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Research on the Impact of R&D Investment on Firm Performance and Enterprise Value Based on Multiple Linear Regression Model and Data Mining

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Abstract

This paper uses 79 listed companies of energy saving and environmental protection board in the Shenzhen and Shanghai Stock Exchange as the research object, and collects the disclosed data in the annual reports from 2011 to 2013. We analyze how R&D investment has contributed to the growth of energy saving and environmental protection industry by examining the effect of R&D investment on firm performance and enterprise value. We find, first, R&D investment has no significant correlation with the current firm performance and R&D investment can improve the current enterprise value. Second, R&D personnel intensity has a positive impact on operating profit margin in one-year and two-year lagged period, and the impact of two-year lagged period is the most significant. Third, R&D investment has a significant short-term lag effect on enterprise value, and the impact of one-year lagged period is the most significant. Fourth, R&D investment has a positive cumulative effect on firm performance, but no effect on enterprise value.

Keywords: *Energy saving and environmental protection, R&D investment, firm performance, enterprise value*

1. Introduction

On September 8, 2010, China's State Council issued a decision on accelerating the cultivation and development of strategic emerging industries, first specifying that energy saving and environmental protection industry is included in the seven emerging industries of strategic importance (*e.g.*, energy saving and environmental protection, new information technology, biotechnology, high-end equipment manufacturing, new energy, new materials and new energy vehicles).

Energy saving and environmental protection industry needs to combine recycling and low carbon. Accelerating the development of energy saving and environmental protection industry is the essence of industrial structure adjustment and economic growth transformation. In spite of this, some problems began to exist in the technological innovation process of energy saving and environmental protection industry, including insufficient R&D investment, the lack of independent innovation consciousness and the weak correlation between technology and economy. These problems have seriously hindered the technological innovation of energy saving and environmental protection enterprises. This paper analyzed 79 listed companies of the energy saving and environmental protection board in the Shenzhen and Shanghai and Stock Exchange,

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aiming to enable the enterprises to take effective R&D strategies to enhance their core competitiveness.

The remainder of this paper is organized as follows. The next section reviews the relevant literature on the impacts of R&D investment on firm performance and enterprise value and develops a set of hypotheses. Section 3 describes the sample and the measurement of key variables. Section 4 reports the empirical findings. The final section presents a conclusion of the results and discusses the contribution of this study.

2. Literature Review and Hypothesis Development

2.1. R&D investment and firm performance

R&D investment can stimulate enterprises to develop new products and new technology. When new technology is applied to industrial process, it may increase sales revenue and profit, expand market share and enhance the core competitiveness of company's products. Early studies made by foreign scholars have documented the correlation between R&D investment and firm performance, so relevant theories and research results are relatively comprehensive. With regard to R&D investment and firm performance, based on the panel data of U.S. companies over the period of 1975- 1985, Sougiannis (1994) examined whether R&D investment could benefit the company. The results showed that a one dollar in R&D expenditure results in a two dollar increase in corporate profits [1]. In terms of the lag effect of R&D investment, Mobrbey and Graham (1989), using the same data, found a positive link between R&D expenditure and sales revenue in the future [2]. Collecting the data of nearly 100,000 U.S. companies, Chambers, *et al.*, (2002) argued that R&D investment has the lag effect on firm performance and the lagged period can last more than 10 years [3].

However, Chinese scholars still hold diversified views on the correlation between R&D investment and firm performance. The majority of Chinese scholars believe that there is a significantly positive correlation, while some suggest that there is no significant correlation. By analyzing 99 manufacturing and IT listed companies during 2005-2008, Lu and Wang (2011) concluded that R&D investment has a negative impact on the current firm performance and the impact of the one-year and two-year lagged period is significant [4]. On the contrary, other study by Chai (2012) found a positive link between R&D investment and firm performance within the pharmaceutical and biological sector and the impact of two-year and three-year lagged period is significant [5]. An empirical study surveyed by Liao (2013) showed that there is a positive relationship between R&D investment and firm performance of 312 manufacturing enterprises in Zhejiang Province [6]. Zhao and Xu (2013) suggested the impact of R&D investment on the current profit margin is negative, but the impact of R&D investment on profit margin in the lagged period is significantly positive [7].

