Original Paper

Equity Incentive, R&D Input and Innovation Output: Based on the Analysis of Small and Medium-sized Enterprises

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Abstract

Under the influence of the general environment, many small and medium-sized enterprises are facing threats. However, some innovative enterprises continue to grow with innovation. This paper studies the relevant data of listed companies on the Growth Enterprise Market (GEM) from 2016 to 2021, aiming at exploring the relationship among equity incentives, research and development inputs and innovation outputs of small and medium-sized enterprises on the GEM. The research found that both equity incentive and R&D investment will bring positive impact on innovation output, and R&D expenditure plays an intermediary role between equity incentive and innovation results. It also inspires enterprises to alleviate the principal-agent problem through equity incentive in practice, to promote enterprise innovation and to promote the sustainable development of enterprises.

Keywords

Equity incentive, Entrusted agency, Research and development investment, Innovative outputs

1. Introduction

In recent years, due to the outbreak of novel coronavirus, the economy has fallen into a systematic stagnation, small and medium-sized enterprises have suffered a severe impact, and their operating conditions have suffered a heavy blow. The cash reserves of enterprises are insufficient to support their sustainable development (Zhu et al., 2020). However, some innovations are dedicated to innovation and research and development in specific areas, so as to overcome difficulties and overcome disadvantages.

Its ability to innovate has become a unique competitive advantage for its own growth and development. "The 14th Five-Year Plan for Promoting the Development of Small and Medium-sized Enterprises" points out that small and medium-sized enterprises, as the micro subject of innovation, play a vital role in accelerating the construction of an innovative country (2021). It is worth discussing to explore the innovation factors that promote small and medium-sized enterprises to obtain sustainable competitive advantages.

Although innovation plays an important role in the positive development of an enterprise, innovation has the characteristics of high cost, high investment and long-term return, and the enterprise is facing huge risks when carrying out innovation. It is the managers who bear this risk, and the managers will reduce the long-term future investment decisions because of the short-term profitability (Flammer & Bansal, 2017). Leading to a lack of investment in innovation and research and development. Equity incentive can further ease the principal-agent problem, and its appearance can ease the managers' neglect of investment due to short-sightedness.

Based on the above, this paper takes small and medium-sized listed companies as an example to explore the relationship among equity incentive, research and development input and innovation output, and whether research and development input plays an intermediary role between equity incentive and innovation output. In order to find out the factors that are beneficial to the innovation of small and medium-sized enterprises and provide reference for the development and growth of small and medium-sized enterprises in a threatening external environment.

2. Literature Review and Research Assumptions

2.1 Equity Incentive and Innovation Output

For equity incentive and innovation output, the existing research is mainly divided into three parts. First, the implementation of equity incentives has a positive impact on innovation output. Through the research on the data of listed companies, the conclusion is drawn that the number of corporate patents granted by equity incentive has increased significantly, and the innovation ability is directly proportional to the intensity of equity incentive (Huang & Chen, 2012). Through the analysis of panel data from 2014 to 2019, we find that equity incentive has a significant positive moderating effect on supply chain concentration and innovation performance (Guo et al., 2022). It is believed that equity incentive can promote the innovation output of enterprises, and the promotion effect of equity incentive for core staff is more obvious than that of equity incentive for management (Zhao & Lin, 2019). Second, equity incentive has no significant impact on innovation output. Research and analysis show that neither the long-term equity incentive nor the short-term salary incentive can improve the innovation ability of enterprises and obtain more innovation outputs (Tien & Chen, 2012). Third, a small number of researchers believe that equity incentives have a negative impact on innovation output. Equity incentives will make executives more resistant to external pressure, but may also exacerbate agency problems, resulting in executives' short-sighted behavior in balancing corporate innovation

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resources with personal interests. This may result in a decrease in innovation resources, which in turn affects innovation output, which in turn decreases (Zhao et al., 2020). Through the above analysis, we can see that the relationship between equity incentive and innovation output is different under different conditions. Most of them are positive, but some studies also point out that the impact of both is not significant or negative. It can be seen that the relationship between the two changes with different conditions. Based on this, this paper proposes hypothesis 1:

Hypothesis 1: under the control of other conditions, equity incentives and innovation outputs are positively correlated.

