# Research on R&D investment and profitability of listed agricultural companies - Moderating effect based on size

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**Keywords:** R&D investment, profitability, listed agricultural companies.

**Abstract:** The influence of R&D expenditure on the profitability of listed agricultural enterprises is unstable and worthy of investigation since agricultural production is subject to various variables, such as the natural environment. In this paper, the impact of R&D expenditure on firm profitability is explored using GMM estimates using a research sample of 34 publicly traded agricultural companies from 2011 to 2020. On this foundation, this research examines the impact of business size as a moderating variable on the link between R&D spending and profitability. The study's findings reveal that R&D investment is considerably negatively associated with profitability, with a lag in this effect, and that a greater firm size will lessen the negative effect of R&D investment on profitability. Listed agricultural enterprises should enhance the intensity of R&D expenditure in accordance with their own scale, while also paying attention to the long-term benefits and consequences of inputs and outputs.

## 1. Introduction

In recent years, international economic turmoil, the impact of trade wars and new coronaviruses have made Chinese agribusinesses increasingly competitive in the market and agricultural development volatile, which makes us realize the importance of agricultural autonomy and control in our country. Modernization of agriculture is an inevitable requirement for modernization of national governance, modernization of governance capacity and modernization of socialism. The security of the agricultural industry chain and value chain, as well as the acquisition of key core technologies, can only be achieved through various innovations by relevant agricultural industry participants, particularly through R&D investment by various agricultural enterprises, which has a direct impact on the efficiency, effectiveness, and impact of innovation in agricultural enterprises, and is the key to achieving high-quality development of agricultural enterprises.

At present, China's economy and society are in a new stage of development, implementing the new development concept and building a new development pattern. In the document No. 1 of the Central Government in 2021, it was pointed out that "we should insist on the self-reliance and self-improvement of agricultural science and technology, improve the stable support mechanism for basic research in the field of agricultural science and technology, deepen institutional reform, and layout and build a number of innovation bases and platforms". The key core of accelerating the modernization of agriculture and rural areas is scientific and technological innovation. Agricultural enterprises are generally aware of the need for strategic changes to "increase efficiency, reduce costs and innovate green", and the importance of innovation-driven enterprise development. Listed agricultural companies are advanced representatives of agricultural enterprises. Their R&D investment, R&D activities and the application of various innovation results will directly improve the quality and level of development of agricultural enterprises, and will enhance the sustainable core competitiveness and profitability of the entire agricultural industry, which is an important force in achieving rural revitalization.

Through literature search and study of the literature, it is found that most studies are on listed companies as a whole, with fewer studies on listed agricultural companies, and even fewer studies on

the relationship between moderating variables affecting R&D investment and corporate profitability. Research on the impact of R&D investment on the profitability of listed companies and research on the impact of moderating variables on R&D investment and thus on the profitability of companies is of practical significance.

This paper presents an empirical analysis of the impact of R&D investment on the profitability of agricultural firms and introduces firm size as a moderating variable to investigate its impact on R&D investment and hence firm profitability. The findings and recommendations developed will be of reference value to all firms in the agricultural industry and other relevant players on how to efficiently invest in R&D to enhance firm profitability.

## 2. Literature review

Many researchers at home and abroad have studied the relationship between R&D investment and company profitability, and most of them tend to believe that R&D investment can effectively improve company profitability. Brown and Petersen's [1] study found that R&D investment has a positive impact on firm value. Through an empirical analysis of the relationship between R&D investment, advertising expenditure and firm profitability, Lihua Wu and Jingrong Huang [2] found that R&D investment has a significant positive impact on firm profitability. However, some scholars argue that the impact of R&D investment on corporate profitability is lagging and may not be positively correlated due to the drawbacks of long lead time, high risk and uncertainty, etc. Markides [3] argues that because of the acceleration trap, continuously increasing and accelerating R&D investment may bring great risks to companies. Hongwei Cheng et al. [4] show that the intensity of R&D investment can significantly and positively affect firm profitability, but this effect is diminishing year by year, so firms need to make continuous R&D investments. Using a sample of 24 A-share listed companies in China, Ma Kexing and Li Jun [5] found no significant effect of innovation investment within agricultural firms on agricultural firm performance. Some other scholars have conducted research on the effect of size on R&D investment on firm profitability, but the findings have not been consistent. Connolly & Hirschey [6] argue that large-scale firms can be efficient enough to obtain higher R&D efficiency and improve the impact of R&D investment on firm profitability. While Mingming Ji [7] found that R&D investment is positively related to firm value, the value effect of R&D expenditure undertaken by small and medium-sized firms is better than that of large-sized firms.