We think the reason that Chinese scholars hold different opinions may be as follows. On the one hand, the samples may be variously selected. The samples that scholars selected are basically listed companies or some certain industries. The time span and research method may also lead to inconsistent results. On the other hand, the evaluation indicators may be different. The incomplete information disclosed by China's listed companies may restrict scholars to choose evaluation indicators. Thus, we come to the following hypothesis:

H1. R&D investment has a positive correlation with the current firm performance.

In the daily production and operation activities, R&D activities will take a long time to make economic benefits from management decisions to the application of

products and technology. It should be noted that new products also need to undergo mass experimental researches from the initial R&D investment to the final stage of commercialization (Wang, 2013) [8]. Therefore, R&D investment will not play an important role in the current period, that is, R&D investment has the lag effect to some extent. Thus, we come to the following hypothesis:

H2. Previous years' R&D investment has a time lag effect on firm performance, and a positive impact on profit margin in the one-year and two-year lagged period.

It is possible that continuous R&D investment is conducive to overcome many technical difficulties, that is to say, the continuous accumulation of R&D investment may have a great effect on firm performance. The cumulative effect is defined as the multiplication of production capacity caused by the increase in knowledge stocks. Wang and Guo (2008) used plant level data for China's IT and manufacturing industry and found that the coefficients of the one-year, two-year and three-year cumulative effect of R&D investment on operating performance are 0.100, 0.230, 0.148 respectively, indicating that continuous R&D investment has the significant cumulative effect and will improve corporate profitability [9]. Thus, we come to the following hypothesis:

H3. R&D investment has a positive cumulative effect on firm performance.

2.2. R&D investment and enterprise value

There is no mandatory requirement of disclosing firm R&D expenditure in the financial report according to the current Chinese accounting standards. However, according to the signaling theory, the R&D information disclosure gives the good news to outside investors, implying that listed enterprises will have new development opportunities to improve the enterprise value. Under the influence of this good news, outside investors tend to invest a lot of money in those listed enterprises. Connolly (2005) stated that R&D intensity has a consistently positive effect on the market value for a sample of U.S. companies [10]. Ehie and Olibe (2010), in the study of U.S. manufacturing and service industries during 1990-2007 found that R&D investment is positively related to business value [11]. Compared with capital market in developed countries, China's capital market mechanism is not yet mature. Although there are a lot of irrational speculative behaviors, most researchers agree that R&D investment can encourage the enterprises to engage in R&D activities and improve the market value (*e.g.*, Chen, Peng, & Lu, 2011; Chun & Tan, 2014; Xu & Tang, 2010) [12-14]. Chen and Lu (2011) pointed out that the relationship between R&D investment and Tobin's Q is significantly positive for non state owned listed enterprises while this relationship is not significant for state owned listed enterprises [15]. Thus, we come to the following hypothesis:

H4. R&D investment can improve the value of the enterprise. Specifically, R&D investment is positively related to enterprise value.

As the market competition is getting more and more intense, new product or technology is subject to be imitated by competitors in a short time. Therefore, R&D investment has a short-term effect on the value of the enterprise. Kang (2014) used data of China's private listed companies in SMEs and GEM board and he concluded that the lag effect of R&D expenditure on firm value can last at least 2 years [16]. Furthermore, Zhou and Zeng (2011) also pointed out that R&D intensity and R&D personnel intensity have a positive effect on operating profit; there is a significant lag effect and the lagged period of R&D intensity and R&D personnel intensity is one year and two years, respectively [17]. Due to the different samples selected,

Chinese scholars have not formed a unified conclusion on the lagged period of R&D investment. Thus, we come to the following hypothesis:

H5. R&D investment has a short time lag effect on firm's value.