2.2 Research and Development Input and Innovation Output

Innovation itself is characterized by high cost, which is reflected in the amount of research and development investment. Research and development investment is a key element of whether an enterprise can innovate and whether innovation is successful. Exploring the relationship between research and development input and innovation output has a strong direction and reference value for small and medium-sized enterprises. On the one hand, a large number of studies point out that R&D input positively affects innovation output. The empirical research on the food processing industry shows that more investment in research and development will result in more innovative results, which will enable enterprises to develop and strengthen their competitive advantages (Vancauteren, 2016). It is believed that the combination of research and development investment and human capital can effectively promote scientific and technological innovation under the new normal of economic development (Zhou & Liu, 2022). Based on the data of 1,597 manufacturing listed companies from 2015 to 2019, this paper empirically analyzes the static and dynamic panel model, and concludes that the research and development input enhances the output of enterprise innovation results (Ba et al., 2022). On the other hand, some studies do not think so, It is concluded that in the research and development stage, especially in technology, research and development investment is positively promoting innovation results, but there is a single threshold for this positive promotion effect, and the promotion effect of research and development investment beyond the threshold on innovation performance will be reduced (Chen et al., 2021). A study of more than 300 enterprises in GEM shows that R&D input and innovation output have an inverted U-shaped effect on each other, i.e., R&D input exceeds a certain value, while R&D input inhibits innovation output of enterprises (Zhang, 2018). Based on the above analysis, hypothesis 2 is proposed:

Hypothesis 2: R&D input and innovation output are positively correlated under the control of other conditions.

2.3 Equity Incentive, R&D Input and Innovation Output

Through domestic and foreign scholars' research on this aspect, most studies point out that there is a positive correlation between the three, It is believed that equity incentive can positively affect the management's behavior and enthusiasm, avoid short-sighted behavior, and spend more time and money on innovation and research and development, so as to improve the performance of the enterprise and

better develop (Chen & Huang, 2006). According to the logical thinking of "equity incentive-decision-making behavior-decision-making results", using the data of A-share listed companies in China from 2009 to 2020, using PSM-DID method, intermediary effect model and so on, this paper systematically studies the mechanism path of the impact of executive equity incentive on enterprise technological innovation, and finds out that equity incentive can be an external financing support for enterprises, which can effectively ease the financing constraints and capital problems of enterprises, increase investment in research and development, and improve enterprise technological innovation (Jiang & Long, 2022). Based on this, this paper would like to further explore the relationship between the three and explore the role of equity incentives between research and development inputs and innovation outputs. Therefore, hypothesis 3 is proposed in this paper:

Hypothesis 3: Under the condition of controlling other conditions, equity incentive affects innovation output by influencing research and development input. Research and development investment plays an intermediary role between equity incentive and innovation output.

3. Empirical Model and Analysis

3.1 Sample Selection and Data Sources

In this paper, companies listed on the GEM from 2016 to 2021 are selected as the research object, and the companies with financial insurance, special treatment and delisting warning are screened out. At the same time, the lack of data is excluded. Finally, 218 valid samples are obtained. The data used in this study are from China Taian (CSMAR) database and are analyzed by SPSS 27.0 software during the subsequent processing.

3.2 Variable Definition

Dependent variable: Innovation output (PATENT). The existing measurement indicators in current research include the number of patents applied, the number of patents granted and the number of patents cited. Due to the time lag between the number of patents granted and the number of patents cited, the innovation output in this paper is measured by the natural logarithm of the number of patents granted+1.

Independent variable: equity incentive (INC). According to the previous research and analysis, this study comprehensively considers the relationship among equity incentive, research and development input and innovation output, and takes equity incentive as the moderating variable to verify its positive moderating effect between research and development input and innovation output. This study uses the ratio of senior management shareholding to total equity to describe this variable.

Intermediate variable: research and development investment (RD). In the existing research, the ratio of research and development expenditure to operating income or average total assets is often used to evaluate the research and development investment. This paper chooses the ratio of research and development expenditure to operating income.

