Decisions on Investing Social Funds in Technology Research and Development Based on Cognitive Psychology

Zhiqin Xie¹*, Xiaoyan Cao², Yan Liu³, Xia Wu¹

ABSTRACT
With the rapid development of the economy, it is an important task for the Chinese private corporates to complete the industrial upgrading in the fierce competition and maintain the vitality and competitiveness. One of the important factors is the serious shortage of R&D investment. Cognitive psychology is introduced in this paper, focusing on the relationship between the cognitive bias of business managers and the R&D decision-making mechanism of corporates. The model of R&D decision-making mechanism is established through theoretical analysis, and the factors that affect R&D decisions are analyzed and discussed, more than 200 corporates are selected to discuss the influence of different cognitive bias on the decision-making mechanism by the empirical analysis. The results show that overconfident managers have positive impact on the R&D intensity of the corporate, however, overly optimistic managers have negative impact on the R&D intensity of the corporate. Finally, based on the management practice, based on the perspective of cognitive psychology, the paper delivers countermeasures and suggestions on how to improve the quality of the R&D decision of private corporates, enriches the influence of cognitive bias on the decision mechanism of R&D of corporates, and provides a reference for the construction of new market economy countries.

Key Words: Cognitive Psychology, Capital Input, Decision Analysis
DOI Number: 10.14704/nq.2018.16.6.1597

Introduction
The rapid development of the economy and the continuous innovation of science and technology put forward higher requirements on the corporates to survive and develop in the increasingly competitive market (Taylor, 2002). At present, the private corporates (Liang et al., 2012) in our country have become the mainstay of China’s economic growth (Wu, 2007), but many corporates are in the low end of the industrial chain and are facing the danger of bankruptcy. Therefore, the key to promote transformation and upgrading of corporates and survive in the market is the R&D and innovation of technology in corporates (Wu, 2009). According to the data collected (Yang et al., 1996), the R&D intensity of private corporates in China has been declining for several years (Zhao, 2009), and its intensity is far below the average level of the world. In such background, the research and development of corporate’s decision-making mechanism and influencing factors (Hsu, 2006) are of great significance for the promotion of corporate research and development Intensity as well as the economic development.

It is impractical to discuss management without the social environment (Maali et al., 2007). In the study of management, the study of...
human behavior is very important. In the management of the corporate (Amabile, 1988), communication with subordinates is important not only to specific matter but also to the management of people. And the manager’s recognition on the subordinates or the situation of the market environment and the company is bound to be affected by various factors (Ozer, 2005), thus producing bias (Hertel et al., 2011). Only when the managers recognize the importance of their cognitive bias to a decision (Haber et al., 2015) can they take effective measures to reduce this cognitive errors and make effective and rational judgment (Lauriola et al., 2007), which is conducive to the long-term development of the corporate. At present, the empirical research on cognitive bias is mainly focused on the financial market, while researches on the cognitive bias (Nooraie, 2012) of the corporate managers are few, therefore, focusing on cognitive bias and decision making (Mantel et al., 2006) can enhance people's understanding of errors and is beneficial to the managers to make more scientific and rational decisions, which is of great social significance.

This paper introduces cognitive psychology to study the cognitive bias of corporate managers and the relationship between the decision-making mechanism of corporate R&D and the relationship between the two, and analyzes and studies the factors that affect the scientific and technological research and development decision of corporates by setting up models and carrying out empirical researches, so as to provide reference to strengthen the technology innovation of corporates in China.

Cognitive psychology

Cognitive psychology is an important branch of psychology and cognitive science. It first appeared in the middle of 1950s. The research of cognitive psychology involves feeling, learning, memory, language, emotion and social cognition, and decision making. It is an important way for human to understand the relationship between itself and the outside world. Cognitive psychology believes that knowledge is a dominant factor in determining human behavior. One can make use of the knowledge and knowledge structure of the brain to judge and determine the current cognitive activities, and thus can directly affect the effectiveness and efficiency of learning. In cognitive psychology, the human brain is somewhat similar to the computer's information processing system, and the cognitive process of human is similar to the input and output process of information. As a subject involving many subjects, cognitive psychology has been applied to many fields, such as education, artificial intelligence, industrial production and medical treatment, and has played an important role.