The improvements on the technological innovation capability require mass funds investment rather than a separate R&D activity, which can constantly stimulate enterprises to improve the enterprise value in the fierce market competition. Guo (2007) explored the relationship between R&D expenditure and market value with a sample of manufacturing and IT listed companies. The results suggested a consistent and positive effect of R&D expenditure on the value of the firm [18]. Based on the enterprise lifecycle theory, Liang, *et al.*, (2010) analyzed the lag effect and the cumulative effect of R&D investment. He concluded that R&D investment of enterprises at the growing stage has a long-term cumulative effect on the current firm performance; R&D investment has a relatively short-term cumulative effect at mature stage; for enterprises at degenerating stage, the cumulative effect is not significant [19]. Thus, we come to the following hypothesis:

H6. There is a cumulative effect between R&D investment and enterprise value in energy saving and environmental protection industry.

3. Methodology

3.1. Sample selection and data collection

We select the listed companies of energy saving and environmental protection board in the Shanghai and Shenzhen Stock Exchange as the research sample. Listed companies should disclose information about R&D expenditure in the financial reports. Therefore, we can collect this information manually from annual reports from 2011 to 2013. Other financial data are from database, Wind and CSMAR database.

After dropping firms whose R&D information disclosure is incomplete, firms that do not conduct R&D activities, firms that are listed in the China's securities market after 2011, we get 79 listed companies from 2011 to 2013.

3.2. Variable definition

Firm performance. The motivation of listed companies is to earn a profit. Outside investors intend to analyze financial indicators to measure firm performance. Operating profit margin (OPM) is the accounting item that we choose as the dependent variable to measure the company's profitability.

Enterprise value. Tobin's Q is an effective indicator used in many studies such as Cockburn and Griliches (1988) [20], Wernerfelt and Montgomery (1988) [21], Hitt and Brynjolfsson (1994) [22], , and Tam (1998) [23] to measure firm value. Tobin's Q is defined as the ratio of market value of installed capital to replacement cost of capital. Unlike accounting indicators and stock market indicators, Tobin's Q is not subject to external factors and great risks of stock market. Therefore, this indicator is selected to measure the enterprise value.

R&D investment. Firms need sufficient funds and human resources to conduct R&D activities. The information of R&D expenditure and the number of R&D personnel can be obtained from the annual report. This paper selects R&D intensity and R&D personnel intensity as the independent variables.

Control variables. Firm size and liability ratio may also affect firm performance (Chen, Ran, & Tao, 2012; Wang, 2005) [24, 25]. This paper selects total assets and debt to assets ratio as the control variables.

Table (1) shows the definition and description of the selected variables.

Table 1. Variable definition

Variable type	Variable	Definition
Dependent variable	OPM	Net profit to sales revenue (%)
	TOBIN	Tobin's Q
	OUT	Main business income in the year of 2013
	VALUE	Corporate market value at the end of 2013
Independent variable	RD	R&D expenditure to business income (%)
	TECH	Total number of R&D personnel to total number of employees (%)
	CRD_1	R&D expenditure in 2013
	CRD_2	R&D expenditure in 2012 and 2013
	CRD_3	R&D expenditure in 2011 to 2013
Control variable	SIZE	Logarithm of total assets
	DAR	Total liabilities to total assets (%)
	LABOR	Average number of employees from 2011 to 2013
	CAP	Average total assets from 2011 to 2013

3.3. Equations

We use multiple linear regression model to study the relationship between R&D investment, firm performance and enterprise value. Cobb Douglas production function is employed to estimate the cumulative effect of R&D investment.