Most of these studies have looked at listed companies as a whole, but few have examined the impact of R&D investment on the profitability of listed agricultural companies and the impact of size on the relationship between R&D investment and profitability, and their findings may not be applicable to listed agricultural companies. Due to the strong uncertainty of STI activities and the weakness of agriculture itself, the investment in innovation is different from the output of innovation results. The efficiency of innovation activities varies considerably within different firms, as do the incentives to utilize innovation outputs, so innovation inputs do not automatically lead to higher firm profitability. It is important to investigate the relationship between moderating variables affecting R&D investment and corporate profitability in order to target R&D strategies and improve the technological innovation capability of agricultural companies. In this paper, the relationship between R&D investment and profitability of agricultural enterprises is investigated by taking listed agricultural companies as the research target, and on this basis, size is introduced as a moderating variable for the study.

## 3. Research hypothesis

### 3.1 Impact of R&D investment on profitability

Schumpeter's innovation theory states that innovation is an essential requirement for economic development and can create new value. In other words, in order to create value and produce market performance, enterprises, as microeconomic subjects, need to increase the necessary investment in innovation, which will in turn promote the continuous development and growth of enterprises. According to the National Statistical Bulletin on Investment in Science and Technology, the intensity

of investment in research and experimental development (R&D) (as a ratio to GDP) was 2.40% in 2020, 0.16 percentage points higher than the previous year, and the intensity of investment in R&D has been steadily increasing. To improve the business performance of enterprises, it is necessary to strengthen investment in innovation to better utilize external resources and stimulate the creativity of employees.

Investments in scientific innovation and R&D are equally important for the development of agricultural enterprises, but, due to the specificity of the industry itself, their investments have a more complex impact on the efficiency and profitability of agricultural production. On the one hand, R&D investment offers the possibility of reducing production costs. By developing equipment and materials with good performance and reasonable prices to replace the original equipment and materials, the quality of agricultural products is optimized, the cost of agricultural products is effectively reduced and the competitiveness of agricultural products is improved, thus making profits. On the other hand, it takes time from R&D investment to production, then to the market launch of the product, and then to the economic benefits of the enterprise, so there may be a lag in the impact of R&D investment. Especially for agriculture, the R&D cycle is longer, more influenced by the environment and more uncertain, requiring enterprises to pay more costs and bear greater risks, and the R&D investment may also affect the enterprise's daily business activities because it takes up the enterprise's resources, thus bringing negative impact on profitability.

Based on the above analysis, this paper proposes the hypothesis:

Hypothesis $1_a$: There is a significant positive effect of R&D investment on the profitability of agricultural firms.

Hypothesis $1_b$: R&D investment has a significant negative impact on the profitability of agricultural firms.

Hypothesis 2: There is a lag in the impact of R&D investment on the profitability of agricultural enterprises.

### 3.2 Impact of size on the relationship between R&D investment and profitability

Fisher and Temin (1973) argue that there are two components to the effect of size on a firm's innovation activity, namely the effect of size on innovation inputs and the effect of size on innovation outputs. For this paper, the study focuses on the first part, i.e. the direction of the moderating effect of size on the intensity of R&D inputs and firm profitability. On the one hand, large-scale firms can be large enough to achieve higher R&D efficiency, and larger firms may enjoy economies of scale in the production or marketing of R&D-intensive products, geographical scope, or have superior financial resources at their disposal compared to smaller firms [6]. On the other hand, large scale companies in China may be less willing to improve innovation efficiency and promote the conversion of innovation results, while small and medium scale companies will actively improve innovation efficiency and promote the conversion rate of innovation activities in order to achieve objectives such as increasing market share and expanding company size, thus leading to an increase in company value [7].