Cognitive bias of corporate managers

The definition and type of cognitive bias: Due to the limitations of human perception, thinking and memory ability, there is an inevitable gap between the facts and the standards in the cognition or judgment of things, which is usually called as cognitive bias. Cognitive bias is a psychological performance of people under uncertainty, which is usually the result of the common effects of cognitive style, processing strategy and emotional factors.

Cognitive process of individual is divided into four parts as shown in Figure 2, in each of which may appear cognitive bias. If classified according to the reason of cognitive bias, it can be divided into correlation bias, psychophysical bias and strategic bias. If classified according to the field of study, it can be divided into attribution bias, reasoning bias and strategic bias. If classified
according to the form of cognitive bias, it can be divided into heuristic bias and self-deception cognitive bias, emotional cognitive bias, and so on.

**Figure 2.** Individual cognitive process

Influence of cognitive bias of managers on decision-making: The manager is the core of the strategy and decision making, and plays an important role in the operation of the corporate. The strategy and decision made by the corporate are directly related to the survival and development of the corporate. Under ideal conditions, managers can have a clear and accurate cognition of the internal and external situations of corporates, and then make rational and rational judgments based on circumstances. However, in the actual situation, the manager of the corporate will be disturbed by various factors in the cognitive process. At the same time, the manager, limited by his/her ability, may not have comprehensive mastery of information. Therefore, errors will be made in judging and decision-making process. (Figure 3)

**Figure 3.** Conceptual model of cognitive bias of business managers

The influence of cognitive bias on managers' decision-making is not all negative and leads to errors. In some cases, the bias may inspire and help managers to make a quick and simple decision; in other cases, business managers should first consider how to avoid catastrophe instead of maximizing utility. Therefore, we can't arbitrarily think that cognitive bias is completely negative and results in harmful results, instead, how to make use of cognitive bias and the cognitive bias of cognition to make decisions more rational and comprehensive should be our focus.

**Behavior decision theory**

According to the research paradigm of modern decision theory, it can be divided into behavioral decision theory and rational decision theory. The theoretical basis of rational decision theory is mathematical statistics and operational research. It is assumed that people are completely rational when they make decisions, and can make judgement based on logic and existing models. The theoretical basis of behavior decision theory is psychology. It is based on a large number of empirical studies to analyze and summarize people's decision in real situations. Theoretical models are then established according to practice. The following Figure 4 shows the difference between the two decision theories in terms of research purpose, results and concerns.

**Figure 4.** Comparison between behavioral decision-making theory and rational decision-making theory

At present, there is a lack of systematic research on behavior decision theory in China, but it develops rapidly. We can precisely summarize the development process of behavioral decision theory into three stages: first, select and judge the information processing process based on cognitive psychology; second, control study is carried out by comparing with the rational decision making model; third, refine the behavior characteristics of the decision-makers as variables, and verify those variables by introducing behavioral variables into the decision-making model.
R&D and inspection on the model of decision impact mechanism

The impact of sources of funds on corporates

In the past thirty years of reform and development, China's economy has maintained high-speed growth. However, these companies largely depend on the government and low-cost work force, while the percentage of high and new technology industries is not high in economic growth. Therefore, how to improve the technological innovation of China's high-tech industry is of great significance for enhancing the core competitiveness of Chinese corporates and maintaining economic growth. The development and innovation of high tech industry is influenced by the scale of corporates, government policies, source of funds and the environment of corporates. The innovation of science and technology needs capital injections, while this kind of investment is of high risk. The main sources of capital are government support, social funds, foreign capital and so on.

Model establishment

Basic model: A company in a certain industry needs to seek for scientific and technological development in order to reduce cost. In order to maximize the overall interests of the corporate, the investment funds of the corporate are mainly from social funds. Suppose that the fund invested by the company in developing a product is $x$, then the production function of the corporate is

$$f_i(x) = \partial_i\sqrt{x}$$

$\partial_i$ represents innovation efficiency. The higher the innovation efficiency, the lower the cost of the product.

