were filtered as follows: (1) Companies listed after 2018 were eliminated to ensure complete and real data in three consecutive years; (2)ST companies were eliminated to ensure the negative impact of regression results from the special value; (3) eliminating all the companies that cannot provide required data for the empirical research. From the filter above, 96 companies in computer application services listed on GEM were selected making total 288 samples for research. The research index data are from CCER economic and financial database and the Guotaian database (Csmar).

3.3 The Model Building

Table 1 definition and description of research variables of enterprise R&D investment and profitability

Variable type	Variable name	Variable code	Variable value taking method or description
Dependent variable	Profit rate of main business	MBRP	Profit from main business/income from main business
	Profit of main business	P	Main business income - main business cost - main business tax and surcharge
Independent variable	Investment intensity of R&D capital	RDI	R&D expenditure/operating income
	R&D expenditure	K	Total R&D expenditure in statistical year
	Investment intensity of R&D personnel	TPI	Total R&D personnel/total employees
	Number of R&D personnel	L	Average number of technical personnel in the statistical year
Control variable	Enterprise scale	SIZE	The total number of assets is taken as the natural logarithm
	lever level	LEV	Total liabilities / total assets

This paper constructs the following models from the perspective of relative value and absolute value respectively according to the above:

$$MBRP=\beta_0+\beta_1 RDI_{it}+\beta_2 TPI_{it}+\beta_3 SIZE_{it}+\beta_4 LEV_{it}+\varepsilon_i \quad (1)$$

P=

$K_{it}^{a}L_{it}^{b}S_{it}^{c}$ (2)

The model (2) is linearized for the convenience of research to obtain:

$$\ln P = \ln A + a\ln K_{it} + b\ln L_{it} + c\ln S_{it} + \varepsilon_i \quad (3)$$

The t value of the above model is limited to study the lag of the impact of R&D investment on profitability of hypothesis 2 enterprises, and the following model is obtained:

$$MBRP = \alpha + \beta_1 RDI_{it-1} + \beta_2 TPI_{it-1} + \beta_3 SIZE_{it-1} + \beta_4 LEV_{it-1} + \varepsilon_i \quad (4)$$

$$P = K_{it-1}^{a}L_{it-1}^{b}S_{it}^{c} \quad (5)$$

Likewise, the model (5) is linearized:

$$\ln P = \ln A + a\ln K_{it-1} + b\ln L_{it-1} + c\ln S_{it-1} + \varepsilon_i$$

Where β_0 is the variable coefficient, ε_i is the error term, a, b, and c are the variable indices. What should be noted is that the t in the model represents the t-th fiscal year, in specific, 2019, 2020, and 2021. Where in the model used to study hypothesis 2, the value of t from t-1 is only 2020 and 2021; i represents i-th sample company.

Table 2 Descriptive statistics of variable

Variable simplified name	Year	Minimum value	Maximum value	Mean value	Standard error	N
MBRP	2018	0.002297	0.459371	0.147246	0.107486	96
	2019	0.008215	0.590034	0.155488	0.116637	96
	2020	0.006312	0.516689	0.169254	0.121564	96
P	2018	45820642	3259803988.71	527191492.5	511950007.7	96
	2019	18340983	3756531161.52	502667079.6	518743110.9	96
	2020	24652315	4254623254.14	536515485.8	579545264.7	96
K	2018	1386279.8	259794336.21	44722064.18	64453411.4	96
	2019	2654578.9	261412458.31	56587456.21	84756524.6	96
	2020	3364528.4	325421223.22	79523212.14	104566542.3	96
RDI	2018	0.012	0.367	0.09	0.072	96
	2019	0.015	0.371	0.10	0.069	96
	2020	0.014	0.382	0.121	0.070	96
L	2018	47	7918	713.7589	978.9247	96
	2019	20	7929	723.2807	1008.886	96
	2020	33	7109	762.7265	1101.886	96
TDI	2018	0.0767	0.9367	0.3948746	0.1953761	96
	2019	0.0882	0.9215	0.4425456	0.1984785	96
	2020	0.0763	0.8946	0.4625894	0.2125458	96
SIZE	2018	19.695	22.354	20.365	0.687	96
	2019	19.742	23.245	21.124	0.768	96
	2020	19.761	24.132	21.698	0.876	96
LEV	2018	0.018	0.680	0.276	0.151	96
	2019	0.024	0.689	0.288	0.146	96
	2020	0.246	0.704	0.304	0.158	96

4. EMPIRICAL RESEARCH

4.1 Descriptive Statistical Analysis

We firstly make annual descriptive statistics on the sample data, details as in Table 2.