For agribusinesses, R&D investments are longer, more costly and more influenced by the natural environment. Objective conditions may play a higher role than subjective intentions. For small and medium-sized enterprises, even if they have the will to drive company profitability, improve market share and expand company scale by strengthening R&D investment, they will be limited by their own volume and resources. Moreover, the technological innovation ability of SMEs is poor, and their own resources and economic strength make them afraid to take the risk of technological research and development. For large enterprises, on the other hand, they themselves enjoy the advantage of scale effect and have more resources at their disposal, providing a solid foundation for R&D investment activities.

Based on the above analysis, this paper proposes the hypothesis:

Hypothesis $3_a$: The larger the firm, the stronger the positive effect of R&D investment on the profitability of agricultural firms.

Hypothesis $3_b$: The larger the firm, the stronger the negative weakening effect of R&D investment on the profitability of agricultural firms.

## 4. Variable description and Model selection

### 4.1 Sample selection and data sources

In this paper, the data of a total of 42 non-ST listed companies in agriculture, forestry, animal husbandry and fishery in the 2012 edition of the industry classification of the SEC from 2011 to 2020 are selected as the original sample. After removing missing data and anomalous indications from the original sample, a total of 248 valid observations for 34 organizations were acquired in order to improve data comparability across time periods and to verify data integrity and validity. The Cathay Capital database (CSMAR) was used to gather the data of listed agricultural companies needed for the study, and stata16.0 was used to analyze the data.

### 4.2 Variable description

The profitability indicators can be expressed in terms of operating income, operating margin, net profit margin, return on total assets and return on net assets, etc. In this paper, the return on total assets (ROA) is chosen to measure the profitability of a company. ROA is one of the most important indices of profitability since it represents a company's capacity to profit from its entire assets. Furthermore, because the impact of R&D expenditure may take time to manifest, the current period ROA is used as the explanatory variable. The ratio of net profit to total assets is used to calculate it.

#### 4.2.1 Explained variables

A company's profitability index can be reflected by operating income, operating margin, net profit margin, return on total assets, return on net assets, etc. In this paper, we use ROA as a measure of company profitability. ROA is a company's ability to use its total assets to make profits and is one of the important indicators of profitability. It is calculated as the ratio of net profit to total assets. Furthermore, because the impact of R&D expenditure may take time to manifest, the current period ROA is used as the explanatory variable. The ratio of net profit to total assets is used to calculate it.

#### 4.2.2 Core explanatory variables

This research uses the R&D investment indicator as the explanatory variable to investigate the impact of R&D expenditure on the profitability of publicly traded agricultural enterprises. Drawing on earlier related literature [1], this research uses R&D investment intensity (R&D1) as an indicator to quantify innovation investment because R&D investment is affected by the size and profitability of businesses, among other factors. The ratio of R&D investment to main company revenue is used to calculate R&D investment intensity. This research splits R&D input intensity into current year innovation input intensity, lagged one-period, and lagged two-period R&D input intensity to investigate the lagging issue.

#### 4.2.3 Adjustment variables

Enterprise R&D investment is closely related to the scale effect of the enterprise itself, and sufficient scale provides a guarantee for enterprise R&D investment. In this paper, enterprise scale is chosen as the moderating variable, and total assets are chosen to represent enterprise asset scale, and its natural logarithm is used as a proxy.

#### 4.2.4 Control Variables

Based on the existing literature [5][8] and related theories, corporate profitability is not only affected by R&D investment, but also by other factors. The following four control variables are selected to better explain the impact of R&D investment on corporate profitability.

Enterprise risk (LEV): Enterprise risk affects the development of enterprises, and profitability is also affected by enterprise risk. Therefore, this paper selects the gearing ratio as its proxy variable.

Cash strength of the enterprise (CASH): The day-to-day operating activities and investment and financing activities of a company are related to its cash capacity, and the cash strength of a company affects its profitability. As net cash flow is an absolute number indicator and will be affected by the

size of the enterprise, in order to make the findings more comparable, this paper uses the relative number indicator cash strength instead of net cash flow as a control variable.