Control variables: referring to the existing research, the control variables are profitability, asset-liability

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ratio and enterprise size. The relevant variable settings are shown in Table 1.

Table 1. Relevant Variables

Type	Name	Symbol	Definition
dependent variable	Innovation output	PATENT	Ln (number of patents granted +1)
independent variable	Equity incentive	INC	Number of senior management shareholding/total number of shares
mediator variable	Research and development investment	RD	Research and development investment/operating income
Control variable	profitability	ROA	Net profit/average total assets
	Asset-liability ratio	LEV	Total assets/total liabilities
	Scale	SIZE	Ln (total assets)

3.3 Model Building

Based on the multiple regression equation shown in model (1), this paper studies the impact of equity incentive on innovation output:

$$Patent=\beta 0+\beta 1INC+\beta 2SIZE+\beta 3LEV+\beta 4ROA+\varepsilon \qquad (1)$$

Among them, $\beta 1$ is the regression coefficient of equity incentive (INC). Under the influence of controlling other control variables, if $\beta 1$ is significantly greater than 0, it indicates that equity incentive positively affects innovation output. This is used to verify hypothesis 1.

The multiple regression equation shown in model 2 is used to study the impact of research and development input on innovation output, as shown in model 2:

$$Patent=\beta 0+\beta 1RD+\beta 2SIZE+\beta 3LEV+\beta 4ROA+\varepsilon \qquad (2)$$

As shown in model (2), $\beta 1$ is the regression coefficient of research and development investment (RD). If $\beta 1$ is greater than 0 and has the hypothesis, the positive impact of research and development investment on innovation output can be obtained. Hypothesis 2 can therefore be verified.

The multiple regression equation shown in model (3) is used to study the mediating effect of research and development investment between equity incentive and innovation output.

$$Patent=\beta 0+\beta 1INC+\beta 2RD +\beta 3SIZE+\beta 4LEV+\beta 5ROA+\varepsilon \qquad (3)$$

3.4 Empirical Analysis

3.4.1 Descriptive Statistics

The results of the descriptive statistics are shown in Table 2:

Table 2. Descriptive Statistical Tables

Variable	Number of cases	Average value	Standard deviation	Minimum value	Maximum
PATENT	219	3.31	0.95	0.69	6.08
RD	219	7.90	5.30	0.06	31.46
INC	219	0.26	0.15	0.01	0.67
ROA	219	0.06	0.09	(0.49)	0.44
LEV	219	0.34	0.18	0.02	0.90
SIZE	219	21.60	0.77	19.94	23.61

First of all, the standard deviation is 0.95, the minimum value is 0.69, and the maximum value is 6.08. The difference in patent licensing is obvious, which indicates that for different innovative enterprises, the innovation output is affected by other factors. Next, is the research and development investment. The standard deviation of the research and development investment is 5.30, the minimum value is 0.06, and the maximum value is 31.46. The difference is very large. It can be seen that different GEM enterprises attach different importance to incentives. Some enterprises attach great importance to incentives, while some enterprises have less incentives. According to the data in Table 2, we can see that there is still room for improvement in the implementation of equity incentives in the sample enterprises. Among the enterprises that implement equity incentive, some enterprises' incentive intensity is far lower than the average level.

3.4.2 Correlation Statistics

The correlation statistics among the variables are shown in Table 3:

Table 3. Correlation Statistics

VARIABLES	PATENT	RD	INC	ROA	LEV	SIZE
PATENT	1					
RD	0.189**	1				
INC	0.370**	0.074	1			
ROA	-0.07	-0.012	-0.023	1		
LEV	0.187**	-0.126	0.071	0.377**	1	
SIZE	0.357**	-0.098	-0.02	-0.001	0.388**	1

* means $p<0.05$, ** means $p<0.01$, *** means $p<0.001$, the same below.

The results in Table 3 show that there is a significant positive correlation between R&D input and innovation output (the correlation coefficient is 0.189 and significant at 1%). There is also a positive promotion between equity incentive and innovation output (correlation coefficient is 0.370, and significant at 1%). Through correlation statistics, Hypothesis 1 and Hypothesis 2 can be initially

verified. In addition, each regression coefficient is a small value, which can be tested by regression.