In terms of the profit rate of main business of relative

value index, the maximum value is tens of times the minimum value in three years, whereas the maximum value (0.516689) of profit value of main business in 2020 is 81 times the minimum value (0.006312), indicating the significant difference in income among sample companies; the average is increased from 0.147246 to 0.169254 in 2018, the larger growth indicates the overall profitability increases among the sample companies. RDI, at the same time, the average value for 2018, 2019, and 2020 was 0.09, 0.10, and 0.121. The overall trend did not change significantly but the corresponding absolute value index K increased from 44,722,064.18 Yuan in 2018 to 79,523,212.14 Yuan in 2020, about double the increase in 2018, which indicated that compared to the income increase, the RDI was not sufficient in intension. TDI is increasing faster and faster.The mean value of the number of R&D personnel L increased year by year in the past three years, indicating that the sample companies saw the excess profit value brought by R&D personnel. The statistical results of SIZE in Table 2 showed that the change was not particularly obvious because the enterprise-scale index used the logarithm of the total assets. From the absolute value of the total assets, the average value of the total assets increased rapidly from 2018 to 2020, indicating the rapid growth of the enterprise scale. In terms of standard deviation, each index had a relatively large standard deviation which showed that different companies in the same industry attached different importance to R&D investment. And the gap between the profitability and the scale index was also relatively large which indicated that the sample selected in the research was representative.

4.2 Pearson Correlation Analysis

In order to preliminarily judge the correlation between R&D investment and profitability, this paper has carried out correlation test on each independent variable, control variable and dependent variable. The test results are shown in Table 3.

Table 3 Correlation analysis among variables

Variable	MRBP	RDI	TPI	LnP	LnK	LnL	SIZE	LVE
MRBP	1							
RDI	0.154*	1						
TPI	0.148*	0.999**	1					
LnP	0.592**	-0.018	0.005	1				
LnK	0.147	0.009	0.007	0.251**	1			
LnL	0.216**	-0.089	-0.074	0.499**	0.364**	1		
SIZE	0.291**	-0.078	-0.060	0.668**	0.243**	0.556**	1	
LVE	-0.276**	-0.134	-0.119	0.082	-0.015	0.178	0.425**	1
N	288	288	288	288	288	288	288	288

Note: * represents the significance at the 0.05 (in both sides); ** represents the significance at the 0.01(in both sides). The same applied below

As seen in Table 3, the relative value of RDI, TPI, and MRBP are all significantly related at the level of 0.05, showing that profitability is greatly influenced by the RDI and TDI. RDI and TPI are significantly correlated at the 1% level, indicating that there is autocorrelation between the independent variables. We will focus on it in the following studies. SIZE and LEV asset-liability ratio are significantly correlated with MRBP at the level of 0.01, indicating the reasonable choice of control variables. In terms of absolute value index, the natural logarithm of R&D capital investment and the number of R&D personnel as well as the enterprise scale are significantly related to the natural logarithm of main business profit

4.3 Analysis of Regression Results

4.3.1 The regression analysis of the impact of R&D investment on the current profitability of enterprises.

We performed regression analysis on the relative value Index data of 288 samples using the model (1). The results are seen in Table 4. From Table 4, it can be seen that the regression results pass the T-test and F-test but the Tolerance of RDI and TDI is 0.02, less than 1, and Variance Inflation Factors are all larger than 500, indicating that the independent variables are collinearity.

Table 4- The regression result of the relative value index of R&D investment and profit rate of main business in 2018

Model1	Coefficient of non - normalization		Standard coefficient	T	Sig.	Collinearity statistic	
	B	Standard error	Trial version			Tolerance	VIF

(Constant)	-1.017	0.192		-5.326	0.000		
RDI	-0.204	0.085	-3.468	-2.560	0.010	0.002	502.395
TPI	0.100	0.039	3.585	2.617	0.009	0.002	501.804
SIZE	0.059	0.009	0.447	6.423	0.000	0.770	1.295
LEV	-0.322	0.049	-0.426	-6.230	0.000	0.818	1.224
R^2	0.314		F value	22.264	0.000		
After adjustmentR^2	0.297		N	288			

The economic significance of the index estimate of -0.024 is not reasonable, and the prediction function of the model fails. The reason behind the results is that the economic variables RDI and TDI have a relatively common trend after analysis, and above regression uses panel data of 96 sample companies for three consecutive years from 2018 to 2020, which leads to the failure of model test due to the limitation of sample data. This paper selected the data of 96 sample companies only in 2020 for re-regression to improve the above approximate collinearity between independent variables. Other sample data in models have no collinearity problem, hence, all samples in other models are regressed. The analysis results are shown in Table 5.

Table 5 The regression of the impact of R&D investment on the current profitability of enterprises.