Growth capacity of enterprises (GROWTH): Corporate life cycle theory suggests that the dynamic trajectory of enterprise development and growth includes several stages of development, growth, maturity and decline, and that the profitability of enterprises may differ significantly at different stages. The study uses the ratio of a firm's current year's main business revenue to last year's main business revenue to measure the firm's growth capability.

Equity concentration (TOP): The equity structure may have an impact on the profitability of a company, and this paper uses the percentage of shares held by the first largest shareholder to measure equity concentration.

Table.1. Definition and description of key variables

| Variable type | Variable name | Symbols | Formula |
|---|---|---|---|
| Explained variables | Return on total assets | ROA | Net Profit / Total Assets |
| Explanatory variables | R&D investment intensity | R & D1 | R&D investment/operating income |
| Adjustment variables | Business size | SIZE | Ln (total assets) |
| Control variables | Business risks | LEV | Total liabilities/total assets |
| | Corporate cash strength | CASH | Cash/total assets |
| | Business growth capability | GROWTH | Operating income for the year / Operating income for the previous year |
| | Concentration of shareholding | TOP | Number of shares held by the largest shareholder/total share capital |

### 4.3 Model setting

This work uses a panel data model to conduct the test in order to incorporate the temporal and geographical properties of the data, limit the interference of variable multicollinearity on parameter estimation, and ensure the robustness of the model estimate findings. The following model is created in this study using the findings of the variable selection and the hypotheses I and II given in the previous paper to examine the impact of R&D expenditure on enterprise profitability in the current period, one period lagged, and two periods lagged.

$$\mathrm{ROA}_t = \alpha_0 + \alpha_1 \times \mathrm{R\&D1}_{i,t} + \alpha_2 \times \mathrm{SIZE}_{i,t^+} + \alpha_3 \times \mathrm{LEV}_{i,t} + \alpha_4 \times \mathrm{CASH}_{i,t} + \alpha_5 \times \mathrm{GROWTH}_{\mathrm{i,t}} + \varepsilon \quad (1)$$

$$\mathrm{ROA}_t = \alpha_0 + \alpha_1 \times \mathrm{R\&D1}_{i,t-1} + \alpha_2' \times \mathrm{SIZE}_{i,t^+} + \alpha_3 \times \mathrm{LEV}_{i,t} + \alpha_4 \times \mathrm{CASH}_{i,t} + \alpha_5 \times \mathrm{GROWTH}_{\mathrm{i,t}} + \varepsilon \quad (2)$$

Where i represents the i-th firm in the study sample, there are 34 firms, i = 1, 2, ..., 34; $\mathrm{R\&D1}_{i,\ t}$, respectively, represents the current year R&D investment intensity of the i-th firm; $\mathrm{R\&D1}_{i,\ t-1}$ represents the 1-year lagged R&D investment intensity of the i-th firm. α is the regression coefficient reflecting the correlation, and ε is introduced to offset the effect of other factors ε is a random variable introduced to offset the effects of other factors.

To investigate the moderating effect of firm size on R&D investment and profitability, this paper introduces an interaction term between firm size and R&D investment for analysis, combining the selection of variables and hypothesis 3 to establish the model.

$$\mathrm{ROA}_t = \alpha_0 + \alpha_1 \times \mathrm{R\&D1}_{i,t} + \alpha_2 \mathrm{R\&D1} \times \mathrm{SIZE}_{i,t^+} + \alpha_3 \times \mathrm{SIZE}_{i,t} + \alpha_4 \times \mathrm{LEV}_{i,t} + \alpha_5 \times \mathrm{CASH}_{i,t} + \alpha_6 \times \mathrm{GROWTH}_{\mathrm{i,t}} + \varepsilon \quad (3)$$

## 5. Results

### 5.1 Descriptive statistical analysis

The descriptive statistics for the main variables are shown in Table 2. The standard deviation of return on total assets (ROA) is 0.0920, with a mean of 0.0260, a minimum of -0.301, a maximum of 0.526, and a standard deviation of 0.0920, indicating that the profitability of listed agricultural enterprises fluctuates greatly. The mean R&D investment intensity (R&D1) is 2.214, with a maximum of 55.13, a minimum of 0 and a standard deviation of 4.728, indicating that the R&D investment intensity of different listed agricultural companies varies significantly from year to year, with the minimum value of R&D investment intensity being 0, indicating that some listed agricultural companies' R&D investment is very low.