Eq. (1) aims to examine the correlation between R&D investment and enterprise's current operating performance.

$$OPM_t = \alpha_1 + \beta_1 RD_t + \beta_2 TECH_t + \beta_3 LnSIZE_t + \beta_4 DAR_t + \varepsilon_t$$

$$(t=2011, 2012, 2013) \quad (1)$$

Eq. (2) aims to examine the correlation between R&D investment and the current enterprise value.

$$TOBIN_t = \alpha_2 + \beta_1 RD_t + \beta_2 TECH_t + \beta_3 LnSIZE_t + \beta_4 DAR_t + \varepsilon_t$$

$$(t=2011, 2012, 2013) \quad (2)$$

Eq. (3) is used to test the lag effect of R&D investment and firm performance.

$$OPM_t = \alpha_3 + \beta_1 RD_{t-j} + \beta_2 TECH_{t-j} + \beta_3 LnSIZE_t + \beta_4 DAR_t + \varepsilon_t$$

$$(t=2012, 2013; j=1, 2) \quad (3)$$

Eq. (4) is used to test the lag effect of R&D investment and enterprise value.

$$TOBIN_t = \alpha_4 + \beta_1 RD_{t-j} + \beta_2 TECH_{t-j} + \beta_3 LnSIZE_t + \beta_4 DAR_t + \varepsilon_t$$

$$(t=2012, 2013; j=1, 2) \quad (4)$$

Eq. (5) is used to test the cumulative effect of R&D investment on firm performance.

$$LnOUT = A + \alpha LnCRDt + \beta LnLABOR + \gamma LnCAP + \varepsilon_t$$

$$(t=1, 2, 3) \quad (5)$$

Eq. (6) is used to test the cumulative effect of R&D investment on enterprise value.

$$LnVALUE = A + \alpha LnCRD_t + \beta LnLABOR + \gamma LnCAP + \varepsilon_t$$

$$(t=1, 2, 3) \quad (6)$$

where A, α, β, γ, respectively, represent presumed parameters; ε, the error item; t, the time period.

3.4. Variable measures

Table 2 and Table 3 report the descriptive statistics of the variables.

Table 2. Descriptive statistics of R&D intensity from 2011 to 2013

Year	Min	Max	Mean	S.D.
2011	0.001319	0.096875	0.032458	0.019090
2012	0.000949	0.319546	0.037501	0.038599
2013	0.000422	0.130903	0.033086	0.022313

Table 3. Descriptive statistics of OPM and Tobin's Q from 2011 to 2013

	OPM			Tobin's Q		
Year	Min	Max	Mean	Min	Max	Mean
2011	0.054479	0.696446	0.295947	0.217109	3.308683	1.497633
2012	0.063271	0.700417	0.284039	0.377190	3.845686	1.476577
2013	0.012417	0.613866	0.273680	0.691014	7.285677	1.826813

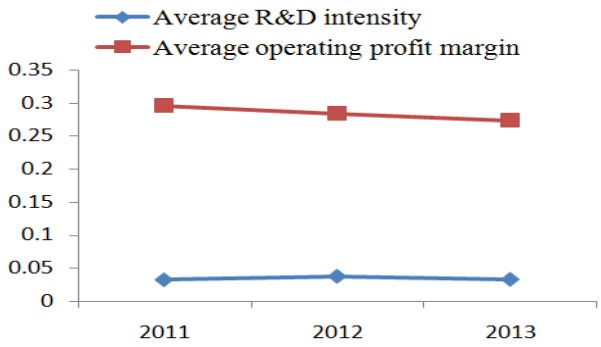

Figure 1. Average R&D intensity and average operating profit margin, 2011-2013

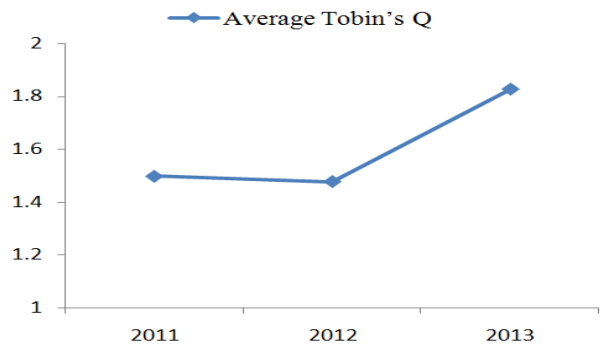

Figure 2. Average Tobin's Q, 2011-2013

It is generally believed that if R&D intensity is higher than 0.02, firms can survive in the fierce market competition. From the above charts and graph, we find that during the three years from 2011 to 2013 R&D intensity fluctuates around 0.03, indicating that innovation capability of the selected energy saving and environmental protection