After the transformation of formulas, the unit cost of the product can be expressed by formula (2).

$$c_i = c - \theta_i\sqrt{x} + x_i$$

if $\theta_i = \partial_i\sqrt{x}$, $x_i = (\frac{\theta}{\partial_i})^2$.

The cost of the product can then be expressed by formula (3)

$$c_i = c - \theta_i + k_i\theta_i^2$$

R&D decision model: The paper establishes a model for the decision-making model of the corporate by reverse induction. The objective function of the corporate is shown as (4):

$$u = u[y, \pi] = my + (1 - m)\pi, 0 < m < 1$$

The production function of an corporate can be revised as shown in formula 5.

$$y = (1 - n)f(k, 1), 0 < n < 1$$

$M$ is the degree of importance attached to output, and $M$ is greatly related to government support. $n$ represents the amount of investment that business managers spend on R&D based on social funds. $k$ and $l$ respectively represent capital elements and labor elements in the corporate.

According to Cournot, $\frac{\partial u}{\partial x} = 0$, the R&D investment can be expressed as follows:

$$x = \frac{k[3c(1-m) + (c-a)k^2(-1+m)^2 + (3a-6c)e^n(1-n)]}{k^2(-6k^2) + 3e^n(-9 + 2k^2)(1-n)}$$

According to the amount of R&D investment and its proportion in business income, the R&D intensity of the corporates can be expressed as follows:

$$R&D = \frac{-k[2(1-m)^2 + 3e^n(-9 + 2k^2)(1-n)]}{(k^2 - 3)(1-m) + k^2(1-m)^2 - (3ak^2 - 9a - 9c)e^n(1-n)}$$

Simulation and analysis

Because the model is relatively complex, it is necessary to use software programming to solve the problem, and this article will choose a company's financial data as an example, and analyze the influence of the related factors on the decision of R&D in the corporate. The setting of the related parameters is shown in the following table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>a</th>
<th>c</th>
<th>m</th>
<th>n</th>
<th>$\partial$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation A</td>
<td>15</td>
<td>3</td>
<td>0.1</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Situation B</td>
<td>17</td>
<td>3</td>
<td>0.5</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Situation C</td>
<td>19</td>
<td>1</td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

The relationship between R&D investment and corporate profit: Figure 5 shows the relationship between corporate profits and R&D intensity under three parameters. Comparing the three figures, we can find that the relationship between the two is basically shown as an inverted “U”. It
shows that the investment intensity of strengthening R&D is helpful to improve the profit of the corporate, but when the intensity of R&D continues to increase, the cost of R&D will be far greater than the cost reduction brought by the results of R&D, and the total profits of the corporate begin to decline. Therefore, the proportion of R&D investment should be maintained at or before the turning point.

Figure 5. The impact of R&D investment on corporate profits

The relationship between output weight and enterprise profit: Figure 6 shows the relationship between the profit and output weights under three parameters. Enterprises will optimize input and output projects according to their own characteristics, so that to get higher input output ratio. As shown in the figure, when m is less than a certain value, the profit and output weight of the enterprise are positively related, but once m exceeds a certain value, the profit of the enterprise begins to decline. If the enterprise expands the scale of the enterprise and seeks the increase of output blindly, and does not pay attention to the core competitiveness of the enterprise, rich profits may be brought in a short time, but in the long run, which, however, is not conducive to its long-term development.

Figure 6. Influence of output weight on corporate profits

Relationship between output weight and R&D investment of enterprises: Figure 6 shows the relationship between output weights and R&D investment under three parameters. From the chart below, we can see that the relationship between them is negatively related, shown in a
shape "U". With the increase of output weight, the investment in scientific and technological research is reduced. After a certain inflection point, the investment in R&D increases with the weight of output. In the development and expansion of enterprises, the proportion of investment in R&D is critical, since R&D projects need high investment and are of high risks. Enterprises often choose to expand production to increase profits, but in order to improve the market share of the enterprise and form core competitiveness, enterprises will choose to increase investment in R&D and improve the innovation ability of enterprises at a certain stage of development to obtain high output and occupy a greater market share. (Figure 7)

**Empirical analysis on the moderating effect of corporate R&D decisions based on cognitive bias**

**Research hypothesis**

Managers may more or less have cognitive bias in the process of decision-making. According to statistics, in different kinds of cognitive deviations, managers are more likely to be overoptimistic and overconfident. Therefore, in designing empirical research, we first put forward two hypotheses.