Table.2. Descriptive statistics of variables

| variable | N | mean | p50 | sd | min | max |
|---|---|---|---|---|---|---|
| ROA | 248 | 0.0260 | 0.0200 | 0.0920 | -0.301 | 0.526 |
| R&D1 | 248 | 2.214 | 0.825 | 4.728 | 0 | 55.13 |
| SIZE | 248 | 22.09 | 22.04 | 0.959 | 20.32 | 25.53 |
| LEV | 248 | 0.438 | 0.427 | 0.187 | 0.0350 | 0.980 |
| CASH | 248 | 0.146 | 0.119 | 0.110 | 0.00100 | 0.650 |
| GROWTH | 248 | 1.151 | 1.071 | 0.314 | 0.469 | 3.017 |
| TOP | 248 | 0.346 | 0.375 | 0.157 | 0.0410 | 0.730 |

### 5.2 Endogeneity test

Firm profitability may be enhanced by moderate R&D investment, whereas improved profitability may result in increased R&D investment expenditure. According to the literature [9] and theoretical grounds, there may be an endogenous relationship between R&D expenditure and business profitability that interacts and might cause endogeneity difficulties in OLS regression results. In this study, we use the Hausman endogeneity test to see if R&D expenditure and profitability are endogenous. The test result P-value is 0.0376, which is significantly non-zero at the 5% level, and the test result passes the endogeneity test, demonstrating that enterprise R&D spending and profitability are endogeneous. The variable has inter-group heteroskedasticity, as determined by the xttest3 inter-group heteroskedasticity test, which had a P-value of 0.0000. As a result, this research uses GMM estimation for regression analysis to mitigate the endogeneity problem and between-group heteroskedasticity in order to successfully estimate the mechanism of action between the two variables.

### 5.3 Regression analysis

In this paper, OLS estimation and GMM estimation regression analyses were conducted separately for the panel data using Stata 16. 0 software. For the GMM estimation, the explanatory variables of the two models with one lagged period were selected as the instrumental variables respectively. Table III presents the results of the OLS regression and GMM regression tests for the previously constructed current period, one-period lagged and two-period lagged models, where the OLS regression did not address the endogeneity issue. In terms of the relationship between R&D investment and firm profitability, the GMM regression estimates and the ordinary OLS regression exhibit partial results in terms of coefficients and correlations, showing that the endogeneity problem of R&D investment and firm profitability can be mitigated by the GMM estimation method.

Table.3. Regression results

| | Current period | | One period behind | |
|---|---|---|---|---|
| | OLS1 | GMM1 | OLS2 | GMM2 |
| | ROA | ROA | ROA | ROA |
| R& D1 | -0.001 | -0.004*** | | |
| | (0.001) | (0.002) | | |
| L.R& D1 | | | -0.002** | -0.003** |
| | | | (0.001) | (0.001) |
| SIZE | 0.021*** | 0.015** | 0.016** | 0.016* |
| | (0.006) | (0.007) | (0.007) | (0.009) |
| LEV | -0.172*** | -0.182*** | -0.171*** | -0.176*** |
| | (0.029) | (0.040) | (0.031) | (0.047) |
| CASH | 0.077 | 0.126** | 0.120** | 0.149* |
| | (0.053) | (0.063) | (0.059) | (0.079) |
| GROWTH | 0.071*** | 0.099*** | 0.102*** | 0.101*** |
| | (0.017) | (0.033) | (0.021) | (0.036) |
| TOP | 0.011 | 0.005 | 0.014 | 0.033 |
| | (0.033) | (0.029) | (0.036) | (0.035) |
| _cons | -0.454*** | -0.342** | -0.380*** | -0.384** |
| | (0.132) | (0.144) | (0.142) | (0.183) |
| N | 248.000 | 212.000 | 212.000 | 178.000 |
| r2 | 0.277 | 0.275 | 0.308 | 0.306 |
| r2_a | 0.259 | 0.254 | 0.288 | 0.281 |