enterprises is still at a low level. What's more, average amount of OPM and Tobin's Q has an inverse relationship with average amount of R&D intensity, implying that R&D investment fails to promote the increase in corporate profitability and enterprise value. One possible reason is that R&D investment is a long process from the preliminary stage to the very end of the R&D project. The minimum number of OPM is 0.063271 and the maximum number is 0.700417. The energy saving and environmental protection enterprises face quite different operation conditions. Profitability for sample firms is not high, since average OPM is declining during the three years. Tobin's Q increases from 1.49 to 1.82, which indicates that energy saving and environmental protection enterprises have the potential for growth.

4. Results

4.1. R&D investment and the current firm performance and enterprise value

The estimation of the above equations is carried out in SPSS 19.0. The results are shown in Table 4, Table 5 and Table 6. According to the regression results for Eq. (1) and Eq. (2) listed in Table 4, Eq. (1) has a better fitting effect than Eq. (2).

In Eq. (1), the coefficient of RD is not significant at the 5% level. This implies that R&D investment has no significant impact on the current firm performance. So H1 is not supported. The industry development of energy saving and environmental protection faces difficulties such as the fierce industry competition and industry barriers that lead to the decline in profitability. The coefficient of DAR is negative and significant, indicating the higher the liability ratio, the worse the current firm performance.

In Eq. (2), the coefficient of RD is positive and significant, consistent with most previous works. The positive impact of R&D on Tobin's Q implies that devoting more R&D effort enables a better enterprise value and R&D is an important factor influencing the enterprise value for China's energy saving and environmental protection industry. Therefore, H4 is supported. As for the coefficient of DAR, it is significant in the year of 2011 and 2013, while it is not significant in the year of 2012.

The coefficient of TECH is not significant in Eq. (1) and Eq. (2). Firm size tends to form scale effect on OPM. Firm size turns out to be less significant, and this may arise from the fact that the historical cost of accounting plays a role.

Table 4. Regression analysis of Eq. (1) and Eq. (2)

	OPM			Tobin's Q		
Variable	2011	2012	2013	2011	2012	2013
C	0.217	0.188	0.018	3.038**	1.674	3.573
	(0.623)	(0.557)	(0.052)	(2.384)	(1.233)	(1.580)
RD	0.185	0.199	0.063	5.732*	3.531**	2.175*
	(0.214)	(0.526)	(0.094)	(1.816)	(2.313)	(0.481)
TECH	0.191*	0.107	0.147	0.199	0.146	0.037
	(1.879)	(1.136)	(1.552)	(0.534)	(0.387)	(0.059)
LnSIZE	0.028*	0.026	0.014	0.091	0.018	0.062
	(1.721)	(1.611)	(0.876)	(1.511)	(0.272)	(0.581)
DAR	0.357***	0.311***	0.210**	0.743***	0.218	1.175*
	(4.746)	(4.038)	(2.359)	(2.696)	(0.702)	(1.967)
adjR^2	0.278	0.196	0.066	0.063	0.018	0.051
F	8.507***	5.760***	2.386*	2.306*	1.363*	2.041*
N	79	79	79	79	79	79

Note: ***, ** and * represent statistical significance at 1%, 5% and 10%, respectively. t values are in parentheses.

4.2. The lag effect of R&D investment

Table 5 reports the regression results for Eq. (3) and Eq. (4). In Eq. (3), with regard to the independent variable RD, it is not significant. The independent variable TECH is significant and the coefficient is 0.138, 0.200 and 0.141 respectively. The coefficient of TECH in the two-year lagged period is the largest. Specifically, 1% increase in R&D personnel intensity two years ago leads to 20.0% increase in operating margin. The rate of R&D achievement transformation is quite fast and competitors are easy to imitate new technology, energy saving and environmental protection enterprises should continue to increase the proportion of R&D personnel and develop new products to maintain the market share.