(1) Overconfident managers are more innovative and more inclined to work on the R&D to maintain the core competitiveness, which is positively related to the R&D intensity of the enterprise.

(2) Over optimistic managers are optimistic about the market environment, who often tends to expand the scale of the enterprise and reduce the proportion of investment in innovation. Therefore, it is supposed to be negatively related to the R&D intensity of the enterprise.

**Research design**

Sample selection and variables: The research samples selected in this paper are private listed companies in China in 2007-2009. The cognitive psychology of the managers can be more clearly understood by analyzing the management and investment strategies made in periods with greater macro-economic fluctuations. In this paper, companies are selected according to certain rules. Finally, 224 samples are selected as research data.

The research object of this paper is the capital investment of R&D. R&D intensity, the ratio of R&D funds to the income of the enterprise, is regarded as the dependent variable. The control variables are size, age, profitability, type of industry, concentration of equity, etc.

Test Model: In this paper, linear regression model is used to study the influence of corporate managers’ cognitive bias on R&D decisions of enterprises.

**Figure 7.** Influence of income weight on R&D investment
$\beta_i$ (i = 0, ...,12) is regression coefficient; SF is the source of funds, OCD is over confidence, OOD is over optimistic.

**Empirical results and analysis**

Figure 8 and Table 2 show the results of the testing respectively in charts and tables. The empirical results show that over 60% of the overconfident corporate managers are more than zero, indicating that the managers of Chinese enterprises are generally overconfident in making decisions, which is closely related to the "monarch" thinking in Chinese traditional culture, in which managers have great power in making decisions, and they tend to believe in their own judgement. In contrast, the proportion of overly optimistic managers less than zero is more than 50%, indicating that managers have a negative attitude towards the future economy, which is related to the economic transformation of private enterprises in China. How to find new economic growth points in the period with great economic fluctuations to obtain core competitiveness of in the market is crucial.

![Figure 8. Measurement of degree of managerial overconfidence (a) and overoptimism (b) of sample](image)

**Table 2. Summary of statistics**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>Minimum</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCD</td>
<td>0.05</td>
<td>0.044</td>
<td>0.275</td>
<td>-0.38</td>
<td>0.088</td>
</tr>
<tr>
<td>OOD</td>
<td>0.015</td>
<td>-0.05</td>
<td>0.729</td>
<td>-0.998</td>
<td>0.338</td>
</tr>
</tbody>
</table>

**Strategies and suggestions**

The continuous development of China's economy depends not only on enterprises to expand the scale of the economy, but also to improve the scientific and technological research and development capabilities, to complete the industrial upgrading as soon as possible, to improve the core competitiveness of the enterprises, and to occupy more market shares on the international stage. This paper, based on the model and empirical analysis above, gives the corresponding suggestions and strategies on how to enhance the R&D intensity of enterprises from three levels, as shown in the following figure 9.

![Figure 9. Strategies and suggestions based on conclusions](image)

**Conclusions**

This paper introduces cognitive psychology to study the corporate R&D decision-making mechanism. Considering the relationship between the cognitive bias of corporate managers and the corporate R&D decision-making mechanism, conclusions can be summarized as follows:

1. The model of R&D decision-making mechanism is established through theoretical analysis, and the factors affecting R&D decisions are analyzed and discussed. The influencing factors include R&D investment, the weight of output and the profit of the corporate, which will enhance the R&D strength of the enterprise as well as the core competitiveness of the enterprises in a certain scope.
2. According to empirical analysis, the influence of managers' different cognitive biases on decision-making mechanism is discussed. According to the data obtained from the model,
overconfident managers have positive impact on corporate R&D intensity, while the overly optimistic manager has a negative impact on corporate R&D intensity.

References