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Based on the results of the GMM estimation test of the current model, it can be seen that the coefficient of R&D1 is -0.004 and the t-test is significant at the 1% level, then it indicates that the intensity of R&D investment is significantly and negatively related to current profitability, the same as hypothesis $1_b$ . Among the control variables, firm size (SIZE), firm risk (LEV), cash strength (CASH) and firm growth capacity (GROWTH) have significant effects on the performance of agricultural firms. The coefficients of firm size, cash strength and firm growth were all 0.015, 0.126 and 0.099 respectively, and the t-tests were significant at the 5%, 5% and 1% levels respectively, indicating that the better the firm's growth capacity, the larger the firm, the better its cash position and the more profitable the firm. The coefficient of corporate risk is -0.182 and the t-test is significant at the 1% level, which indicates that the higher the risk of the company, the lower the profitability may be as a result, and that corporate debt should be kept within reasonable limits.

According to the results of the GMM estimation test of the lagged one-period model, it can be seen that the coefficients of the lagged one-period R&D1 are -0.003 respectively, and the t-test is significant at the 5% level, then it indicates that the intensity of R&D investment is significantly and negatively related to the lagged one-period profitability, and there is a lag in the impact of R&D investment on the profitability of agricultural enterprises, the same as hypothesis 2.

Combining the results of the current and lagged period analyses, the correlation coefficients between the dependent variable and the independent variables remain stable, while the regression results of both models are significant, i.e. the impact of R&D investment on profitability of listed agricultural companies is lagged. The intensity of R&D investment in the current year and the lagged year significantly inhibits profitability, indicating that there is a lag in innovation investment and that R&D investment does not immediately improve profitability, but may instead inhibit profitability by taking up too many resources. This is mainly due to the seasonal and geographical nature of agricultural production and the long transformation cycle of scientific and technological innovations, which may take longer from research and development to large scale application.

### 5.4 Moderating effects

Based on the above findings, which indicate that the intensity of R&D investment has a negative impact on the profitability of listed agricultural companies in the current period, this paper will use firm size as a moderating variable to investigate how the difference in firm size affects this relationship. The results of this paper are shown in Table 4.

Table.4. Moderating effects

| | OLS | GMM |
|---|---|---|
| | ROA | ROA |
| RD1 | -0.008 | -0.063* |
| | (0.036) | (0.036) |
| RS | 0.000 | 0.003* |
| | (0.002) | (0.002) |
| SIZE | 0.020*** | 0.010 |
| | (0.007) | (0.008) |
| LEV | -0.173*** | -0.188*** |
| | (0.029) | (0.041) |
| CASH | 0.078 | 0.136** |
| | (0.053) | (0.065) |
| GROWTH | 0.071*** | 0.099*** |
| | (0.018) | (0.033) |
| TOP | 0.012 | 0.014 |
| | (0.034) | (0.031) |
| _cons | -0.444*** | -0.232 |
| | (0.145) | (0.169) |
| N | 248.000 | 212.000 |
| r2 | 0.277 | 0.265 |
| r2_a | 0.256 | 0.240 |

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As shown in the GMM regression results, we find that the coefficient of the interaction term between R&D investment intensity and firm size is 0.003 and is significant at the 10% level, which is consistent with the original hypothesis. In terms of the moderating effect of firm size, a larger firm size will improve the negative impact of R&D investment on the current profitability of listed agricultural companies, in line with hypothesis $3_b$ . If a company is small in size, its R&D investment activities will be risky and may take up a lot of resources, affecting its daily business activities. If the company has a large scale and financial strength, it will be able to provide some protection for research and innovation, without affecting its normal business activities and providing a new impetus to its profitability.

### 5.5 Robustness tests

This paper uses the natural logarithm of operating income instead of return on total assets as the explanatory variable for robustness testing, while mirroring the interaction term between operating income and firm size to test the Moderating effect of firm size. The results of the test are shown in Table V. The direction of the coefficients of the explanatory variables is the same as before the replacement, and they are all significant, and the conclusions remain consistent.