In Eq. (4), as for R&D investment, results show that it has a significantly positive relationship to Tobin's Q in the current and one-year lagged period. The coefficient of RD in one-year lagged period is 4.161. So for every unit increase in RD, a 4.161 unit increase in the value of the following year is predicted, supporting H5.

As for the control variables, liability ratio has a significantly negative effect on firm performance measured by operating profit margin. This means firms with less debt are valued higher in the market. Firm size and liability ratio have insignificant effect on firm's Tobin's Q.

Table 5. Regression analysis of Eq. (3) and Eq. (4)

	OPM			Tobin's Q		
	One year lag	Two years lag	The current period	One year lag	Two years lag	The current period
C	0.196 (0.842)	0.055 (0.163)	0.141 (0.740)	2.697** (2.014)	3.854* (1.702)	2.879*** (2.855)
RD	0.050 (0.148)	0.341 (0.406)	0.134 (0.446)	4.161** (2.129)	0.301 (0.053)	3.234** (2.038)
TECH	0.138** (2.070)	0.200** (2.014)	0.141*** (2.603)	0.044 (0.116)	0.080 (0.119)	0.084 (0.294)
LnSIZE	0.026** (2.370)	0.013 (0.803)	0.023** (2.575)	0.050 (0.788)	0.072 (0.668)	0.066 (1.365)
DAR	0.314*** (5.861)	0.219** (2.442)	0.304*** (6.777)	0.236 (0.712)	1.201 (1.979)	0.113 (0.476)
adjR^2	0.222	0.085	0.211	0.028	0.048	0.011
F	12.192***	2.807**	16.738***	2.130*	1.979	1.685*
N	158	79	237	158	79	237

Note: ***, ** and * represent statistical significance at 1%, 5% and 10%, respectively. t values are in parentheses

4.3. The cumulative effect of R&D investment

In terms of the cumulative effect of R&D investment, the results are presented in Table 6. For the results of Eq. (5) and Eq. (6) displayed in Table 6, the Adjusted R2 values are both over 0.8, implying the regression model is reliable as a whole. In Eq. (5), the coefficient of CRD is 0.261, 0.256 and 0.262, respectively. It is shown that the accumulated R&D investment in energy saving and environmental protection industry is positively related with firm performance and significant at the 1% level, consistent with previous. So H3 is supported. In addition, labor input has the positive cumulative effect on firm performance, and two-year cumulative effect is greater than one-year and three-year cumulative effect, consistent with the finding of Doms, *et al.*, (1995).

In Eq. (6), the coefficient of CRD is not significant at the 5% level, which indicates that the accumulated R&D investment has no significant impact on enterprise value. So H6 is not supported. We find that the coefficient of LABOR is 0.105, 0.100 and 0.095, respectively, indicating that labor input has a negative cumulative effect on enterprise value. The reason is that due to mass R&D personnel input, companies are forced to pay

excessive labor costs and training costs and the decrease in cash reduces the market value. The coefficient of CAP is significant at the level of 1%, which indicates that capital investment of energy saving and environmental protection industry has a positive cumulative effect on the value of the company.

One thing worth noting is that capital investment, which is measured by the amount of average total assets, has a positive effect on firm performance and value. It suggests that small and medium sized enterprises (SMEs) are reluctant to increase their operating performance. The positive effect of CAP on firm performance seems to decline over time.

Table 6. Regression analysis of Eq. (5) and Eq. (6)

	OPM			Tobin's Q		
	One-year accumulation	Two-year accumulation	Three-year accumulation	One-year accumulation	Two-year accumulation	Three-year accumulation
C	1.253 (1.011)	1.077 (0.846)	1.103 (0.865)	1.005 (0.886)	1.067 (0.939)	1.163 (1.018)
LnCRD	0.261*** (6.158)	0.256*** (5.632)	0.262*** (5.623)	0.056 (1.452)	0.052 (1.278)	0.038 (0.919)
LnLABOR	0.170*** (2.751)	0.184*** (2.913)	0.182*** (2.891)	0.105* (1.856)	0.100* (1.785)	0.095* (1.683)
LnCAP	0.763*** (11.138)	0.747*** (10.478)	0.739*** (10.307)	0.973*** (15.523)	0.971*** (15.264)	0.976*** (15.174)
adjR^2	0.874	0.866	0.866	0.849	0.848	0.846
F	181.038***	169.729***	169.543***	147.159***	146.095***	144.335***
N	79	79	79	79	79	79