Model (1)			Model (2)		
Variable	Regression coefficient	T value	Variable	Regression coefficient	T value
(Constant)	1.286**	3.488	(Constant)	-2.248**	-1.186
RDI	0.209**	4.914	LnK	0.392*	1.608
TPI	0.046**	3.768	LnL	0.214**	2.468
SIZE	0.071**	4.043	SIZE	0.874**	8.864
LEV	-0.240**	-2.488			
R^2	0.338		R^2	0.480	
After adjustmentR^2	0.281		After adjustmentR^2	0.472	
N	96		N	288	

The multicollinearity problem in the previous regression was solved well by grouping the sample data. As seen from the above regression, the regression coefficients of R&D capital investment and personnel investment in model (1) and model (2) are all positive and pass the significance test no matter in terms of relative value index or absolute value index, that is, no matter the R&D investment in capital or personnel, it is conducive to the significant improvement of the current profitability of listed companies in computer application service industry. Hence, H1a and H1b are supported and are consistent with the theoretical hypothesis in this paper.

4.3.2 The regression analysis of lag effect in time of R&D investment on the profitability of enterprises.

To study the lag effect in time of R&D investment on the profitability of listed companies in the computer application service industry, the data in 2018 and 2018 are used as explanatory variables. And the data in 2019 and 2020 are used as corresponding dependent variables and control variables. A total of 288 independent sample data are substituted into model (3) and model (4) to carry out corresponding regression analysis. The results are shown in Table 6 on the following page. The coefficients of RDI and TPI are non-negtive, inline with the economic significance. From the relative value index point of view, the T value of the independent variable RDI in the model (3) is 1.424, which failed to pass the significance test, indicating that the lag effect of RDI on the improvement of enterprise profitability is not obvious, and H2a is not valid; the coefficient of independent variables of TPI passes the significant test at the level of 0.05, which shows that the TPI has more significant impact to the profitability in terms of lag effect and therefore H2b is proved. In terms of absolute value index, the regression of model (4) is very similar to that of model (3), and the goodness of fit is higher in the C-D production function model established by using the absolute value index. To sum up, it is safe to say that H2a is not valid while H2b has been proved.

Table 6 The regression of the impact of R&D investment on the current profitability of enterprises

Model (3)			Model (4)		
Variable	Regression coefficient	T value	Variable	Regression coefficient	T value
(Constant)	1.368**	4.768	(Constant)	-0.781**	-0.316
RDI	0.226	1.424	LnK	0.051	0.341
TPI	0.110**	1.724	LnL	0.214*	1.706
SIZE	0.071**	5.227	SIZE	0.874**	9.090
LEV	-0.214**	-2.803			
R^2	0.3339		R^2	0.589	
After adjustmentR^2	0.218		After adjustmentR^2	0.577	
N	288		N	288	

The results are explained from the economic point of view that the computer application service industry is a new industry that adopts advanced theory and communication technology based on certain scientific and technological development. It is part of the high-tech service-oriented industry whose high efficiency makes the R&D capital investment intensity index does not show the lag effect on the profitability. The enterprises must constantly inject innovative blood and introduce a large number of R&D personnel while increasing the investment intensity of R&D capital. While the new personnel in high-tech enterprises often need special training before bringing value to the enterprises, which requires the enterprises to pay a large amount of cost in labor and time in the early stage, also making the investment intensity index of R&D personnel have a significant impact on the profitability in time lag.

4.4 Robustness Test

Although this paper has demonstrated the impact of R&D investment on the profitability of listed companies in GEM in the computer application service industry from the perspective of absolute value and relative value respectively by using two models considering the inconsistency of the existing research conclusions, it uses the multivariable regression model and C-D production function model to regress by replacing the MBRP with ROA (return on total-assets), P with BI (Business income) as the proxy variable of the relative value index and absolute value index of profitability and maintain other variables. The test results have no significant difference from the above empirical results, indicating the robustness of the model. The test is not repeated due to the limitation of space.

5. CONCLUSIONS

This paper takes the listed companies in the computer application industry in China from 2018 to 2020 as the research sample, supplements the lack of industry division in the existing literature, and enriches such research. The research finds that the growth level of R&D investment of listed companies in the computer application service industry is higher than the national average but the gap between those companies is large in terms of enterprise size, R&D investment, and profitability. The overall R&D investment intensity is low and the upward trend is not obvious, which indicates that enterprises still need to improve their attention to R&D investment. In addition, the empirical results show that the R&D investment of the listed companies in the computer application service industry on GEM is conducive to the improvement of operating profit. There is a lag in time in the process that the R&D investment is converted into new technology, and new technology brings higher profit to the company but this lag in the information technology industry is different from other ordinary manufacturing.

As the empirical results, the R&D capital investment has no significant impact on the lag effect of corporate profitability, while the R&D personnel investment has a significant impact on the lag effect of the enterprise performance.

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