Table.5. Robustness tests

| | Current period | One period behind | Moderating effects |
|---|---|---|---|
| | REVENUE | REVENUE | REVENUE |
| RD1 | -0.052*** | | -0.005*** |
| | (0.020) | | (0.002) |
| L.RD1 | | -0.045*** | |
| | | (0.012) | |
| REVENUE*SIZE | | | 0.044*** |
| | | | (0.000) |
| SIZE | 0.970*** | 0.968*** | -0.940*** |
| | (0.050) | (0.057) | (0.016) |
| LEV | 0.425 | 0.512* | 0.018 |
| | (0.272) | (0.281) | (0.029) |
| CASH | 0.435 | 0.534 | -0.124** |
| | (0.383) | (0.461) | (0.057) |
| GROWTH | 0.198 | 0.250 | -0.006 |
| | (0.153) | (0.170) | (0.024) |
| TOP | 0.111 | 0.166 | -0.001 |
| | (0.280) | (0.313) | (0.039) |
| _cons | -0.469 | -0.599 | 21.518*** |
| | (1.114) | (1.234) | (0.231) |
| N | 212.000 | 178.000 | 212.000 |
| r2 | 0.724 | 0.737 | 0.997 |
| r2_a | 0.716 | 0.728 | 0.997 |

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

## 6. Conclusion and recommendations

This paper takes the data of listed agricultural companies as the research object, analyses the relationship between R&D investment and enterprise profitability, and on this basis, analyses the moderating effect of enterprise size, and proposes corresponding suggestions for the development of R&D investment of listed agricultural companies of different sizes. The study found that for agricultural enterprises, R&D investment has a significant negative impact on profitability in the current period with a lag, and the larger the size of the enterprise, the more it can weaken this negative impact. Based on the findings of the study, the following recommendations are made.

### 6.1 Appropriate increase in the intensity of R&D investment by enterprises

Although the intensity of R&D investment as a whole is significantly and negatively related to the profitability of a firm in both the current period and the lagged period, it can be seen from the moderating effect of firm size that when a firm is large enough, R&D investment can improve the profitability of the firm. This means that although the investment in research funding does not have a significant positive effect within the current phase, its impact can be reflected over a period of time. For small-scale enterprises must not blindly increase R&D investment, to ensure their own daily business activities under the premise of R&D activities to start, according to their ability; for medium-sized enterprises, to strengthen R&D investment, can not be short-sighted, stuck in the current period of return, to provide continuous impetus to improve the profitability of enterprises; for large-scale enterprises, to continue to strengthen R&D investment, enhance the core competitiveness of enterprises,. For large-scale enterprises, they should continue to strengthen their R&D investment, enhance their core competitiveness and dare to innovate by taking advantage of their own advantages. In short, for listed agricultural companies, they must strengthen R&D investment appropriately

according to their own scale, improve the capitalization of R&D expenses, and make use of modern technology to achieve intelligence through innovative operation, so as to gradually form the core competitiveness of the company.

### 6.2 Enterprises to improve the efficiency of R&D investment and strengthen the budgetary management of R&D expenditure

The intensity of R&D investment has a significant negative correlation with the profitability of enterprises in the current period, one period behind. It is possible that agriculture is a weak industry compared to other industries, and that the risk of R&D investment in agricultural enterprises is higher and the transformation ability of enterprises' R&D results is weaker. Therefore, listed agricultural companies should not only strengthen their R&D investment appropriately, but also pay more attention to improving the efficiency of investment and enhancing the ability to convert research investment into profit. At the same time, due to the lag in the role of research investment and the long cycle of R&D projects, which means there may be no return in the early stages of R&D, businesses must manage a fair R&D budget in tandem with their financial status and R&D development.

### 6.3 Enhanced government support for agricultural innovation

The government should increase support for agricultural enterprises' R&D investment, improve tax relief policies, and increase innovation investment subsidies for listed agricultural companies, especially small and medium-sized agricultural enterprises, to encourage their innovation R&D activities and guide the direction of agricultural innovation. Agricultural listed companies should also respond to the development of digital economy, actively transform and upgrade, improve innovation management system, improve industrial chain management, use new sales channels such as the Internet, and strive to improve R&D efficiency and accelerate the transformation of innovation results.


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