Note: ***, ** and * represent statistical significance at 1%, 5% and 10%, respectively. t values are in parentheses

4.4. Robustness check

We conduct two different sets of robustness tests. First, we use ROE (Rate of Return on Common Stockholders' Equity) instead of OPM (operating profit margin) as an indicator to measure firm performance. Second, we use ROA (Return on Assets) instead of Tobin's Q value to measure enterprise value, respectively. The results are similar to our previous results.

5. Conclusion and Implications

5.1 Conclusions

This paper examines the impact of R&D investment on firm performance and enterprise value of energy saving and environmental protection enterprises. The main conclusions are as follows:

Firstly, R&D investment has no significant impact on the current firm performance, but it can improve the value of the enterprise. R&D personnel intensity and firm size has no significant impact on firm performance and enterprise value, but corporate capital structure has a negative correlation with firm performance.

Secondly, the impact of R&D investment on operating profit margin is not significant in the current period and one-year and two-year lagged period. On the contrary, there is a positive relation between R&D personnel intensity and operating profit margin during the above period and the impact of two-year lagged period is the most significant. Besides, R&D investment has a significant short-term lag effect on enterprise value and the impact of the one-year lagged period is the most significant.

Thirdly, R&D investment has a positive cumulative effect on firm performance, and has no cumulative effect on enterprise value. Additionally, there is a positive cumulative effect between labor input and firm performance and a negative cumulative effect

between labor input and enterprise value. The cumulative effect of capital investment on firm performance and enterprise value is significantly positive.

Due to the shortcomings of disclosure system in China and the motivation of earnings management, it is difficult to collect more accurate data of R&D investment, so the number of the observed samples is not sufficient. In addition, there are many factors that affect firm performance and corporate market value, including internal and external and factors, so further researches need to be conducted to analyze more factors.

5.2 Implications

From the results of this study, we can derive the following important managerial implications for managerial practitioners. First, on the one hand, energy saving and environmental protection enterprises should enhance the independent innovation capacity, constantly encourage technological innovation and improve corporate core competitiveness. On the other hand, enterprises should increase R&D investment and shorten the life cycle of research and development. Firms with the systematic technical personnel hierarchy can speed up the transformation of scientific and technological achievements. Therefore, top managers should establish a comprehensive technological innovation mechanism and set up research and development centers that provide a platform for technological innovation.

Second, energy saving and environmental protection enterprises should increase the proportion of R&D personnel. Our findings show that R&D personnel intensity can improve corporate profits in the future. Human resource is one of the most important capitals in the technology intensive industries. Firms with few human capital investments cannot tend to conduct R&D activities. Therefore, enterprises should attach great importance to the cultivation of human capital and strengthen the system construction of R&D personnel. In order to improve the comprehensive quality of science and technology talents, the continuous training and education should be greatly focused.

In addition, energy saving and environmental protection enterprises should ensure continuity of R&D investment. The empirical results show that R&D investment has the cumulative effect on firm performance. If the enterprise cannot sustain the continuous R&D investment, it will affect R&D activities and reduce the technology innovation capability, which will lead to the loss of the cumulative effect of R&D investment. Therefore, enterprises should maintain continuous and sufficient R&D investment to ensure that the cumulative effect of R&D investment is effective.

Finally, local government should formulate relevant policies of tax incentives and financial supports and encourage energy saving and environmental protection enterprises to increase R&D investment in order to obtain the core competitive advantage. For the country, intellectual property protection system should be established and external financing environment should be improved.

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