3.4.3 Regression Analysis

The results of the regression analysis using SPASS are shown in Table 4 below:

Table 4. Regression Analysis Results Table

VARIABLES	(1) PATENT	(2) PATENT	(3) PATENT
INC	0.375***		0.358***
RD		0.235***	0.205***
ROA	0.013	0.33	0.026
LEV	0.028	0.096	0.057
SIZE	0.353***	0.342***	0.362***
R2	0.256	0.184	0.311
ΔR2	0.14	0.054	0.041
F	19.776	12.079	19.197

In model (1), there is a positive correlation between equity incentive and innovation output ($\alpha=0.375$, $p<0.001$). More and more effective innovation outputs require managers to make strategic decisions. In the past, due to the principal-agent problem, managers paid less attention to innovation for their own interests. The emergence of equity incentive effectively alleviates this problem, connects the value of the enterprise with the value of the executives themselves, and enables managers to make innovative decisions that are beneficial to the enterprise. Hypothesis 1 is verified: there is a positive correlation between equity incentive and innovation output.

In model (2), research and development input positively promotes innovation output ($\alpha=0.235$, $p<0.001$). Innovation is a high-risk and high-cost process. The role of research and development investment in innovation cannot be underestimated. More research and development investment will make every innovation step perfect and the innovation output will obtain effective results. Hypothesis 2 is verified: there is a positive correlation between R&D input and innovation output.

First in the model (1), suppose 1 has been verified, then according to the model (3), the mediating effect can be verified. It can be seen that equity incentive affects innovation output by influencing research and development input ($\alpha=0.205$, $p<0.001$). Through the implementation of equity incentives, enterprises can effectively alleviate the problem of managers' short-sightedness. It is managers who increase research and development investment for the common interests of enterprises and themselves, and then enable enterprises to obtain more effective and richer innovation outputs. Hypothesis 3 is verified: research and development inputs mediate between equity incentives and innovation outputs.

4. Conclusions and Recommendations

At present, our country pays more attention to the importance of innovation. The success of innovation lies not only in research and development input but also in innovation output. Only when the input is changed into the output can the enterprise obtain a sustainable competitive advantage and a sustainable development.

4.1 Result Analysis

First of all, this paper empirically studies the relevant data of companies listed on the Growth Enterprise Market from 2016 to 2021, which have a positive impact on the innovation output of equity incentive and research and development input respectively, and the mediating role of research and development input between equity incentive and innovation output.

From the results, we can see that equity incentive can positively affect innovation output, and the formulation of an appropriate equity incentive system can effectively alleviate the principal-agent problem and enable managers to serve the long-term development of the enterprise. Research and development input also positively affects innovation output. By investing more in innovative projects, the project's budget is increased, the salaries of project staff are increased, and the quality of the tools used is increased, resulting in more innovative outputs. In addition, equity incentives affect research and development inputs and thus innovation outputs.

4.2 Research Significance

This paper not only studies the positive impact of equity incentive and research and development input on innovation output, but also explores the intermediary effect of research and development input, and studies the brand-new relationship between the three. In practice, small and medium-sized enterprises should pay attention to their own innovation in today's complex environment to obtain sustainable competitive advantages unique to competitors. Through the way of equity incentive, we can alleviate the principal-agent problem and obtain more innovative outputs.

4.3 Research Prospects and Shortcomings

This paper only studies the companies listed on the Growth Enterprise Market from 2016 to 2021. The sample size is small, and it does not involve more types of enterprises. The follow-up research can expand the sample for research and improve it.

The independent variable in this paper is measured by the ratio of the number of executive shares to the total number of shares, and the main research is also the impact of executive incentives. However, with the development of society and the development and perfection of incentive theory, more and more incentive objects turn to research and development personnel. Future research can also study the relationship between executive incentive and R&D personnel incentive or both

The innovation output of this paper is measured by the number of patents granted. However, due to the state's friendly subsidies for innovation of small and micro enterprises, the innovation performance of most companies is not obvious, which does not bring sustainable competitive advantages to the enterprises. Only in this way can preferential policies be obtained. Therefore, in the follow-up research,

indicators can be added to measure innovation output, such as the number of patents cited.

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